Evaluation of a structured physiotherapy treatment model for patients with lumbar disc herniation

Gunilla Limbäck Svensson

Department of Orthopaedics
Institute of Clinical Sciences
Sahlgrenska Academy
University of Gothenburg

UNIVERSITY OF GOTHENBURG

Gothenburg, Sweden 2013

http://hdl.handle.net/2077/31996
ISBN 978-91-628-8600-4

Sahlgrenska Academy
University of Gothenburg

Tryck: Ineko AB, Bangårdsvägen 8, 428 35 Kållered

Cover illustration:
Signe Svensson

Abstract

Symptoms from lumbar disc herniation are common in the general population. Many discs heal spontaneously and the patient's symptoms cease. When people have severe pain and sciatica, the recommendation is to start with physiotherapy treatment and pain medication for at least six to eight weeks before surgery is considered. There is, however, limited evidence relating to the effects of physiotherapy treatment for patients diagnosed with lumbar disc herniation. One common management method for patients with low back pain and sciatica is Mechanical Diagnosis and Therapy (MDT) or the McKenzie method, which aims to eliminate or minimise pain. However, MDT is seldom recommended for patients with disc herniation with a ruptured outer annulus, as the method is not expected to be effective on these patients.

The overall aim of this thesis was to evaluate a structured physiotherapy treatment model for patients who qualified for lumbar disc surgery by having severe, long-standing pain and an MRI-verified lumbar disc herniation.

Study I evaluated fear-of-movement/kinesiophobia in patients who were treated surgically for lumbar disc herniation. *Study II* evaluated a structured physiotherapy treatment model in patients who qualified for lumbar disc surgery. *Study III* described the experience of health among patients three years after treatment with either structured physiotherapy or surgery. *Study IV* evaluated the occurrence of centralisation of pain in relation to the patients' disability, self-efficacy and kinesiophobia, after two weeks of McKenzie therapy.

Study I showed that, 10-34 months after surgery for disc herniation, half the patients were classified as having kinesiophobia. These patients were more disabled, had more pain, more catastrophising thoughts, more symptoms of depression, lower self-efficacy and poorer health-related quality of life than patients who were not classified as having kinesiophobia.

Study II showed that the patients had already improved significantly three months after the structured physiotherapy treatment model

in all assessments: disability, leg and back pain, kinesiophobia, health-related quality of life, depression and self-efficacy. The improvement could still be seen at the two-year follow-up.

Study III showed that the patients, in the group treated with structured physiotherapy, expressed the most descriptions in feeling of well-being and they were physically active despite symptoms. In the group treated with surgery patients expressed more feeling of ill-being and were anxious and expressed that they avoided physical activity.

Study IV showed that 21 of the 41 patients were classified as centralisers after two weeks of structured physiotherapy treatment. These patients had significantly less disability, less leg and back pain, higher self-efficacy and less kinesiophobia three months after treatment was started, compared with non-centralisers. Both the centralisers and the non-centralisers improved statistically over time with regard to several parameters.

The overall conclusion from this thesis is that a structured physiotherapy treatment model for patients with pain and disability due to a lumbar disc herniation should be recommended before surgery is considered.

Keywords: Intervertebral disc displacement, rehabilitation, physical therapy modalities, qualitative research, surgery.

Sammanfattning

Besvär från diskbråck i ländryggen är tämligen vanligt i befolkningen, även om förekomsten varierar mellan olika vetenskapliga studier. Symtomen varier ofta över tid och många patienters diskbråck läker utan åtgärd och därmed försvinner symtomen. Hos patienter med ischias (utstrålande bensmärta), så läker diskbråcken hos en tredjedel av patienterna redan efter cirka två veckor och symtomen försvinner. Vid smärta från diskbråck rekommenderas ofta behandling såsom sjukgymnastik, medicinering, information och råd. Olika sjukgymnastiska behandlingar används för patienter med diskbråck i ländryggen, men det finns endast begränsade vetenskapliga bevis för hur effektiv sjukgymnastisk behandling är vid dessa besvär. En vanlig behandlingsmetod för patienter med utstrålande bensmärta, av annan orsak än diskbråck (t.ex. en buktande disk), är Mekanisk Diagnostik och Terapi (MDT), också kallad McKenzie-metoden. MDT syftar till att minska eller helt ta bort smärtan med hjälp av olika rörelser och positioner. Metoden rekommenderas däremot sällan för patienter då diskbråcket är bekräftat med magnetkameraundersökning. Anledning till att MDT-metoden inte används vid diskbråck är att metoden då inte förväntas ha någon effekt.

Det övergripande syftet med denna avhandling var att utvärdera en strukturerad sjukgymnastisk behandlingsmodell för patienter med svår, långvarig smärta på grund av diskbråck, som bekräftats med magnetkameraundersökning och kriterierna för operation uppfylldes.

Studie I utvärderade rörelserädsla hos patienter som var opererade på grund av diskbråck i ländryggen med avseende på patienternas ryggfunktion, smärta, katastroftankar, depression, tilltro till sin förmåga och upplevelse av hälsa.

Studie II utvärderade en strukturerad sjukgymnastisk behandlingsmodell för patienter med diskbråck i ländryggen som bedömdes behöva operation.

Studie III beskrev patienternas upplevelse av hälsa tre år efter strukturerad sjukgymnastik eller operation på grund av diskbråck i ländryggen.

Studie IV utvärderade förekomsten av centralisering av smärta (hur smärtans utbredning ner i benet drog sig tillbaka mot ländryggen) i relation till patienternas ryggfunktion, tilltro till sin förmåga och rörelserädsla, efter två veckors behandling med McKenzie-metoden hos patienter som uppfyllde kriterierna för operation av diskbråck.

Den strukturerad sjukgymnastisk behandlingsmodellen bestod av MDT och stabiliserande träning av bålmuskler inklusive träning med vikter och träningsmaskiner. Kriterier för att delta i studierna var att patienten hade haft smärta i minst sex veckor, uppfyllde kriterierna för diskbråcksoperation samt att magnetkameraundersökning överensstämde med de kliniska fynden. I delarbete I, II och IV användes validerade frågeformulär för att utvärdera kinesiofobi (rörelserädsla), ryggfunktion, smärta, katastroftankar, depression, tilltro till sin förmåga, hälsorelaterad livskvalitet, arbetsförmåga och nöjdhetsgrad. Delarbete III var en kvalitativ intervjustudie, som analyserades enligt metoden innehållsanalys, med tio patienter som opererats och tio som behandlats med den strukturerade sjukgymnastiska modellen. I delarbete IV utvärderades hur patienternas smärta centraliserade, det vill säga minskade i utbredning, vilket är ett positivt tecken som ger snabbare tillfrisknande. Centralisering anses inte kunna ske med MDT-behandling hos patienter med diskbråck i ländryggen.

Studie I visade att hälften av patienterna klassificerades som kinesiofoba (rörelserädda) ett år efter operation. Dessa patienter hade signifikant sämre ryggfunktion, mer smärta, mer katastroftankar, mer depression, lägre tilltro till sin förmåga och upplevde sämre hälsa än patienterna som inte klassificerades som kinesiofoba.

Studie II visade att patienterna förbättrades statistisk signifikant och påtagligt redan tre månader efter behandling med strukturerad sjukgymnastik i alla utvärderingar: ryggfunktion, smärta, depression, tilltro till sin förmåga, rörelserädsla och hälsa. Förbättringen kvarstod vid två-årsuppföljningen.

Studie III visade att patienterna som behandlats med sjukgymnastik upplevde hög grad av välbefinnande och var fysiskt aktiva trots besvär. Patienterna som opererats upplevde hög grad av illabefinnande samt beskrev oro och undvek därför fysisk aktivitet.

Studie IV visade att smärtan centraliserade hos hälften av patienterna redan två veckor efter McKenzie-behandling. De patienter där smärtan centraliserade hade statistiskt signifikant bättre ryggfunktion, mindre ben- och ryggsmärta, högre tilltro till sin förmåga och mindre kinesiofobi jämfört med icke-centraliserare efter tre månader. Både centraliserare och icke-centraliserare förbättrades statistiskt signifikant över tiden på de flesta parametrar.

Den övergripande slutsatsen av denna avhandling är att patienter med diskbråck i ländryggen rekommenderas en strukturerad sjukgymnastisk behandling som minskar eller tar bort patientens smärta, stärker patientens tilltro till sin egen förmåga och ger patienten en positiv syn på fysisk aktivitet, innan operation övervägs.

List of papers

I Limbäck Svensson G., Lundberg M., Östgaard HC., and Kjellby Wendt G. (2011). High degree of kinesiophobia after lumbar disc herniation surgery. *Acta Orthopaedica*. 82, 732 – 736.

II Limbäck Svensson G., Kjellby Wendt G., and Thomeé R. A structured physiotherapy treatment model can give rapid relief to patients who qualify for lumbar disc surgery. *Submitted*.

III Limbäck Svensson G., Kjellby Wendt G., Thomeé R., and Danielson E. (2013). Patients' experience of health three years after structured physiotherapy or surgery for lumbar disc herniation. *Journal of Rehabilitation Medicine*. 45, 293 – 299.

IV Limbäck Svensson G., Kjellby Wendt G., and Thomeé R. The occurrence of centralisation of pain after McKenzie therapy for patients with MRI-verified lumbar disc herniation and long-standing pain. *Submitted*.

Contents

Abbreviations

EQ-5D	The European Quality of Life in 5 Dimensions Questionnaires
HRQoL	Health Related Quality of Life
ICD-10	International Statistical Classification of Diseases and Related Health Problems
ICF	International Classification of Functioning, Disability and Health
IQR	Interquartile Range
LBP	Low Back Pain
MDT	Mechanical Diagnosis and Therapy
MIC	Minimal Important Change
MRI	Magnetic Resonance Imaging
NSAID	Non Steroidal Anti-Inflammatory Drugs
ODI	The Oswestry Disability Index
OG	Operative Group
PCS	The Pain Catastrophising Scale
RCT	Randomised Control Study
SD	Standard Deviation
SES	The Self-Efficacy Scale
SLR	Straight Leg Raising
SOC	Sense Of Coherence
SPG	Structured Physiotherapy Group
TSK	The Tampa Scale For Kinesiophobia
VAS	Visual Analogue Scale
WHO	The World Health Organisation
ZDS	The Zung Self-Rating Depression Scale

Introduction

History and prevalence of low back pain and sciatica

People have always had back pain. Back pain was described in the distant past in old texts from 1500 BC. The word sciatica has been used since Ancient Greek times and Hippocrates (460-370 BC) described "ischiatic" pain as mainly affecting men aged 40-60 years (Allan and Waddell, 1989). However, it was not until 1934 that Mixter and Barr (1934) described disc herniation as a cause of sciatica.

Today, back pain is a common problem and a recent systematic review concludes that low back pain (LBP) continues to be a common problem at global level (Hoy et al., 2012). With ageing populations, the absolute number of people with LBP is likely to increase over the coming decades. According to the same review, the mean point prevalence was 18%, the one-year prevalence was 38% and the mean lifetime prevalence was 39% (Hoy et al., 2012). Similar results were reported in a Swedish study (Björck-van Dijken et al., 2008), in which 41% of the 5,798 participants reported LBP. Moreover, individuals with LBP more frequently had a physically demanding job and a high physical work activity level but a low physical activity level during their leisure time (Björck-van Dijken et al., 2008). However, sciatica prevalence estimates vary widely between different studies, according to a systematic review from 2008 (Konstantinou and Dunn, 2008). The variation may be due to differences in definitions and methods of data collection. The review comprised just one study that based the sciatica diagnosis on a standardised physical examination. This was a Finnish study by Heliövaara et al. (1987) who investigated the prevalence of lumbar disc herniation in a sample of 8,000 people, where the lifetime prevalence was 5% for men and 4% for women.

Anatomy and biomechanical function

The spine has three important biomechanical functions; 1) to protect the spinal cord and other nerve structures, 2) to transfer weight between the

head, trunk and pelvis and 3) to permit motion of the spine and the adjacent body parts. The spine consists of a complex system of vertebrae that articulate with one another through joints, ligaments and discs (Figure 1).

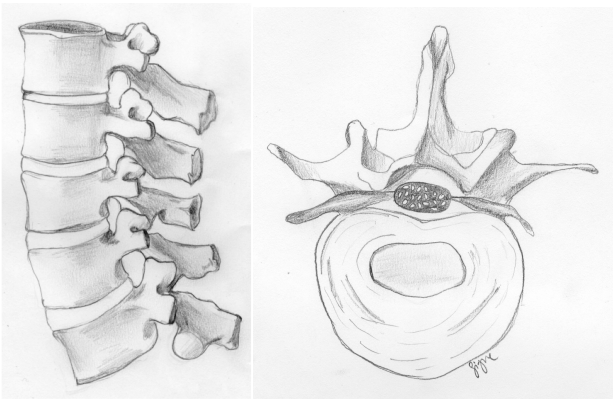


Figure 1: The spine includes five lumbar vertebrae with discs. A healthy disc with the nucleus pulposus and annulus fibrosus.

The trunk muscles must have sufficient strength and endurance to satisfy the demands of control, but the efficacy of the muscle system is dependent on its controller, the central nervous system (CNS) (Panjabi, 1992). Different muscles in the trunk perform different tasks; there are both superficial muscles and deep intrinsic muscles. The superficial muscles, rectus abdominis, obliquus externus abdominis and to some extent obliquus internus abdominis, produce flexion, lateral flexion and rotation moments and control external forces from these directions (Bergmark, 1989). Transversus abdominis (TrA) is the deepest of the abdominal muscles. It is suggested that TrA makes a specific contribution to spinal stability and should be trained separately from other muscles (Hodges and Richardson, 1999). The function of TrA can be impaired in the presence of low back pain (Hodges, 2000).

Intra-abdominal pressure is maintained by activity in the surrounding muscles. The mechanical role of intra-abdominal pressure is not fully understood, but there appears to be a correlation between an increased load on the trunk and intra-abdominal pressure (Bergmark, 1989). Another factor to consider may be breathing control. Optimised breathing control may

provide increased segmental control of the spine through the production of increased intra-abdominal pressure. Studies have investigated the role of breathing control during lifting and lowering tasks and they have concluded that patients with LBP had increased inspired volume during lifting and lowering tasks (Hagins and Lamberg, 2011; Lamberg and Hagins, 2012).

The disc is an avascular structure and contains a gelatinous nucleus pulposus, the surrounding fibrous zone, annulus fibrosus, and the vertebral endplates (Figure 1). In healthy young people, the water content in the nucleus is 80-90%. The water content decreases with age, mainly after the fourth decade of life (Adams and Roughley, 2006).

The disc is an absorber of load forces, mainly compressive loads, but it also absorbs tensile stresses during motions of flexion, extension and lateral flexion. Axial rotation of the torso causes torsional loads and shear stresses in the disc (White and Panjabi, 1978). The disc allows motion in all directions, but the direction of the facet joints restricts the motion in the segment. The direction of the facet joints differs in the spine and, in the lumbar spine, mainly flexion and extension are possible.

The mechanical load on the disc is particularly important for maintaining a healthy disc. On the other hand, prolonged exposure to hypo- or hyperphysiological loading can damage the disc. The magnitude, frequency and duration of dynamic loading together determine the destiny of disc cells (Chan et al., 2011). It has been shown that hydrostatic pressure influences the intervertebral disc cell metabolism. Moreover, abnormal hydrostatic pressure may accelerate disc degeneration (Handa et al., 1997). The load applied to the disc is more complex than only compression and hydrostatic pressure; other physical factors and different types of mechanical load also affect disc cell behaviour (Chan et al., 2011).

Lumbar disc herniation

Disc herniation is preceded by annular tears (or annular fissures). The nucleus pulposus, sometimes the annulus fibrosus and material from the end plates can penetrate the annular tears and cause a bulging disc. A bulging disc can develop into a complete disc herniation. Herniation is defined as the localised displacement of disc material beyond the limits of the intervertebral disc space (Fardon and Milette, 2001).

One common classification of disc herniation involves distinguishing between protrusion, extrusion and sequestration (Fardon and Milette, 2001).

The difference between disc protrusion and disc extrusion is based on the shape of the displaced material. The disc herniation can be contained or uncontained. A contained herniation has an intact outer annulus in contrast to an uncontained herniation that has a broken outer annulus. Sequestration occurs if the displaced disc material has lost continuity with the parent disc (Figure 2).

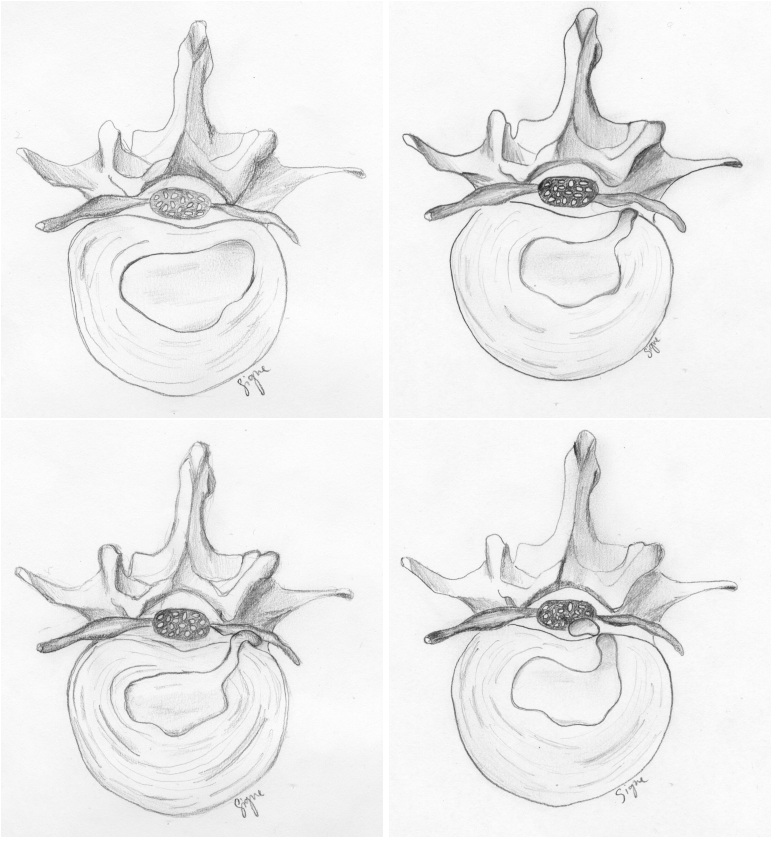


Figure 2: Different severities of disc herniation. From upper left: Disc bulge, protrusion, extrusion, and sequestration.

A disc herniation can cause the mechanical compression of a nerve root,

which can lead to symptoms and leg pain in particular (Rydevik et al., 1984). Furthermore, several studies have shown that sciatica depends not only on mechanical nerve root compression but also on biochemical factors (Brisby et al., 2000; Kayama et al., 1996; Olmarker et al., 1996, 1993). For example, experiments in pigs have shown that the epidural application of autologous nucleus pulposus without mechanical nerve root compression induced a pronounced reduction in nerve conduction velocity in the cauda equina nerve roots, compared with the epidural application of retroperitoneal fat in control experiments (Olmarker et al., 1993). In addition, it has been shown that the nucleus pulposus can induce morphological and structural changes in the nerve root (Kayama et al., 1996; Olmarker et al., 1996). In conclusion, there appear to be several pathophysiological explanations for the generation of symptoms due to disc herniation.

Symptoms and clinical findings from lumbar disc herniation

Persons with lumbar disc herniation do not necessarily have any symptoms. With Magnetic Resonance Imaging (MRI) bulging discs have been demonstrated in 81% of healthy volunteers without back problems and focal disc protrusions in 33% of the included persons (Stadnik et al., 1998). Another study investigated a group of patients with sciatica severe enough to require a discectomy and compared them with an age-, gender- and risk factor-matched group of asymptomatic individuals. The results showed that, in the matched group of asymptomatic individuals, there was a very high prevalence (76%) of disc herniation. It was concluded that individuals with minor disc herniations (i.e. protrusion, contained disc) were at high risk that their MRI findings not were a causal explanation of pain because a high rate of asymptomatic subjects had comparable morphological findings (Boos et al., 1995). It is therefore most important to evaluate MRI findings together with clinical findings to be able to clarify whether or not a disc herniation is giving the patient the symptoms.

When a person with a suspected lumbar disc herniation is examined, the clinical tests include a neurological examination of motor function, sensation, reflexes and the straight leg raising test (Hoppenfeldt, 1976). Back range of motion is also often examined. According to Vucetic and Svensson (1996), lumbar range of motion and the crossed Lasègue sign were the only physical signs that predicted 71% of the ruptured annuli and 80% of the intact annuli. Moreover, a thorough anamnesis, including both present and past history of pain and other symptoms, is necessary when patients

with suspected disc herniation are examined, in order to make the correct diagnosis (Koes et al., 2007).

Recurrent back pain is a common occurrence prior to the first appearance of radiating leg pain, which could be a sign of lumbar disc herniation. The most common symptom associated with lumbar disc herniation is leg pain in the affected nerve root dermatome (Weber, 1994). In addition, weakness or complete loss of motor function could appear and superficial sensibility can be reduced or totally lost in the affected nerve root dermatome. Moreover, the patient may describe different qualities of pain such as aching, pins and needles, numbness and muscle cramp pain.

Pain due to lumbar disc herniation is often known to be more severe than pain in other orthopaedic diagnoses. Furthermore, patients with signs of nerve root involvement are more severely affected than those with low back pain and pain referred to the legs (Kongsted et al., 2012). A study showed that an excess of 30 mm corresponded to moderate pain and an excess of 54 mm on the VAS was proposed as severe pain (Collins et al., 1997). Since the pain is often severe, it might influence the patients' ability to function in daily life. Pain can also be long-standing and lead to long periods of sick leave due to pain and disability (Dawson et al., 2011). Sick leave often results in negative economic consequences for the individual, as well as for society (Hansson and Hansson, 2005). Several studies have also reported that depressive symptoms can accompany disc herniation (Arpino et al., 2004; Zieger et al., 2011, 2010).

Natural healing

Evaluating treatment effects on patients with symptoms from a lumbar disc herniation is a challenge, as spontaneous healing is common. The symptoms often vary over time and many discs heal spontaneously and the symptoms cease. In patients with sciatica but without confirmed disc herniation on MRI, about one-third recover two weeks after the onset of sciatica and approximately three-quarters recover after three months (Vroomen et al., 2002). Von Korff (1994) has pointed out problems associated with studying the natural course of back pain and argues that studies of natural history must investigate the development of the back pain in the absence of clinical intervention. This is a major problem, as it is ethically questionable not to offer treatment to patients with lumbar disc herniation who experience severe pain and/or long-standing pain.

The natural course of sciatica, but without confirmed disc herniation on MRI, was evaluated in a randomised controlled trial, which compared non-steroidal anti-inflammatory drugs (NSAID) with placebo. The patients were, however, examined within 14 days after the onset of radiating leg pain, which meant that the opportunity to draw definite conclusions was limited. Approximately 40% of the 183 patients had back pain and restrictions in work and leisure after three months, while the corresponding figure after one year was 30% of 173 patients (Weber et al., 1993).

In a study designed to investigate the natural history of morphological changes on MRI, it was found that 37 of 42 patients (88%) showed an effective reduction in herniated mass on MRI 3-12 months after the onset of symptoms (Takada et al., 2001). To be more precise, after three months, eight patients' (19%) disc herniations were classified as being in regression. However, the so-called natural history included treatment with bed rest, non-steroidal, anti-inflammatory drugs, pelvic traction and caudal epidural block. The opportunity to draw definite conclusions about natural healing is therefore limited. Moreover, the results showed that sequestered hernias and transligamentous extrusions appear to be more easily and rapidly absorbed than other types of herniation.

Saal et al. (1996) reviewed the literature on natural history and non-operative treatment for patients with lumbar disc herniation and concluded that lumbar disc herniation has a favourable prognosis in the majority of patients. He also recommended that, because of the positive natural history within the first three months, surgery is rarely indicated before 6-12 weeks. A general recommendation is to wait 6-8 weeks before surgery (Bono et al., 2006)

Taken together, the true natural healing and history of lumbar disc herniation disease is not clear.

Treatments and outcomes for patients with lumbar disc herniation

Physiotherapy treatment

The general recommendation, when patients report symptoms from lumbar disc herniation, is to start with non-surgical treatment (Bono et al., 2006; Saal et al., 1996; Weber, 1994). There are many different treatment methods for patients with low back pain and sciatica. However, there is limited

evidence relating to the effects of physiotherapy treatments for patients diagnosed with lumbar disc herniation.

Recent clinical guidelines for low back pain include guidelines for patients with the ICD diagnosis of lumbago with sciatica and the associated ICF diagnosis of acute, sub-acute and chronic low back pain with radiating pain (Delitto et al., 2012). The guidelines are extensive and include guidelines for diagnosis, examination and interventions. The diagnosis is based on impairment/function and no MRI is used. For this reason, the interventions are not clearly formulated for patients with lumbar disc herniation and sciatica. However, there are some cohort studies, RCTs and systematic reviews, which are presented below, designed to evaluate the efficacy of treatments for patients with lumbar disc herniation and sciatica. A systematic review with the aim of evaluating the efficacy and adverse effects of treatments for patients with lumbar disc herniation and radiculopathy reported moderate evidence favouring stabilisation exercises over no treatment, manipulation over sham manipulation and the addition of mechanical traction over medication and electrotherapy. Adverse events were primarily experienced in association with traction treatment (Hahne et al., 2010).

Another systematic review (Luijsterburg et al., 2007) was unable to conclude whether physiotherapy, bed rest, manipulation or medication should be recommended as the most suitable treatment for patients with disc herniation. Traction, corticosteroid injections and acupuncture could not be recommended according to the same review, as several trials indicate no evidence of any effect. On the other hand, a recent RCT (Moustafa and Diab, 2013) evaluated lumbar extension traction versus a control group in patients with L5-S1 radiculopathy. At inclusion, the 64 patients had a duration of symptoms of more than three months and mild to moderate disability up to 40% on the ODI (ranges 0-100%). Patients who were unable to tolerate extension positions were excluded. The study showed that lumbar extension traction restored lumbar lordosis, reduced pain and disability and increased segmental intervertebral movements compared with a control group who received hot packs and interferential therapy. Another RCT (Unlu et al., 2008) compared three different physiotherapy treatments; traction, ultrasound and low-power laser. The 60 patients were diagnosed as having lumbar disc herniation with symptoms lasting less than three months. The treatments were applied over a period of three weeks, five days a week, and with a follow-up period of three months. The results showed that all three treatments were equally effective in terms of pain and disability.

In a retrospective cohort study (Saal and Saal, 1989), all 58 patients un-

derwent an aggressive physical rehabilitation programme including several treatment methods for pain control as well as for exercise training. All the patients were diagnosed using CT or MRI showing lumbar disc herniation. The results for the total group were 90% good or excellent outcome on a self-reported 4-grade scale (excellent, good, fair and poor). However, the evaluation was only performed on one occasion, approximately 31 months after treatment, which makes it difficult to disregard natural healing. Another retrospective cohort study (Hahne et al., 2011) also reported good results for patients with lumbar disc herniation using a physiotherapeutic functional restoration programme. Like Saal and Saal (1989), this study evaluated the effect of treatment several months after treatment began and had in addition a long treatment period of 8.7 months. This long treatment period makes it difficult to disregard natural healing. One randomised controlled study (Albert and Manniche, 2012) compared two types of active treatment for patients with sciatica; one group with symptom-guided exercises and the other with sham exercises, where both groups were given information and advice to stay active. The conclusion was that both groups were equally effective. However, this study did not control adequately for natural healing, since, at inclusion, some patients had only had sciatica for two weeks and the patients' diagnoses were not confirmed with an MRI.

One common management method for patients with low back pain and sciatica is Mechanical Diagnosis and Therapy (MDT), also known as the McKenzie method, which aims to eliminate or minimise pain (McKenzie and May, 2003). A systematic review showed that patients with low back pain treated with MDT reported a greater, more rapid reduction in pain and disability compared with NSAIDs, educational booklets, back massage and back care advice, strength training, spinal mobilisation and general exercises (Clare et al., 2004). In an RCT with a one-year follow-up, Paatelma et al. (2008) found that the McKenzie method was only marginally more effective compared with only giving advice to patients with low back pain. For patients with sciatica and a verified lumbar disc herniation, it has, however, been shown that a selected group of patients who responded to MDT after five days of treatment reported that they were satisfied after 55 weeks (Brötz et al., 2003). The patients started treatment just 12 days after the onset of symptoms and the effects of spontaneous healing cannot therefore be excluded. However, according to the MDT method, the hydrostatic mechanism in the disc is a prerequisite for being able to influence the internal disc displacement. The conceptual model according to the MDT method implies that it is possible to influence the internal disc displacement by re-

peating movements and positions, thereby influencing the patient's symptoms (McKenzie and May, 2003). When a disc has herniated, the annular wall is breached by the herniated material and the hydrostatic mechanism in the disc is lost. In this case, according to McKenzie and May (2003), the repeated movements and positions used with the MDT method can no longer be expected to influence the symptoms. Consequently, physiotherapists trained in the MDT method rarely use this method if disc herniation is confirmed with an MRI. However, symptom-guided treatment has been shown to have an effect on patients with lumbar disc herniation (Albert and Manniche, 2012), but further evaluation is required.

Trunk stabilisation exercises, which aim to restore deep trunk muscle control, have been used for the prevention and rehabilitation of low back pain (Hodges et al., 2003). A randomised controlled trial revealed a reduction in the recurrence of low back pain episodes after specific trunk stabilisation exercises compared with a control group receiving advice and the use of medication (Hides et al., 2001). Dynamic lumbar stabilisation exercises have been found to relieve pain and improve function in patients who have undergone microdiscectomy (Yilmaz et al., 2003). The effects of trunk stabilisation exercises combined with MDT have, however, not been studied in patients with non-operated lumbar disc herniation.

Surgery

As stated earlier, disc herniation commonly heals spontaneously and with decreasing symptoms over time (Weber et al., 1993). For this reason, it is common to allow some time to pass for healing before surgery is considered. If other treatment does not succeed within 6-8 weeks, surgery may be considered in patients with severe symptoms (Bono et al., 2006). A Swedish study shows a mean annual incidence of lumbar disc surgery of 24/100,000 inhabitants a year. The ten-year rate of re-operations in the same study was 10%. The 30-day mortality rate was 0.5 per 1,000 operations (Jansson et al., 2004). Lumbar disc surgery rates vary widely between different countries from 16 to 125/100,000 inhabitants (Rasmussen et al., 2005). The number of back operations has been shown to be 40% higher in the United States than in any other country (Cherkin et al., 1994).

One exception is the cauda equina syndrome, which is an acute condition that influences the function of the bladder, sometimes the intestinal function and the superficial sensibility in the genital area can be reduced. An absolute indication for lumbar disc surgery is a progressive neurolog-

ical deficit commonly associated with the cauda equina syndrome (Bono et al., 2006). Likewise, Cakir et al. (2009) state that the only clear and objective indication for early surgery is the cauda equina syndrome. However, the same authors also point out that striking evidence with regard to the necessity for immediate surgery does not cover even this severe complication. The relative indications for discectomy vary between surgeons and patients. According to Bono et al. (2006), it is incumbent on clinicians to discuss the advantages, disadvantages, risks, alternatives and estimated expected outcomes with patients.

Most of the time, the primary aim of lumbar disc surgery is to relieve the patient from pain in the leg. Other symptoms, such as back pain and possible muscle weakness in the leg, appear to be more difficult to reduce with surgery.

Aspects of evaluations for patients with lumbar disc herniation

In connection with spinal disorders, evaluations of the following domains are recommended for inclusion when evaluating the effects of treatment for patients with lumbar disc herniation: back-specific function, generic health status, pain, work disability and patient satisfaction (Bombardier, 2000). The results of a systematic review indicated that socio-demographic, clinical, work-related and psychological factors predict the outcome of lumbar surgery (den Boer et al., 2006b). A systematic review of non-surgical treated sciatica concluded that psychological factors were rarely investigated and saw a need of a consistent definition of sciatica (Ashworth et al., 2011).

In this thesis, these recommendations were followed as basic evaluation domains. In addition, the following domains are included: different aspects of health, centralisation of pain and kinesiophobia.

Health from quantitative and qualitative perspectives

The WHO defines health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (World Health Organisation, 1948). Health is a fundamental human right and people should therefore have access to basic resources for health. Obviously,

health is not a state that is easily measured, although several attempts have been made to measure quality of life and health (Garratt et al., 2002).

Health is an experience full of nuances and it is therefore not easily captured with standardised questionnaires. People's perception of quality of life also varies between individuals and is dynamic within them (Carr et al., 2001). For this reason, it may be suitable to evaluate health with interviews in which people are free to speak out about their own experiences, making it possible to give other perspectives than questionnaires permit.

In qualitative research, the interviewer is trained to put open-ended questions and open-ended follow-up questions, in order to explore the unique individual's perspective. Open-ended questions are said to yield in-depth responses about people's experiences, perceptions, opinions, feelings and knowledge. The data consist of verbatim quotations with sufficient context to be interpretable (Patton, 2002).

Taken together, standardised questionnaires and interviews illustrate different perspectives of health and answer different research questions. For this reason, both types of evaluation are important and together they can give a more detailed, deeper understanding of health than if just one perspective is investigated.

Centralisation of pain

The centralisation phenomenon is a concept within the MDT method that describes the reduction and elimination of distal pain in response to the therapeutic loading strategies. The centralised pain can increase in intensity in the back, but, as long as the distal pain is reduced in distribution, it is interpreted as a good sign and a sign of recovery. The increased central pain is presumed to decrease later during the treatment period (McKenzie and May, 2003).

The centralisation phenomenon was first described in 1981 (McKenzie, 1981). Thereafter, studies supported the hypothesis that end-range movements could influence the intensity and location of pain (Donelson et al., 1991, 1990).

Definitions of the centralisation phenomenon have differed between studies and standardised criteria are requested (Berthelot et al., 2007). The criteria compiled by Werneke et al. (1999), with three well-described categories, centralisation group, non-centralisation group and partial reduction group, are commonly used.

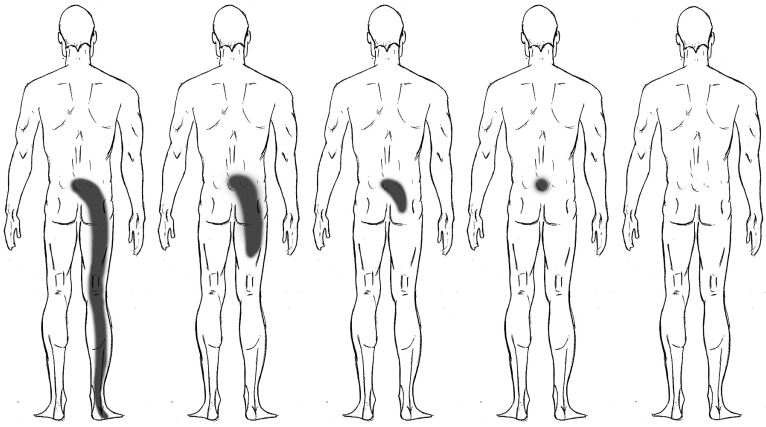


Figure 3: Centralisation phenomenon, centralisation of distal pain to a more central location.

Centralisation group

1. A clinically induced change in the location of pain/symptoms referred from the spine moves from the most distal position toward the cervical or lumbar midline. Note: For patients with only central or midline pain, the midline pain must cease during initial visit.

2. The change in pain location or abolition of midline pain must remain better (i.e., the lateral or distal pain does not reappear), as a result of mechanical movements/positions.

3. The change in pain location initially observed on the first visit must continue its proximal movement on subsequent trials until all symptoms are abolished. *Note:* Midline pain must remain abolished on subsequent visits.

Non-centralisation group:

1. No changes in the location pain occurs, or

2. The location of pain changes from a central to a more distal location throughout all treatment visits.

Partial reduction group

1. The location of pain changes from a more distal to a more central location during each visit, without a progressive movement in initial pain location toward the midline at consecutive visits, or

2. No change in pain location occurs during any one visit, but the patient has a gradual decrease in pain location over subsequent visits.

The centralisation phenomenon has been shown to be associated with a good prognosis; i.e. patients who centralise do better (Aina et al., 2004; Albert et al., 2012; Skytte et al., 2005; Werneke et al., 2008).

If the centralisation phenomenon and direction of preference (i.e. movements in one direction reduce the pain and movements in the opposite direction increase it) are considered when exercise is prescribed and, when the exercise matches the direction of preferences, it leads to a better outcome in subgroups of patients with LBP than if exercise in the opposite direction is used (Long et al., 2004; Long, 1995).

Studies have shown that patients with sciatica and suspected disc herniation who have centralised will have better outcomes than non-centralisers (Albert et al., 2012; Broetz et al., 2010; Skytte et al., 2005). However, these studies have included patients with short duration of pain, which makes it difficult to disregard natural healing. Moreover, MRI had not confirmed the disc herniation. The centralisation phenomenon is not expected to occur in patients in whom uncontained disc herniation is confirmed with MRI, according to McKenzie and May (2003); for this reason, MDT is seldom recommended when patients are diagnosed with disc herniation.

Kinesiophobia and fear of movement

Fear of movement and kinesiophobia are two concepts, which are frequently used synonymously in the literature. Another term used to describe fear in relation to pain is pain-related fear. Pain-related fear is a broad, general term that incorporates all kinds of fear related to pain (Crombez et al., 1999). Fear of movement/(re-)injury is described as "a specific fear of movement and physical activity that is (wrongfully) assumed to cause reinjury" (Vlaeyen et al., 1995b). In the most extreme situation of fear of movement, the term 'kinesiophobia' can be used, according to Kori et al. (1990).

The cognitive-behavioural fear-avoidance model (Figure 4) is often used when describing the different paths a patient with chronic pain can follow

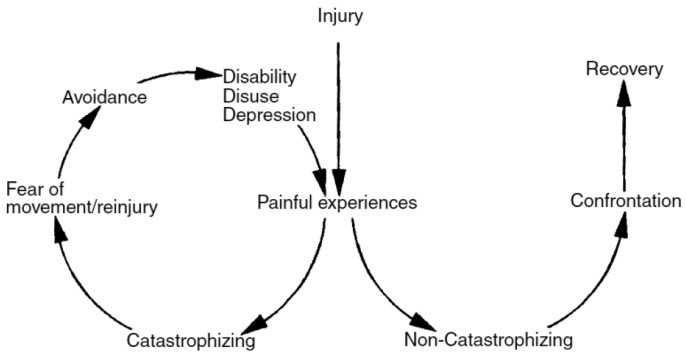


Figure 4: A cognitive-behavioural model of fear of movement/(re)injury by Vlaeyen et al. (1995b). This figure has been reproduced with permission of the International Association for the Study of Pain® (IASP). The figure may not be reproduced for any other purpose without permission.

(Vlaeyen et al., 1995b). The model suggests two responses to pain after an injury; catastrophising, with fear of fear of movement/(re)injury and avoidance followed by disability and consequently a vicious circle, or non-catastropising and confrontation, which are assumed to lead to recovery 4.

Originally, the fear-avoidance model was used on patients with chronic low back pain (Boersma and Linton, 2006; Picavet et al., 2002; Vlaeyen et al., 1995a). Kinesiophobia is thought to play a negative role in the outcome of rehabilitation for patients with low back pain and a high prevalence of kinesiophobia has been observed among patients with persistent low back pain (Lundberg et al., 2004; Picavet et al., 2002). During the last decade the number of studies concerning the fear-avoidance model have increased substantially (Vlaeyen and Linton, 2012). The model and conception of fear of movement have spread and have been used for patients with cervical radiculopathy (Dedering and Börjesson, 2012), upper extremity disability (Das De et al., 2013; Feleus et al., 2007), patients with knee problems (Domenech et al., 2012) and acute low back pain (Ostelo et al., 2007).

Summary of problem areas

Lumbar disc herniation is fairly common in the general population and can lead to severe, long-standing pain (Hoy et al., 2012). Many lumbar disc herniations heal spontaneously, but many patients have to endure a long period of pain and symptoms. Non-surgical treatment including pain medication are recommended as the first choice for patients with severe pain from a lumbar disc herniation (Bono et al., 2006). However, there is little evidence to support the effect of physiotherapy treatment methods. In order to account for the complexity of pain, symptoms, impaired function and disability these patients present, it seems necessary to design a structured physiotherapy treatment model. The treatment should aim for a reduction in the patients' pain and disability and also to empower the patients and increase their self-efficacy, so that they will be able to cope more easily with their back problem in the future.

Health-related quality of life (HRQoL) is assessed at an earlier stage in patients in relation to lumbar disc surgery (Hansson and Hansson, 2007). A more detailed description of patients' experience of health a couple of years after structured physiotherapy treatment or surgery is, however, lacking. A qualitative interview study with open-ended questions to patients with lumbar herniation could yield in-depth responses about their experiences, perceptions, opinions, feelings and knowledge.

The centralisation of pain is not expected to occur in patients when disc herniation is confirmed with MRI and, for this reason, MDT is seldom recommended when patients are diagnosed with disc herniation (McKenzie and May, 2003). At our hospital, however, we have good clinical experience of MDT treatment for this group of patients. An evaluation of the centralisation phenomenon in relation to a structured physiotherapy treatment model for patients with lumbar disc herniation therefore appeared to be justified.

Fear of movement is thought to play a negative role in the outcome of rehabilitation for patients with low back pain and a high prevalence of kinesiophobia has been observed among patients with persistent low back pain (Lundberg et al., 2004; Picavet et al., 2002). It could therefore be assumed that fear of movement might also influence patients with lumbar disc herniation.

Aims

The overall aim of this thesis was to evaluate a structured physiotherapy treatment model for patients, who qualified for lumbar disc surgery by having severe, long-standing pain and an MRI-verified lumbar disc herniation.

The specific aims were to:

- study kinesiophobia in patients who were treated surgically for lumbar disc herniation and relate the results to established outcome measures (Study I)
- evaluate a structured physiotherapy treatment model in patients who qualified for lumbar disc surgery (Study II)
- describe the experience of health among patients three years after treatment with a structured physiotherapy model or surgery due to lumbar disc herniation (Study III)
- evaluate the occurrence of the centralisation phenomenon in relation to the patients' disability, self-efficacy and kinesiophobia, after two weeks of McKenzie therapy for patients who qualified for lumbar disc surgery (Study IV)

Patients and Methods

All the patients in this thesis qualified for lumbar disc surgery. However, there were two study populations (Table 1) — patients who were treated surgically at Södra Älvsborg Hospital (Study I) and patients who were identified as surgical candidates at Sahlgrenska University Hospital (Studies II-IV). Orthopaedic surgeons determined whether the patients qualified for lumbar disc surgery after MRI and a physical examination according to the recommendations of the American Academy of Orthopaedic Surgeons for patients with lumbar disc herniation (Nachemson, 1993) and also according to more recent recommendations by Bono et al. (2006).

Inclusion criteria

Patients were included if they were between 18-65 years of age, had an MRI confirming disc herniation and explaining the clinical findings, had severe leg pain and symptoms for at least six weeks (minimising the effects of spontaneous healing), and pain distribution with concomitant neurological disturbances correlated to the affected nerve root.

Exclusion criteria

Patients were excluded from participation in Studies II, III and IV if they had the cauda equina syndrome, previous spinal surgery, other spinal diseases, such as spinal stenosis and spondylolisthesis, and inadequate command of Swedish language.

Study I

All 97 patients between 18 and 65 years of age who had undergone standardised open discectomy in 2004 and 2005 at Södra Älvsborg Hospital (Sweden) were invited to participate in the study. Questionnaires were sent to the patients in September 2006. If no response was received after two mailed reminders, the patients were reminded by telephone. Eighty-four (48 men) of 97 patients (87%) returned the questionnaires. The patients had a mean age of 43 (SD 11) years.

Table 1: Overview of the studies included in the thesis

Study	Number of patients	Treatments	Aim	Study population
I	84	Surgery	Study kinesiophobia	Södra Älvsborg Hospital
II	41	Structured physiotherapy treatment	Evaluate structured physiotherapy treatment	Sahlgrenska University Hospital
III	20 (10+10)	Structured physiotherapy treatment and surgery	Describe experience of health	Sahlgrenska University Hospital
IV	41	Structured physiotherapy treatment	Evaluate centralisation phenomenon	Sahlgrenska University Hospital

Studies II and IV

One hundred and fifty patients, who were referred to the orthopaedic clinic at Sahlgrenska University Hospital, Gothenburg, Sweden, from November 2003 to January 2008, were identified as potential participants in Studies II and IV. The patients were examined and disc herniation was confirmed by MRI. The spontaneous resolution of symptoms occurred in 70 patients (Figure 5). The remaining 80 patients had MRI-verified disc herniation, met the inclusion criteria and qualified for surgery. Orthopaedic surgeons determined whether the patients qualified for lumbar disc surgery after MRI and a physical examination according to the recommendations of the American Academy of Orthopaedic Surgeons for patients with lumbar disc herniation (Nachemson, 1993).

Initially, Study II was planned as a randomised controlled trial (RCT) comparing a structured physiotherapy treatment model and surgery, but the number of patients was not large enough to obtain acceptable power, despite a long period of inclusion. Eighteen of the 80 patients were initially randomised to physiotherapy, 17 patients were randomised to surgery and 45 patients did not accept randomisation. Twenty-seven of the 45 patients

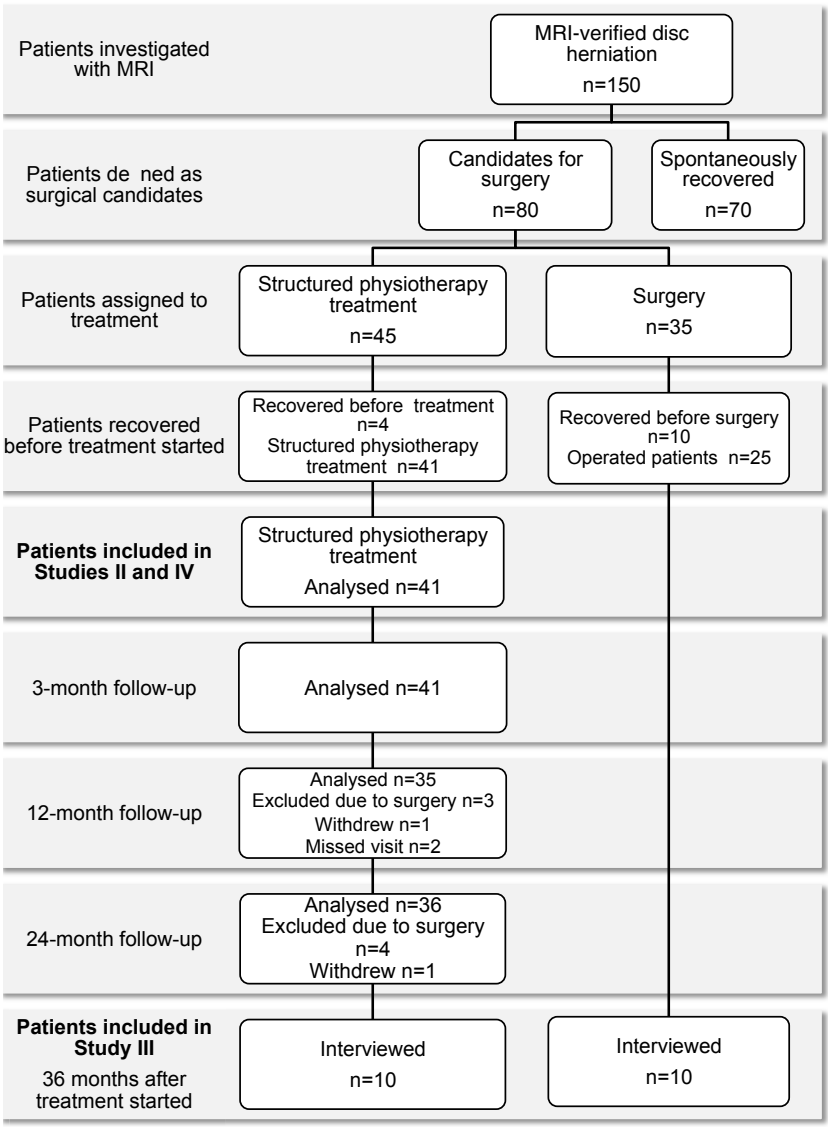


Figure 5: Flow chart Studies II-IV

who did not accept randomisation agreed to take part in the structured physiotherapy treatment and 18 patients decided to undergo surgery. A decision was therefore made solely to present a cohort of 45 patients treated according to the structured physiotherapy treatment protocol. Before the structured physiotherapy treatment began, four patients recovered to the extent that they could no longer be accepted as surgical candidates and they were therefore excluded from the studies. The remaining 41 patients treated according to the structured physiotherapy model will be presented in Studies II and IV (Figure 5).

Independent examiners, who were not involved in the treatment, distributed the questionnaires before treatment and at the three-, 12- and 24-month follow-ups.

The patients had a mean age of 42 (SD 9.1) years. Of the 41 patients, 19 (46%) were men.

Study III

Three years after completing either structured physiotherapy treatment (n=10) or surgery (n=10), the patients were selected for this interview study (Figure 5). The patients were selected from the cohort that was initially planned as an RCT (Study II) of a structured physiotherapy treatment model and surgery and a cohort of patients who had chosen treatment (structured physiotherapy treatment model or surgery). Earlier quantitative studies show no differences between surgery and non-surgical treatments after one and two years (Jacobs et al., 2011). A decision was therefore made to include both patients who were treated with surgery and patients who were treated with structured physiotherapy, as these patients could be regarded as a homogeneous group. There was, however, no intention to compare the two groups. A convenience sample of ten patients from each treatment group was consecutively selected, meaning that ten patients had undergone surgery, of whom five were randomised to treatment and five had chosen surgery in Study II. This group was named the Operative Group (OG). Correspondingly, ten patients had been treated with structured physiotherapy, of whom five patients were randomised to treatment and five patients chose physiotherapy treatment in Study II. This group was named the Structured Physiotherapy Group (SPG). Patients that had surgery on more than one occasion and patients who first received physiotherapy treatment but then required surgery were not selected for this study. In order to prevent uneven distribution in the two groups (SPG and OG), a check was made of the in-

tensity of pain in the leg and back two years after treatment. In both groups, the selected patients had a wide spread of pain intensity in the leg and back, documented with a Visual Analogue Scale (VAS) two years after treatment.

The twenty patients were 25-66 years old (median age 43.5), nine women and eleven men. The patients in the SPG, six women and four men, were 31-66 years old (median age 49.5) and the patients in the OG, three women and seven men, were 25-59 years old (median age 40.5). During the interviews, three patients reported other diagnoses that could influence their health. In the SPG, one patient had a whiplash disorder and another had concentration problems following a virus in the CNS. In the OG, one patient had varicose ulcers. Two years after treatment, the patients answered questionnaires, which revealed that three patients experienced kinesiophobia, 13 patients had no leg pain and likewise 13 patients reported no back pain. No disability was reported by 15 patients.

Treatment methods

Surgical treatment was performed on all the patients in Study I. The structured physiotherapy treatment model was used for all the patients in Studies II and IV. In Study III, ten patients were treated with structured physiotherapy and ten with surgery.

Surgical treatment, Studies I and III

The surgical treatment comprised a standardised open discectomy performed by spinal surgeons. The post-surgery rehabilitation included early active rehabilitation according to Kjellby-Wendt and Styf (1998). The surgical treatment is expected to reduce leg pain and thereafter the post-surgery rehabilitation aims to restore function, such as strength and flexibility, in order to return to work and physical activity.

Structured physiotherapy treatment model, Studies II-IV

Six physiotherapists, with MDT credentials, examined and treated the patients during a nine-week period (Figure 6).

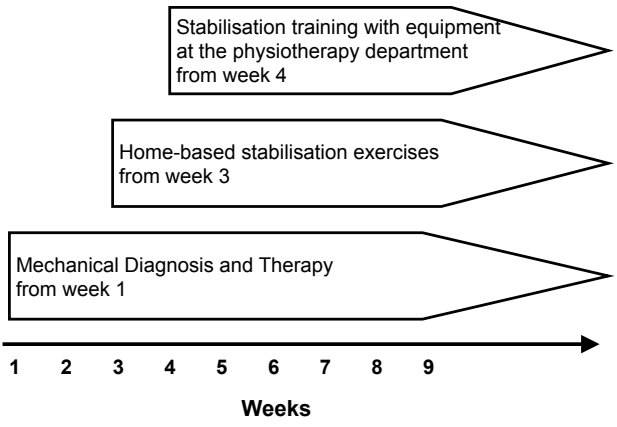


Figure 6: A graphic illustration of the structured physiotherapy treatment model. A total of nine weeks of treatment and thereafter a follow-up in week 13. Patients were empowered to continue the training on their own.

Figure 7: The best-known movements associated with MDT are extension exercises. Picture: Anders Agetorp

Phase 1 – MDT, weeks 1-2

For the first two weeks, an MDT protocol was followed based on individual clinical examinations of mechanical and symptomatic responses to positions and movements (Figure 6). The aim of the protocol was to minimise pain and it was conducted with the emphasis on self-management and the empowerment of the patient. The key management decision is to determine

Figure 8: Side-gliding as the patient's own exercise and as a physiotherapist-assisted exercise. Photo: Göte Norgren

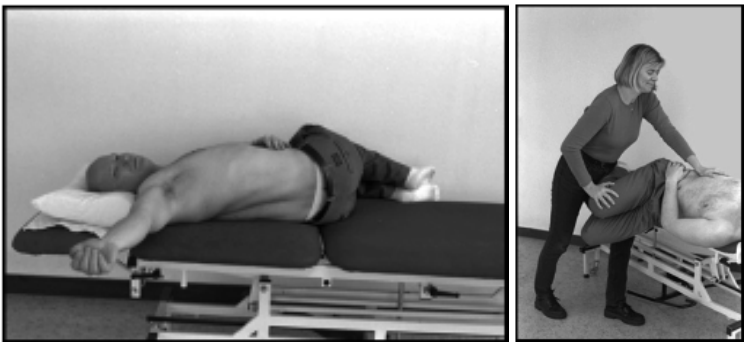


Figure 9: Rotation in flexion as patient's own exercise and as a physiotherapist assisted exercise. Photo: Göte Norgren

the direction of loading that is necessary primarily to reduce the symptoms in the leg. The best-known movement associated with MDT is extension exercises (Figure 7). However, in patients with lumbar disc herniation, it is often movements in other directions that reduce pain, so-called lateral procedures such as side glide(Figure 8) and rotation in flexion (Figure 9). The patients were instructed to perform exercises several times a day with the aim of reducing the leg pain. The fact that the patients were aware of the effect of different postures and mechanical loads and were able to adjust posture and loads from symptomatic responses was just as important as the exercises. The patients were educated in the principles of the MDT method in order to evaluate the effect of the home-based exercises themselves. This meant that the patients could decide whether to continue with the exercise or interrupt it until the next meeting with the physiotherapist. Sometimes, it may be necessary to introduce manual techniques performed by the physiotherapist in order to produce a reduction in pain. Most patients will then be able to continue with their home exercises several times a day (McKenzie and May, 2003). The MDT method is characterised by the collaboration between the patient and the physiotherapist. The aim with the collaboration is to encourage empowerment and give the patients tools to treat themselves.

Evaluation of the centralisation phenomenon (Study IV)

Two weeks after MDT treatment began, the physiotherapist who treated the patient evaluated the centralisation phenomenon on the basis of the self-reported pain drawings and the assessments made by the physiotherapist, see also Assessment of the centralisation phenomenon, page 34.

Phase 2 – Home-based stabilisation exercises, week 3

During the third week (Figure 6), graded trunk stabilisation exercises in lying, sitting, and standing were added to the MDT. The purpose of graded trunk stabilisation exercises was to improve muscle control. Initially, the stabilisation exercises were home based and performed without any equipment.

Phase 3 – Stabilisation training with equipment at the physiotherapy department, weeks 4-9

The training was then scheduled at the physiotherapy department three times a week (Figure 6). In the training, dumbbells, expanders and weight

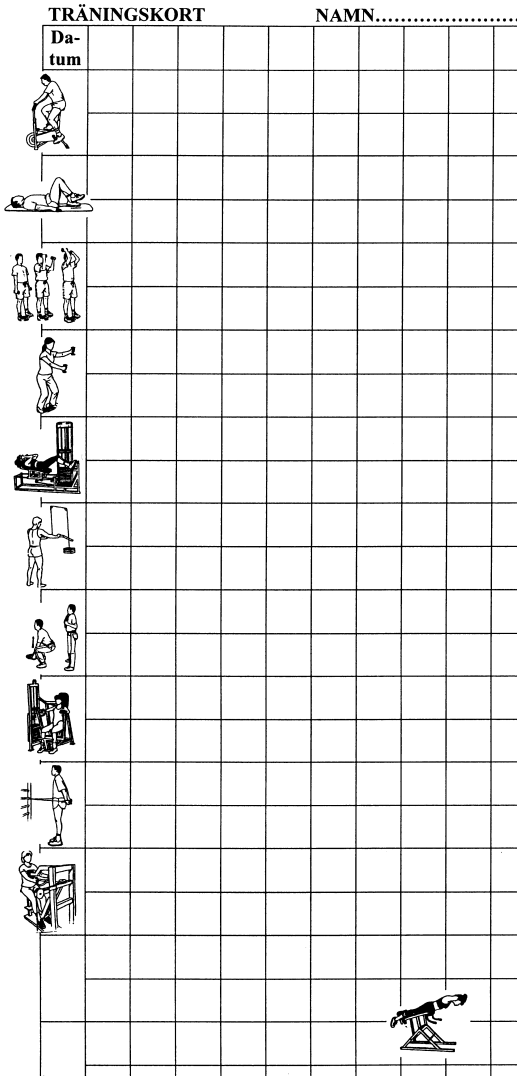


Figure 10: Training program. The pictures are from the MOBILUSw training application.

machines for strength training were used. The low-load muscular endurance exercises were gradually increased in intensity on an individual basis with respect to the patients' reported leg pain and the observed movement control and quality. A schedule was used to record the progress in the number of exercises and weights throughout the training period. An example of the training program can be seen in Figure 10). During the last weeks, the patients were encouraged to continue exercising on their own at a gym or to perform some other type of physical training of their own choice. Throughout the training period, the patients proceeded with the MDT exercises, which were continuously discussed and evaluated by the physiotherapist in collaboration with the patient.

Follow-up visit

Four weeks after the completion of the nine-week physiotherapy treatment period, the patients attended a follow-up visit to the physiotherapist. The aim of this visit was to encourage a high level of compliance with respect to continued trunk stabilisation exercises and MDT practice.

Evaluation methods

In this thesis, there are three types of evaluation methods; questionnaires, interviews and assessments of the centralisation phenomenon. The data were then analysed statistically (Studies I-II, IV) or using content analysis (Study III).

Questionnaires

All the patients presented in this thesis answered questionnaires, which have been found to be reliable and valid. The questionnaires included descriptive data including age, gender and duration of pain before treatment. Patients in Study I also answered questions about their history of previous disc herniation surgery.

Pain

Pain intensity was rated on two Visual Analogue Scales (VAS), one for leg pain and one for back pain (Scott and Huskisson, 1976). The VAS ranges

from 0 to 100 mm, from “no pain” to “maximum pain”. A score of 0-10 mm on the VAS was defined as no pain (Öberg et al., 2003).

Back-specific function

The Oswestry Disability Index (ODI) comprises ten items assessing back-specific function (Fairbank et al., 1980). Each item is scored from 0 to 5. The total score is expressed as a percentage, where 0% represents no disability. An ODI disability score of 0-20% was defined as minimal or no disability, 21-40% moderate disability, 41-60% severe disability, 61-80% crippled and a score above 80% was defined as either bedbound or exaggerating their symptoms (Fairbank et al., 1980). According to Öberg et al. (2003), a score of 0-10% was defined as no disability. Good reliability and validity have been reported (Fairbank and Pynsent, 2000; Grönblad et al., 1993).

Kinesiophobia

The Tampa Scale for Kinesiophobia (TSK) questionnaire comprises 17 items assessing the subjective rating of kinesiophobia. Each item has a 4-point Likert scale with scoring alternatives ranging from “strongly disagree” to “strongly agree”. A total sum is calculated after inversion of the individual scores for items 4, 8, 12 and 16. The total score varies between 17 and 68. A high TSK value indicates a high degree of kinesiophobia. Vlaeyen et al. (1995a) defined a cut-off of >37 as a high degree of kinesiophobia. The TSK-SV has been found to be reliable and valid for use in Swedish patients with persistent low back pain (Lundberg et al., 2004).

Self-efficacy

The Self-Efficacy Scale (SES) consists of eight items assessing functional self-efficacy beliefs specifically related to various basic physical activities (Estlander et al., 1994). Each category is scored on an 8-point Likert scale whereby the patients estimate how long they believe they would be able to endure the activity, from less than 2 minutes to more than 45 minutes. The total score range is 8-64, with higher scores indicating more positive beliefs. The reliability has been tested in a Swedish population of LBP (Johansson, 1999).

Catastrophising thoughts

The Pain Catastrophising Scale (PCS) comprises 13 items assessing catastrophising thoughts (Sullivan et al., 1995). Each item is scored from 0 to 4 and the scores are added up from 0 to 52, where 0 is no catastrophising thoughts. Patients scoring above 24 on the PCS are classified as catastrophisers and below 15 as non-catastrophisers (Sullivan et al., 1995). The PCS is a reliable and valid measurement of catastrophising (Sullivan et al., 1995).

Health-related quality of life

The European Quality of Life in 5 Dimensions (EQ-5D) questionnaire was used to measure health-related quality of life (HRQL) (Rabin and de Charro, 2001). The EQ-5D consists of two parts; the first part involves five dimensions with three levels of answers. Possible values range from –0.59 to 1.0, where 1.0 is optimal health. The mean EQ-5D index is 0.86 for a Swedish population aged 40-49 years (Burström et al., 2001b) and a value of ≤ 0.86 could therefore be defined as normal for this age group. The second part is the EuroQol Visual Analogue Scale (EQ-VAS) ranging from 0 (worst possible health state) to 100 (best possible health state). The EQ-5D has been tested and validated (Burström et al., 2001a).

Depressive symptoms

The Zung Self-Rating Depression Scale (ZDS) consists of 20 items assessing depressive features (Zung, 1965). Each item has a 4-point Likert scale from "seldom" to "almost always". The scores are added up from 20 to 80. The more depressed the patient is, the higher the score obtained. A score of 35 or higher would indicate depressive symptoms (Arpino et al., 2004; Zung, 1965). The ZDS is a reliable and valid measurement (Zung, 1965).

Patient satisfaction

Patient satisfaction with treatment was measured on a three-grade Likert scale – satisfied, less satisfied and dissatisfied (Strömqvist et al., 2001).

Work disability

Work status was measured using a three-grade Likert scale – working full time, full-time sick leave and part-time sick leave.

Pain drawing

The area of pain distribution was marked on a body outline drawing (front and back, full view) to record the location of pain or symptoms. Four different symbols were used for different qualities of pain; aching, pins and needles, numbness and muscle cramps. These features were chosen with regard to the fact that all patients had disc herniation. The pain drawings were evaluated with a clear overlay body template and the most distal pain was coded (Donelson et al., 1991; Long, 1995; Werneke et al., 1999). Figure för att visa områdena.

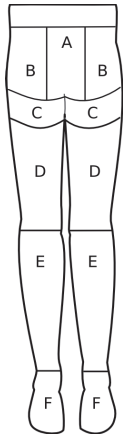


Figure 11: Body outline template used for indicating pain distribution.

Interview

Data were collected through interviews in Study III. An interview guide with open-ended question areas was composed with regard to health and everyday living. For the purpose of this study, the following question was analysed; Could you please describe how you are feeling?

The patients were contacted by phone, informed about the study and asked if they would like to participate. The interviews were conducted in a separate room at the physiotherapy department by a researcher familiar with the rehabilitation process for patients with disc herniation.

The interviews took place over a period of four months in 2009, approximately three years after treatment started. In the SPG, the interviews lasted 25-46 minutes (median 31.5 minutes) and, in the OG, 18-97 minutes (median 31 minutes). In all, 11 hours and 58 minutes of interviews were tape-recorded and then transcribed verbatim. The researcher listened to the interviews and corrected the transcripts as necessary before starting the analysis. The text was then analysed according to content analysis, see page 36.

Assessment of the centralisation phenomenon

Before and after each visit to the physiotherapist, the patients completed a pain drawing. Two weeks after the treatment started, centralisation or non-centralisation was determined on the basis of the self-reported pain drawings and the assessments of the physiotherapist who treated the patient. There were three definitions: the centralisation group, the non-centralisation group and the partial reduction group. The definitions by Werneke et al. (1999) were somewhat modified in this study to suit patients with lumbar disc herniation, all of whom had radiating leg pain and qualified for lumbar disc surgery on the basis of their symptoms and MRI verification. Later on, the non-centralisation group and the partial reduction group were merged into one group, named non-centralisers, in order to obtain an acceptable sample size.

Centralisation group

1. A clinically induced change in the location of pain referred from the spine goes from the most distal position toward the lumbar midline. At a minimum, the pain must move from one body part to the next (for example, from the foot to the calf or from the calf to the thigh).

2. The change in pain location must remain positive, i.e. centralised (the lateral or distal pain does not reappear), as a result of mechanical movements/positions. Pain that was centralised during repeated movements or positions must remain positive/centralised after resuming weight-bearing position.

3. The changes in pain location initially observed on the first visit must continue their proximal movement on subsequent trials (until all symptoms have disappeared).

Non-centralisation group

1. No change in pain location occurs, or

2. The location of the pain changes from a central to a more distal location on all treatment visits.

Partial reduction group

1. The pain location changes from a more distal to a more central location during each visit, without any progressive movement of the initial pain location toward the midline at consecutive visits, or

2. No change in pain location occurs during any one visit, but the patient experiences a gradual decrease in pain and a shift in pain location during subsequent visits.

Analysis

In this thesis, a different statistical analysis was used for questionnaires and for the assessment of the centralisation phenomenon. In the qualitative study, content analysis was performed (Table 2).

Statistical analysis

Study I: The results are presented as median values and range, except for age, which is presented as the mean and standard deviation (SD). The significance level was set at 5%. Statistical comparisons between those with and without kinesiophobia were made from logistic regression with adjustment for age and gender. Comparison without adjustment was calculated with the chi-square test, with pooling of categories when necessary.

For five patients, one TSK item was missing and we used imputation with linear regression to replace the lost information. The imputation technique used here may lead to an underestimation of the variance, but the small number of imputed data made this a minor problem. The ODI score

Table 2: Statistical analyses used in the studies

Analysis	Study
Median values and IQR	II, IV
Median values and range	I, III
Mean SD	I, II, IV
Logistic regression with adjustment for age and gender	I
Mann-Whitney U test	II, IV
Wilcoxon's signed rank test	II, IV
Chi-square test	I
Linear regression to replace the lost information	I
Content analysis	III

was calculated as the sum of the ODI items divided by the number of valid items. In four patients, one item was missing.

Study II and IV: The results are presented as median values and interquartile ranges (IQR), except for age, which is presented as the mean and SD. Changes over time within groups were analysed with Wilcoxon's signed rank test. Changes between groups were analysed with the Mann-Whitney U test. Statistical significance was set at an alpha level of 0.05.

For two patients, one item on the TSK was missing and missing data imputation was used to recover the lost information. For nine patients, one ODI item was missing. The ODI score was calculated as the sum of the ODI items divided by the number of valid items.

Content analysis

Study III: The interview texts were analysed by content analysis. Content analysis can be used both qualitatively and quantitatively. Content analysis is useful both as a method and a technique in analyses of texts. Krippendorff (2012) emphasises the importance of making replicable, valid inferences from texts or other meaningful matter to the contexts of their use. Content analysis proceeds step by step, in order to recognise patterns, themes and sub-themes (Figure 12) (Patton, 2002).

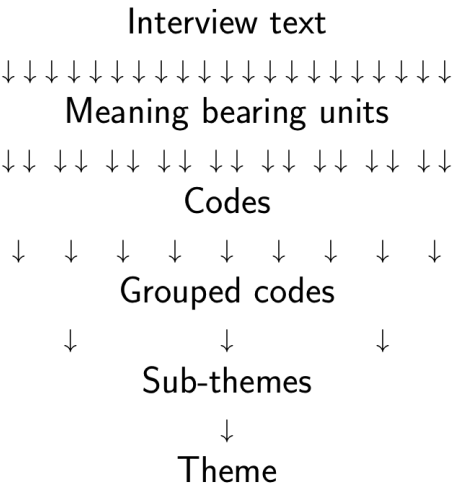


Figure 12: A graphic illustration of content analysis

The researcher and interviewer (GLS) and the experienced qualitative researcher (ED) read all the interviews in order to grasp the content. GLS then analysed the data and ED followed the paths shown in the analysis. In the analysis, the meaning units were condensed and coded according to their content. Since there were more negative comments in the OG compared with the SPG, a decision was made to mark the codes as positive, negative or neutral. Each patient's codes were then summed up in positive, negative and neutral descriptions and a predominant judgement of codes per patient and per group was made. In order better to illustrate the two treatment groups, a choice was made to specify the number of codes in each group (Krippendorff, 2012). The codes with similar content were counted and formed into sub-themes. Finally, sub-themes were formed into themes. Every part of the analysis was continuously re-read and discussed by GLS and ED to improve credibility.

Ethics

Written information was sent together with the questionnaires to the patients in Study I. The patients in Studies II and IV were given verbal and written information and informed consent was obtained. Written informed consent was obtained from each patient in Study III before the interview commenced. The Regional Ethical Review Board approved the studies (No. Ö246–03).

Summary of results

Study I – High degree of kinesiophobia after lumbar disc herniation surgery

Study I was a cross-sectional study of 84 patients who were operated on due to lumbar disc herniation, at Södra Älvsborg Hospital, 10-34 months prior to this study. Twenty of the 84 patients had previously undergone surgery for lumbar disc herniation. Of these 20, 18 were operated on twice, one patient had been operated on three times and one patient had been operated on five times.

Eighty patients answered the Tampa Scale for Kinesiophobia (TSK). Approximately half of them (36/80) were classified as having kinesiophobia, scores of more than 37 on the TSK. Descriptive data were comparable between the groups with and without kinesiophobia in terms of age, gender, place of birth, number of operations and disc herniation level. Before surgery, patients with kinesiophobia had not experienced symptoms any longer than patients without kinesiophobia.

Patients classified as having kinesiophobia obtained statistically significantly poorer results in eight of ten outcome measurements in comparison to those without kinesiophobia (Table 3). In Figure 13, the number of patients with each score on the TSK is shown.

Study II – A structured physiotherapy treatment model can give rapid relief to patients who qualify for lumbar disc surgery

Study II was a prospective cohort study with a 24-month follow-up after structured physiotherapy treatment. No patient had undergone surgery at the three-month follow-up. At the 12-month follow-up, three patients had undergone surgery and, at the 24-month follow-up, one additional patient had been operated on. After surgery, these four patients were excluded from further follow-ups.

Table 3: Patients 10-34 months after surgery were classified as having kinesiophobia or not having kinesiophobia

Assessments (n)	Kinesiophobia median (range)	No kinesiophobia median (range)	p-value
ODI	32 (0–74)	12 (0–64)	<0.001
EQ-5D index	0.72 (-0.07 to 1.0)	0.80 (-0.16 to 1.0)	0.01
EQ-5D VAS	68 (15–97)	80 (2–100)	0.01
VAS back pain	44 (0–89)	12 (0–87)	<0.001
VAS leg pain	23 (0–91)	8 (0–84)	0.01
ZDS	40 (22–67)	34 (22–51)	0.01
PCS	26 (4–45)	14 (0–28)	0.01
SES	35 (12–62)	51 (19–64)	<0.001

Kinesiophobia is defined as >37 on The Tampa Scale for Kinesiophobia (TSK) which ranges from 17-68, with lower score indicating less severe symptoms.
ODI = Oswestry Disability Index
EQ-5D index = European Quality of Life in 5 Dimensions questionnaires index
EQ-5D VAS = European Quality of Life in 5 Dimensions questionnaires VAS
VAS = Visual Analogue Scales
ZDS = Zung Self-Rating Depression Scale
PCS = Pain Catastrophising Scale
SES = Self-Efficacy Scale

A statistically significant improvement was seen in all outcome measurements at the three-month follow-up: disability, leg and back pain, kinesiophobia, HRQoL, depression and self-efficacy ($p<0.001$). These improvements could still be seen at the 12- ($p<0.001$) and 24-month ($p<0.001$) follow-ups compared with baseline (Figures 14 and 15). Baseline values were collected when the patients had had symptoms at least six weeks.

Before treatment, all patients reported leg pain. Three months after treatment, the median on the VAS was 9 mm, i.e. classified as no leg pain (Öberg et al., 2003). Twenty-three patients (56%) reported no leg pain at the three-month follow-up. At baseline, 22 patients (54%) reported severe disability (>40 on ODI) and three patients reported no disability. The degree

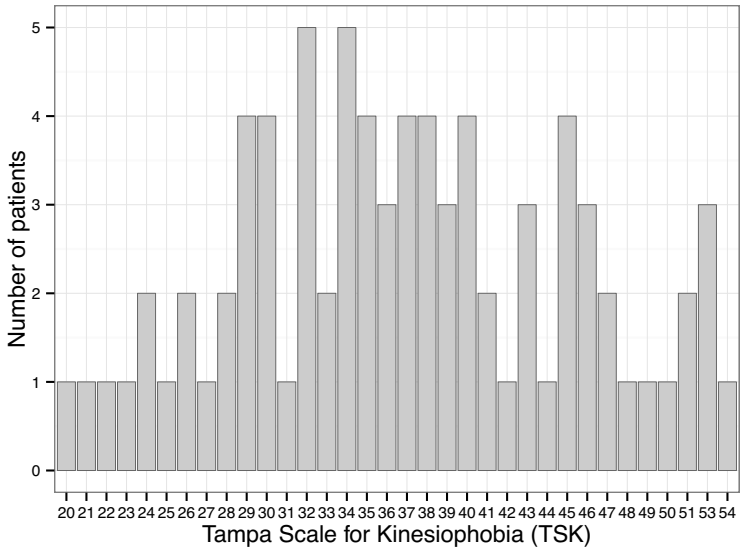


Figure 13: Number of patients for each score on the TSK. The TSK ranges from 17-68. Patients with a score of more than 37 were classified as having kinesiophobia.

of disability decreased at the three-month follow-up, as only nine patients (22%) reported severe disability and 26 patients (64%) reported no disability.

At the three-month follow-up, 32 (78%) of 41 patients were satisfied with the structured physiotherapy treatment. At the two-year follow-up, the number of satisfied patients was 29 (78%) of 37 patients.

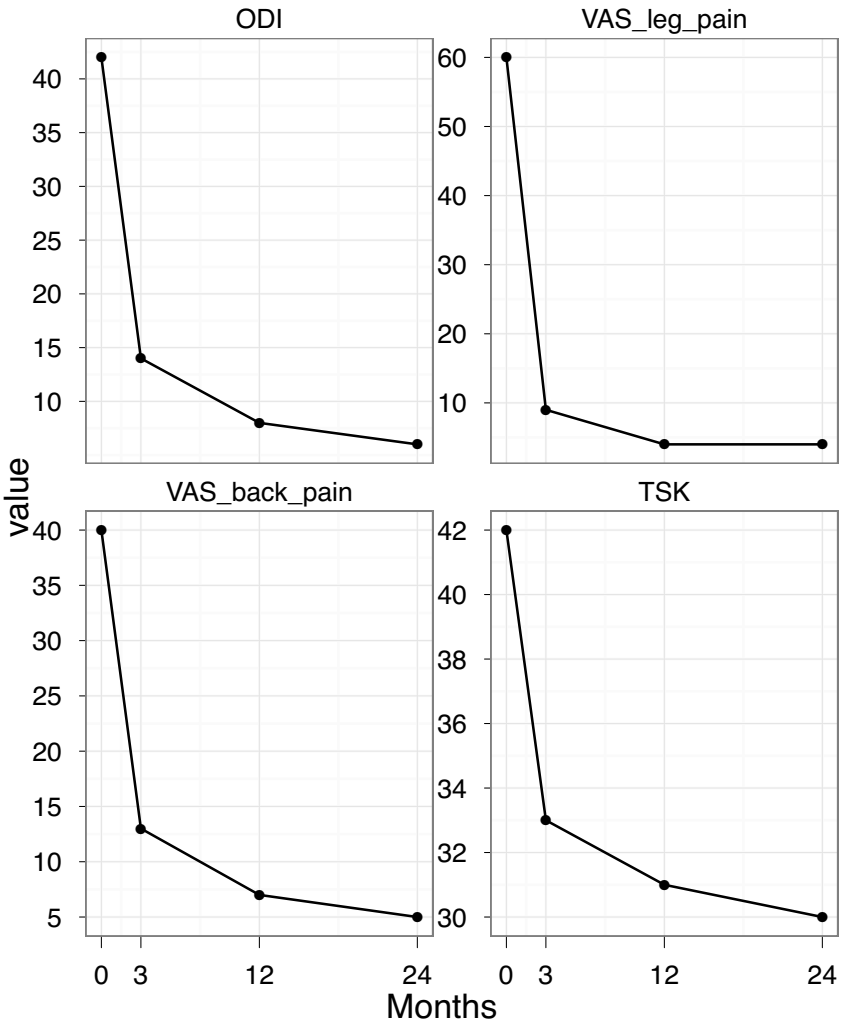


Figure 14: The figure shows the rapid relief of the patients' disability (ODI = Oswestry Disability Index), pain intensity in the leg and back (VAS = Visual Analogue Scale) and fear of movement (TSK = Tampa Scale for Kinesiophobia). A substantial and significant improvement was seen at the three-month follow-up and it could still be seen at 12 and 24 months. At baseline, the patients had had symptoms for at least six weeks. The graph shows the median values from all outcome measurements at baseline and at the 3-, 12- and 24-month follow-ups.

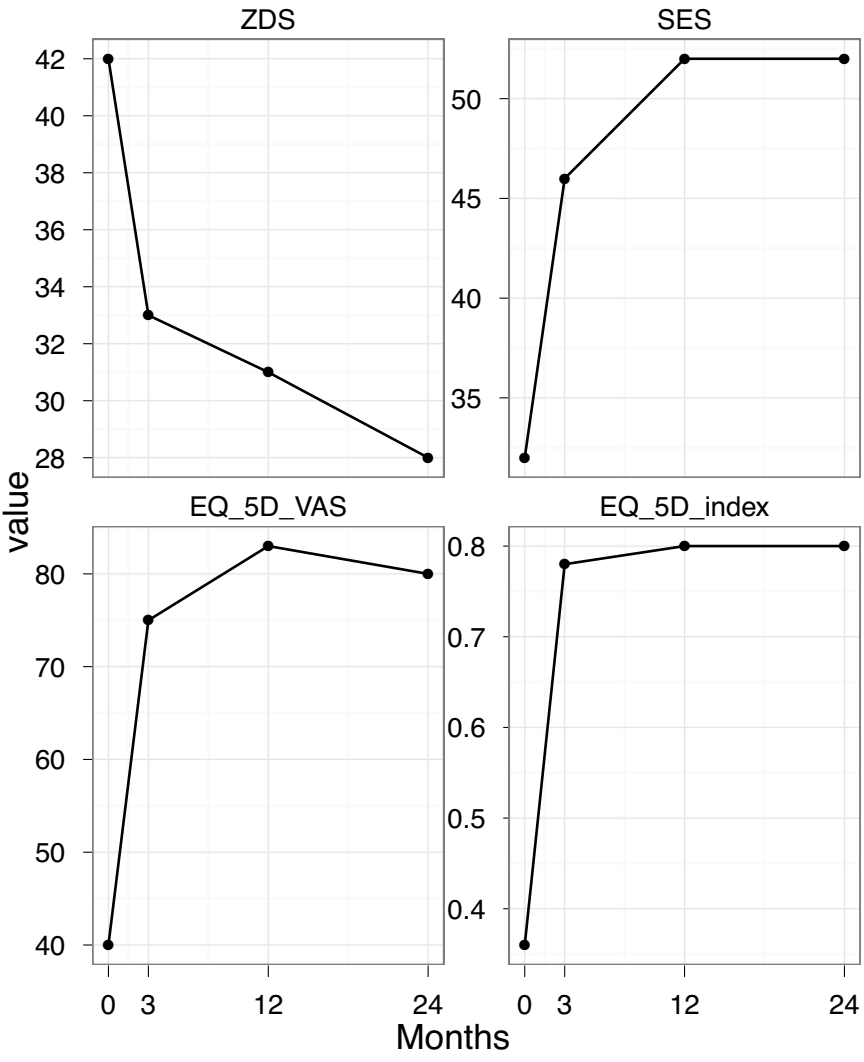


Figure 15: The figure shows the rapid relief of the patients' depression (ZDS = Zung Self-Rating Depression Scale) and self-efficacy (SES = Self-Efficacy Scale), while health-related quality of life is measured by the EQ-5D VAS and EQ-5D index. A substantial and significant improvement was seen at the three-month follow-up and it could still be seen at 12 and 24 months. At baseline, the patients had had symptoms for at least six weeks. The graph shows the median values from all outcome measurements at baseline and at the 3-, 12- and 24-month follow-ups.

Study III – Patients' experience of health three years after structured physiotherapy or surgery for lumbar disc herniation

Study III was a qualitative interview study. The interviews showed that the patients experienced both a feeling of well-being and a feeling of ill-being. The patients who felt good said that they felt good most of the time but that they sometimes had symptoms of various kinds (Figure 13). Some patients said that they did not take that much notice of their symptoms and that they were active despite symptoms. The patients also said that, when symptoms occurred, they could deduce why they did so, which made it easier to handle and cope with the symptoms. Patients treated with structured physiotherapy expressed a high level of well-being.

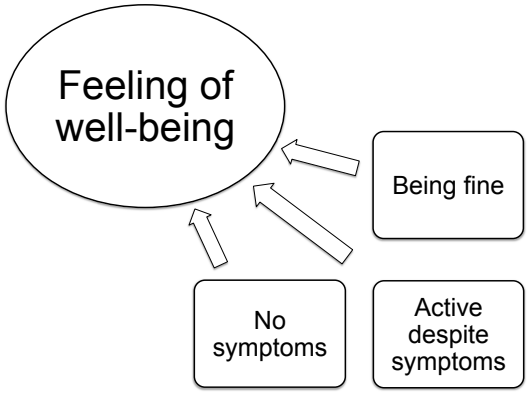


Figure 16: An illustration of the theme "Feeling of well-being" including the sub-themes. It describes the patients' experience of feeling fine, having no symptoms and being physically active despite symptoms.

The patients who said that they felt bad (ill-being) had both physical and psychological symptoms. They also stated that they were anxious that their symptoms would return. This anxiety led to their avoiding physical activity. It was only patients in the Operative Group (OG) that expressed anxiety.

Both the patients that were operated on and the patients that were treated

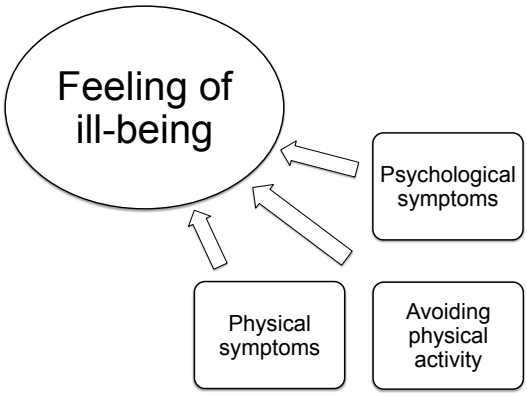


Figure 17: An illustration of the theme "Feeling of ill-being" including the sub-themes. It describes the patients' experience of feeling bad, with both physical and psychological symptoms, including anxiety. The anxiety led the patients who had undergone surgery to avoid physical activity.

with structured physiotherapy (SPG) expressed feelings of well-being and ill-being. However, when a quantitative analysis of the number of codes was performed, it showed that, in the SPG, a high number of codes were found for the theme Feeling of well-being and, in the OG, a high number of codes were found for the theme Feeling of ill-being. The codes were then summarised per patient, Table 4.

Table 4: Predominant judgement of codes per patient.

Group	Positive patients	Neutral patients	Negative patients
SPG	3	4	3
OG	0	2	8

Study IV – The occurrence of centralisation of pain after McKenzie therapy for patients with MRI-verified lumbar disc herniation and long-standing pain

This study was a prospective cohort study with prognostic value. At baseline, the majority of the patients had experienced severe leg pain for more than three months. Twenty-one of the 41 patients centralised two weeks after the McKenzie therapy had started, 14 patients achieved a partial reduction in symptoms and six patients were non-centralisers. Patients in the partial reduction group and the non-centralisers were pooled into one group, labelled non-centralisers, resulting in two groups; centralisers (n=21) and non-centralisers (n=20). At baseline, the pain distribution and pain intensity were equal in both groups. Thirty-two patients reported symptoms in the foot as the most distal symptom. After two weeks, ten patients (24%) had no pain; they were all centralisers. Fourteen patients still had symptoms in the foot; twelve of them were non-centralisers (Figure 18). One of the two centralisers with symptoms in the foot described "pins and needles" and numbness, while the other patient had pain but only 7 mm on the VAS (VAS 0-10 mm was defined as no pain). The change in pain distribution corresponded well with the physiotherapists' assessment of the centralisation phenomenon. At the three-month follow-up, 23 patients (56 %) reported no leg pain (0-10 mm on the VAS). Of these, 15 were centralisers and eight were non-centralisers.

Both groups had improved significantly with regard to their leg pain at the three-month follow-up ($p < 0.001$) and centralisers also improved with regard to back pain ($p = 0.001$). Furthermore, centralisers reported statistically significantly lower pain intensity in both the leg ($p = 0.014$) and the back ($p = 0.006$), compared with non-centralisers at the three-month follow-up. However, there were no statistically significant differences in the degree of change between the two groups regarding pain intensity in the leg or back over time.

At baseline, there was a statistical difference between centralisers and non-centralisers ($p = 0.038$) regarding disability, as evaluated with the ODI. The non-centralisers were more disabled than the centralisers. In spite of the baseline difference the centralisers had improved statistically significantly ($p = 0.024$) more than the non-centralisers at the three-month follow-up. The centralisers' results at the three-month follow-up were significantly better than those of the non-centralisers ($p < 0.001$). However, both centralisers

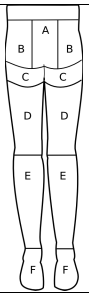
Patients' recorded most distal pain location at baseline				Patients' recorded most distal pain location after two weeks		
Area of pain location	Centralisers n = 21	Non-centralisers n = 20		Area of pain location	Centralisers n = 21	Non-centralisers n = 20
No pain				No pain	10	
A				A	2	
B				B	2	1
C				C	2	1
D	2	1		D	1	2
E	3	3		E	2	4
F	16	16		F	2	12

Figure 18: Change in pain location; baseline compared with two weeks after start of McKenzie therapy.

and non-centralisers improved significantly over time.

Regarding self-efficacy, there was a significant difference at baseline between centralisers and non-centralisers, where centralisers reported higher self-efficacy ($p = 0.026$). Both groups improved significantly over time. However, the centralisers had improved significantly more ($p = 0.041$) than the non-centralisers at the three-month follow-up. Moreover, the results at the three-month follow-up showed that the centralisers had higher self-efficacy than the non-centralisers ($p < 0.001$). The TSK scores differed significantly between centralisers and non-centralisers at baseline ($p = 0.010$) and at the following follow-ups. There were statistically significant improvements over time in both groups. There was, however, no significant difference in the degree of change between the two groups.

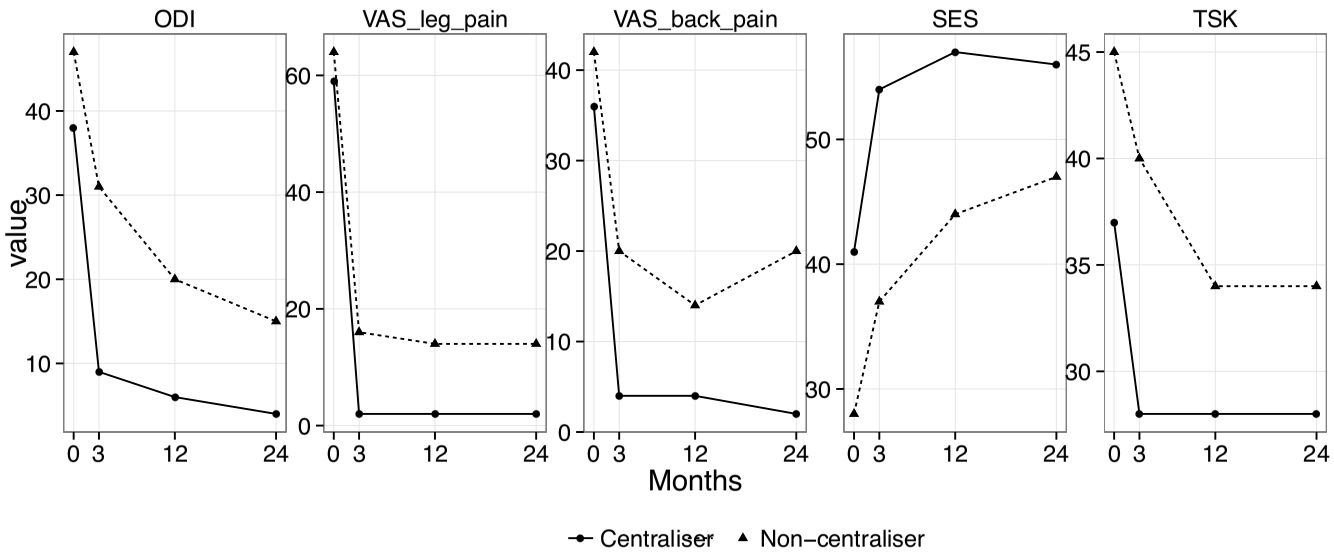


Figure 19: The graphs show the change in disability (ODI = Oswestry Disability Index), pain intensity in the leg and back (VAS = Visual Analogue Scale), self-efficacy (SES = Self-Efficacy Scale) and fear of movement (TSK = Tampa Scale for Kinesiophobia) in the two groups, Centralisers and Non-centralisers. At baseline, the patients had had pain for at least six weeks. Both groups improved significantly in all outcome measurements, apart from Non-centralisers, who did not experience a significant improvement regarding leg pain at the three-month follow-up. At the three-month follow-up, Centralisers had obtained a significantly higher value on all measurements compared with Non-centralisers.

Discussion

This thesis shows that the structured physiotherapy treatment model produces early, significant and substantial improvements in all the measured domains for patients with severe, long-standing pain due to lumbar disc herniation. Furthermore, the improvements could still be seen at the two-year follow-up. Moreover, half the patients with lumbar disc herniation centralised their pain after two weeks of McKenzie therapy, in spite of the fact that they were surgical candidates. Study III, which had a qualitative research approach, showed that, three years after treatment, patients treated with structured physiotherapy experienced well-being and were physically active despite their symptoms. Patients treated with surgery experienced ill-being and were avoiding physical activity due to anxiety.

Evaluation of patients with lumbar disc herniation

One aim of medical research is to produce evidence of the effects of treatment. When it comes to patients with disc herniation, there are problems measuring the effects of treatment, as natural healing is regarded as fairly extensive and is difficult to estimate. It has been shown that one third of the patients with sciatica recovered within two weeks and approximately 75% within three months (Vroomen et al., 2002). According to another study, 60% of the patients with disc herniation had recovered after three months and 70% after twelve months (Weber et al., 1993). With these results in mind and the guideline of waiting six to eight weeks before surgery is considered (Bono et al., 2006), the inclusion criterion for the present studies was set at six weeks in order to minimise the effect of natural healing. Moreover, the majority of patients in the present studies had had pain for more than three months at inclusion, which would further minimise the effect of natural healing.

To date, the present studies are unique because of the patients' long period with severe pain before the structured physiotherapy treatment began. The intention was to try to avoid patients whose disc herniation had healed naturally. There are some studies that have investigated physiotherapy treat-

ment for patients with disc herniation, but they have had a period of pain shorter than six to eight weeks before treatment began (Albert et al., 2012; Albert and Manniche, 2012; Brötz et al., 2003). These studies were therefore unable to control for natural healing. Likewise, a large, randomised, multicentre study, the spine patient outcomes research trial, had difficulty controlling for natural healing. Its aim was to compare surgery with so-called usual care. The problem consisted of cross-over between the two randomised groups. Due to natural healing, patients randomised to surgery crossed over to usual care and, the other way around, patients who were randomised to usual care had undergone surgery within six weeks (Weinstein et al., 2008, 2006b). To summarise, RCTs and cohort studies have had difficulty controlling for the natural healing of the disc herniation and the results are therefore inconclusive and difficult to interpret.

Surgery for lumbar disc herniation has been investigated in numerous studies. Surgery has been compared with a variety of treatments such as education, chiropractic, unspecified physiotherapy, acupuncture, injections and medication (Atlas et al., 2005; Peul et al., 2008; Weber, 1983; Weinstein et al., 2006a,b). Surgery has been well described in these studies, but the other treatments have only been vaguely described and various treatments have been used. Previous studies have reported favourable short-term (after three months - one year) outcomes for surgery, but no major differences between surgical and other treatments have been demonstrated in the long term (more than two years) (Jacobs et al., 2011; Osterman et al., 2006; Weber, 1983; Weinstein et al., 2006a,b). The conclusions that are drawn from the comparison between surgery and non-systematic other treatments may thus be misleading.

In order to compare the effects of surgery with physiotherapy, it is necessary that not only surgery but also physiotherapy has a well-structured treatment protocol. In this thesis, we have evaluated a structured physiotherapy treatment model, but we have not compared it with surgical treatment. However, Studies II and IV illustrated a rapid (two weeks and a three-month follow-up), statistically significant and substantial improvement from structured physiotherapy treatment. The improvements could still be seen at the two-year follow-up in terms of all outcome measurements.

Different aspects of health and empowerment of patients

In Study II, the change over time in Health Related Quality of Life (HRQoL) was measured using the EQ-5D instrument; it had improved significantly after only three months. However, health is a subjective experience of the utmost importance to the individual but without apparent disease correlates. The WHO has defined health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" (World Health Organisation, 1948).

Many of the most commonly used quality of life measurements are considered incomplete in their ability to capture the quality of life of the individual patient (Carr and Higginson, 2001). Since quality of life is seen as an individual construct, it was decided also to conduct interviews on patients' experiences of health in Study III. Surprisingly, despite the fact that the interviews were conducted as long as three years after treatment, a variation was found between patients who had undergone surgery and those that had had physiotherapy treatment.

Patients who were treated with structured physiotherapy described a high degree of well-being and were active despite their symptoms. Patients who had undergone surgery reported the opposite – namely, a high degree of ill-being and the avoidance of physical activity because of fear of pain. It can be speculated that the feeling of well-being might be explained by the ability of the structured physiotherapy treatment to empower the patients to increase their self-efficacy. This is in line with Bandura (2004), who states that health is greatly influenced by lifestyle habits and increased self-efficacy enables people to take some control of their health. The patients who underwent surgery were not treated with the structured physiotherapy model.

The philosopher Gadamer (1996) stated that the question "Do you feel healthy?" is an absurd question since health is not a feeling. Health instead means being engaged in what happens around us in private life, as well as in the world around us, being together with people around us and being actively involved and rewarded in our everyday lives. From the opposite perspective, he also claims that the medical field is oriented towards mastery and gaining control of illness. This is perhaps what happened to the patients who underwent surgery in Study III; the operation mastered the illness on behalf of the patients. They were unable to master their illness by themselves. It is possible to speculate about whether the patients became worried after surgery when they felt symptoms and they therefore

avoided activity, in order not to end up in the same position again, needing surgery to master illness. On the other hand, the patients who were treated with structured physiotherapy may have learnt to master illness by themselves and their self-efficacy increased. If the symptoms recurred, they would probably be able to master their illness again. Moreover, the patients treated with physiotherapy described themselves as active. Being active and being involved were defined as a part of the condition of health by Gadamer (1996).

The high degree of well-being in the physiotherapy group in Study III and the positive results at the three- and 24-month follow-ups (Study II) might be explained by the strategies for patient empowerment in the MDT method. The use of empowerment strategies has been promoted, as it is thought to improve the effects of physiotherapy treatment (Perreault, 2008). Furthermore, the results of a study by Pellino et al. (1998), comparing the preoperative education of patients randomised between an empowerment teaching method and a traditional teaching method, showed that patients in the empowerment group obtained significantly higher self-efficacy than the control group. One desired outcome in traditional teaching is compliance with the prescribed treatment. In empowerment teaching, the desired outcome is an informed patient who is qualified to make his/her own decisions about his/her own health care (Funnell et al., 1991). In the empowerment model, the patients and the provider form a partnership in teaching/learning and shared decision-making. It is shown that only a minority of patients do not wish to have a role in, or responsibility for, treatment decision-making (van Til et al., 2010). This description of empowerment teaching and shared decision-making corresponds well with the goal of the MDT method and of the treatment that the patients in the structured physiotherapy group used in this thesis were offered. However, interestingly enough, the concept of empowering the patient is not mentioned by McKenzie and May (2003). It is possible to speculate about whether patient empowerment might be the most powerful part of the MDT and of the structured physiotherapy treatment model used here, but this has to be evaluated in more detail in future studies.

Centralisation of pain

A key part of the MDT concept is centralisation of pain, which is evaluated with different purposes in several studies (Aina et al., 2004; Albert et al.,

2012; Laslett et al., 2005; Long, 1995), including Study IV in this thesis. Study IV showed that, in half the patients, pain centralised after only two weeks of MDT treatment, in spite of having MRI-verified disc herniation with a broken outer annulus. However, McKenzie and May (2003) have stated that MDT is not effective if the patients have a disc herniation with a broken outer annulus, since the hydrostatic mechanism in the disc is a prerequisite for influencing the internal disc displacement and thereby enabling centralisation. This statement has led physiotherapists educated in the method to avoid using MDT when a disc herniation is confirmed on MRI.

In this thesis, what actually happens in the disc is not investigated, but, in Studies II, III and IV, we investigated the patients' experience of reduced symptoms. However, it has previously been shown that there is no obvious link between MRI-verified improvements in disc herniation and nerve root compression in relation to definite recovery (Jensen et al., 2007). Earlier studies have also questioned McKenzie's statement, but there are some limitations to those studies. The first limitation is that, in two studies, the disc herniation was not confirmed by an MRI (Albert and Manniche, 2012; Skytte et al., 2005). Secondly, one study group only included patients who responded with centralisation of pain during the first five daily physiotherapy sessions, which means they included a highly selected group of patients who were already improving (Broetz et al., 2010; Brötz et al., 2003). Thirdly, one study showed that 43 of 46 patients with extruded or sequestered discs centralised, but a vague definition of the centralisation phenomenon was used. So-called unstable centralisers were defined as pain centralised during movements, but, after resuming a weight-bearing position, the pain reappeared (Albert et al., 2012). In spite of this, Albert et al. (2012) support the results of Study IV. Moreover, Adams et al. (2010) have re-interpreted the scientific literature regarding the healing of intervertebral discs. They suggest that physiotherapists who traditionally employ mechanical loading as a healing stimulus should evaluate therapies to relieve discogenic pain by promoting healing in the disc periphery by stimulating cells, boosting metabolic transport and preventing adhesion and re-injury. Taken together, the results of Study IV are important for physiotherapists working clinically, as we now have evidence that patients with MRI-verified disc herniation can be successfully treated with MDT.

Fear of movement and empowerment of patients

As presented in Study I, half the patients who had undergone surgery ten to 34 months earlier were classified as having kinesiophobia. These results were surprising, as it was a long time after surgery and the patients had been recommended to exercise, according to an early, active training model (Kjellby-Wendt and Styf, 1998). It was therefore expected that the patients would have again returned to an active life. However, 62 of 80 patients (78%) were actually back at work, but half of them were classified as having kinesiophobia. The number of sick-listed patients corresponds fairly well with the findings of den Boer et al. (2006a), who reported reduced work capacity in 25% of the patients six months after lumber disc surgery. Furthermore, fear of movement/(re)injury before surgery has predicted more disability and severe pain six month after lumbar disc surgery (den Boer et al., 2006b).

In contrast, in the patients treated with structured physiotherapy in the prospective Study II, only four of 35 patients (11%) were classified as having kinesiophobia one year after treatment started and 33 patients (94%) were back at work. The discrepancy between the results in Studies I and II is interesting. One explanation could be that, in Study I, the patients who had had surgery more than once were included. Twenty of 84 patients (24%) had previously undergone back surgery, so there was a large number of re-operations compared with other studies that report a re-operation rate of 5-10% (Jansson et al., 2004; Morgan-Hough et al., 2003). As a result, several of the operated patients had had pain longer before surgery in Study I than the patients had had before physiotherapy in Study II. Another reason for the difference in kinesiophobia between Study I and Study II may be the effect of the structured physiotherapy treatment in Study II, which aims at empowering the patients, increasing self-efficacy and reducing fear of movement.

It has previously been shown that patients with chronic pain and a high degree of kinesiophobia, who participated in a multidisciplinary programme, including physiotherapy, increased their physical activity and reduced their degree of kinesiophobia at the six-month follow-up (Koho et al., 2011). The above reasons could all be possible mechanisms for reducing the number of patients who were classified as having kinesiophobia in Study II. Another thing to bear in mind as a doctor or physiotherapist is that it has been shown that health-care providers who hold beliefs reflecting fear avoidance may influence the patients to be more fear avoidant

(Coudeyre et al., 2006; Linton et al., 2002). The way physiotherapists introduce the training post-surgery and the way doctors and physiotherapists express themselves regarding post-surgery activities is therefore important. If it is the empowerment component that makes the difference between the two groups in Study I and Study II, then it seems reasonable that the post-surgery treatment should be updated and include a more patient-empowering treatment strategy.

Kinesiophobia and fear of movement are often used synonymously in the literature. During the last decade, an increasing number of studies supporting the basic assumptions of the fear-avoidance model have been published (Vlaeyen and Linton, 2012). However, the fear-avoidance model has also been questioned and it needs to be conceptually expanded and further tested in order to provide adequate clinical utility (Pincus et al., 2010).

In a study of 64 patients with LBP and a mean of 41.6 on the TSK, the relationship between kinesiophobia and avoidance of lifting was studied and no relationship was confirmed (Reneman et al., 2003). In part, the same authors performed an additional study with an extended study group and concluded that the relationship between pain and pain-related fear and functional capacity was weak or non-existent in patients with chronic LBP (Reneman et al., 2007).

In an event-related functional MRI study of neural correlates of the fear of movement, 60 women (30 chronic LBP, 15 healthy controls and 15 women with arachnophobia (fear of spiders)) were included. The chronic LBP patients were divided into a high and low fear-avoidance group according to the TSK, with a cut-off value of 35.5 on the TSK, with 15 patients in each group. The participants viewed photos with neutral or back-stressing movements and pictures of spiders, while the functional MRI data were acquired. The patients with chronic LBP and high fear avoidance did not differ from those with low fear avoidance or pain-free participants in their reaction to the back-stressing photos. However the arachnophobic individuals reacted with the expected fear reaction to the pictures of spiders and activations in "fear areas" in the brain. The authors conclude that the concept of fear of movement is not really a fearful emotional state but something different (Barke et al., 2012). These results are interesting when you consider the results in Study III where just one of ten operated patients reported kinesiophobia, in spite of the fact that the operated group experienced ill-being and avoided activity. Moreover, two patients reported kinesiophobia in the physiotherapy group, despite the fact that they experienced well-being and were active in spite of their symptoms.

Patient empowerment may be the most important part of the MDT concept, but how does the MDT succeed in empowering patients? There are probably several reasons. Number one could be the expected immediate effect of the positions and the repeated movements the patient performs. The patient often experiences an instant change in pain, due to different movements and positions, and the patient learns how to evaluate the change. This immediate effect of pain response is empowering for the patient and the patient learns how he/she by him/herself can influence and control the pain, which results in increased self-efficacy. Another important factor is that the next appointment with the physiotherapist is within a short period of time, one or two days, to be able to guide the patient further (McKenzie and May, 2003). An important motivator in learning is pain; when it comes to both removing pain and empowering the patient to increase his/her self-efficacy and probably also in the opposite way – increased pain can cause people to become fear avoidant and kinesiophobic.

Methodological considerations

RCTs are regarded as the most reliable method for determining the efficacy of different treatments and minimising bias. However, despite the good reputation of RCTs, conflicting conclusions among RCTs are not uncommon. It has also been shown that agreement between pairs of randomised trials and non-randomised studies was most common when the pairs were of high methodological quality and when there was a clinical similarity between the pairs in terms of settings, populations, interventions and outcomes (Furlan et al., 2008). In the absence of well-executed RCTs, evidence must rely on observational studies (Rosén et al., 2009). Study II was planned as an RCT, but the number of patients available for inclusion was not sufficient, in spite of a long period of inclusion. It was therefore decided to present the results as a prospective cohort study, since we judged the results to be interesting for physiotherapists and doctors working clinically and their patients.

It should be pointed out that well-educated people are generally more knowledgeable about medical options and are in better position to promote their own interests (Rosén et al., 2009). This might be a limitation in Studies II, III and IV, as we did not investigate the level of education or socioeconomic conditions. Moreover, 45 of 80 patients (56%) did not want to

participate in the randomisation procedure; they wanted to decide for themselves whether to obtain surgery or physiotherapy treatment. This could be a limitation in our study, but shared decision-making is also an important and promoted part of today's medical treatment.

In Studies II and IV, 41 patients were analysed after completing treatment according to a structured physiotherapy model. The number of patients was quite small, but the statistically significant differences from baseline to the three-month follow-up were strong in all the measurements included in Study II and in all the measurements apart from pain intensity in the back in non-centralisers in Study IV. Moreover, the minimal important change (MIC) is proposed as a 15-mm decrease on the VAS and a 10-degree decrease on the ODI (Ostelo and Vlaeyen, 2008). The MIC was achieved on the VAS for leg and back pain and on the ODI in Study II and, correspondingly, for both centralisers and non-centralisers at the three-month follow-up in Study IV.

After structured physiotherapy treatment, there are no known risks, at least not if the physiotherapist has an examination in the MDT method and is thereby experienced in the treatment of patients with LBP. However, the patient needs to invest time and energy in movements and training in order to succeed and get better. On the other hand, after surgery, the patients may be pain free immediately on the day after surgery, without any training and without any effort of their own. However, there are several risks, such as infection, when it comes to surgery. Clinical practice today is that many patients are recommended simply to wait for healing and stay as active as possible during the healing period. If patients cannot bear to wait until the pain decreases, surgery is presented as a leg-pain-reducing treatment. Since we have shown positive results just two weeks after structured physiotherapy treatment and significant and substantial results at three months, this would not be a long time to wait for surgery, especially since the waiting time for an appointment with an orthopaedic surgeon in Sweden can be fairly long. It would probably save time for the patient to begin a structured physiotherapy treatment at an early stage, before an appointment is made with a surgeon. There may also be a risk of persistent pain if patients only wait at home and are worried because of the intense pain. Furthermore, it is costly for both the individual and society just to wait and be on sick leave. We therefore argue that it is beneficial for the patient to reduce pain with proper treatment and economically beneficial for society to start structured physiotherapy treatment before surgery is considered.

In Study IV, the physiotherapist who treated the patient also made an

evaluation of whether or not the patient had centralised after two weeks. This might be a limitation of the study. An independent observer or examiner would have been better. It was, however, not possible to organise a person who observed all the evaluations. The evaluation of whether or not the patient centralised was made after two weeks by the physiotherapists from the collected experience of the patient's response to movements and positions during the last two weeks and the pain drawings the patient filled in by him/herself before and after each visit. In some studies, the evaluation of centralisation was made after only one visit (Albert et al., 2012; Edmond et al., 2010; Laslett et al., 2005). In Study IV, the evaluation was made after the compiled experience from two weeks, which, we argue, is a strength.

According to research practice, we have dichotomised the TSK and patients with a value of over 37 were classified as having kinesiophobia (Vlaeyen et al., 1995a). Two values close to each side of a border are therefore categorised in two different classes (Harms-Ringdahl, 2012), as shown in Figure 13 in Study I. This is a way to simplify reality, in order to be able to study it statistically. However, this is not a "true" value and, in a clinical setting, it is important to consider whether or not the individual has a high fear of movement. Classifying the individual as having or not having kinesiophobia based simply on a value of 37 on the TSK is therefore questionable.

Similarly, discussion, such as that valid for kinesiophobia, is possible regarding the cut-off scores for several other instruments. In Studies I-IV, 0-10 mm on the VAS was defined as no pain (Öberg et al., 2003). In Studies I and II, a value of over 0.86 on the EQ-5D was defined as normal HRQoL (Burström et al., 2001a). Antonovsky (1991) questions the approach to health as a dichotomy variable, where you can be healthy or not healthy. He promotes health as a continuum where you can have better or poorer health. He has advocated a salutogenic concept in contrast to a pathogenic approach. The salutogenic concept includes sense of coherence (SOC). SOC consists of three dimensions: comprehensibility, manageability and meaningfulness. These three dimensions are key factors for people's perception of health and the way people view life and stressful situations, according to Antonovsky (1991). It is therefore important to evaluate patients' perspectives of health with methods other than questionnaires. This is supported by Underwood et al. (2006), who concluded that their qualitative analysis found clearer differences between groups than their main quantitative analysis regarding patients' perceptions of physiotherapy treatment. It is a methodological strength in this thesis that both quantitative and

qualitative methods were used to evaluate experiences of health. This has provided a deeper understanding of the patients' experiences, which would not have been achieved using nothing but questionnaires.

Conclusions

In this thesis, all the included patients had severe, long-standing pain due to lumbar disc herniation and they all qualified for lumbar disc surgery. The conclusions from the studies are as follows.

Study I One year after surgery, half the patients were classified as having kinesiophobia and these patients reported significantly more symptoms in all the measured domains than the patients that were classified as not having kinesiophobia.

Study II The patients treated with a structured physiotherapy model had improved significantly and substantially in all assessments: disability, leg and back pain, kinesiophobia, health-related quality of life, depression and self-efficacy at the three-month follow-up. These results could still be seen at the 24-month follow-up. Consequently, these patients did not qualify for lumbar disc surgery after they completed the structured physiotherapy treatment. The structured physiotherapy treatment model can therefore be recommended before considering surgery, when patients report symptoms such as pain and disability due to lumbar disc herniation.

Study III Patients treated with either structured physiotherapy or surgery described varying experiences of health three years after treatment for lumbar disc herniation. The interviews showed that the patients, in the group treated with structured physiotherapy, expressed the most descriptions in feeling of well-being and they were physically active despite symptoms. In the group treated with surgery patients expressed more feeling of ill-being and were anxious and expressed that they avoided physical activity. It it possible to speculate that the experience of well-being may be explained by the ability of structured physiotherapy treatments to empower patients.

Study IV Half the patients with MRI-verified disc herniation and severe, long-standing pain reported that their pain centralised two weeks after treatment according to the McKenzie therapy. The centralisers

improved significantly more than the non-centralisers in terms of disability and self-efficacy. The centralisers and the non-centralisers improved significantly and substantially over time in terms of leg pain, disability, self-efficacy and kinesiophobia. The findings in this study support the belief that patients with lumbar disc herniation can be treated successfully with the MDT method.

Thesis The overall conclusion from this thesis is that a structured physiotherapy treatment model for patients with pain and disability due to a lumbar disc herniation should be recommended before surgery is considered

Clinical implications

When planning the treatment protocol for patients with lumbar disc herniation, it appears to be important to remember that many patients experience various degrees of fear of movement. As many as about half the patients in this thesis were classified as having kinesiophobia, i.e. a fairly high degree of fear of movement, one year after surgery. As treatment after surgery involves physical training, the physiotherapist needs to have a knowledge of how to deal with patients with a high degree of fear of movement when introducing the various movements, positions and training exercises in the treatment protocol. The MDT method aims to reduce the patients' pain using various positions and movements and to encourage empowerment and give the patients tools to treat themselves. This was probably the reason for the low degree of fear of movement in Study II (approximately 10% were classified as having kinesiophobia) one year after the structured physiotherapy treatment. Strategies of empowerment can be recommended for implementation in the treatment protocol for postsurgical rehabilitation.

This thesis recommends the structured physiotherapy treatment model for nine weeks before considering surgery, when patients report severe pain and disability due to lumbar disc herniation. It appears to be important to give the patients with severe pain the opportunity to obtain effective structured physiotherapy treatment at an early stage, rather than passively waiting for healing. The treatment model can therefore be recommended for patients with back and leg pain assessed by physiotherapists educated according to the MDT method, even though a lumbar disc herniation has not been confirmed with an MRI.

In Study III, the importance of the patients' own experiences and thoughts about their pain and their relationship with surgery, physiotherapy, attitudes to physical activity and their own health was illustrated. It is possible that, if a more structured physiotherapy model including empowerment had been used for the patients that underwent surgery, these patients would not have reported ill-being. Well-being reported by the patients treated with structured physiotherapy after three years is a pleasure to see. The reasons for this need to be explored in detail in future research, as the results can be expected to be of great importance for not only patients with lumbar disc herniation but also patients with other musculoskeletal problems.

Future perspectives

To further confirm the results of these studies, it would be appropriate to conduct an RCT comparing the structured physiotherapy treatment model with natural healing or surgery for patients with lumbar disc herniation.

Future research is also needed to examine the impact of psychological components in relation to the centralisation phenomenon and how the empowerment of patients, according to the MDT method, influences the patients' symptoms.

The qualitative interview (Study III) provided a deeper understanding of health from the patients' perspective than was possible using the questionnaires. It seems reasonable to use qualitative interview studies more frequently in order to include the patients' perspectives and thereby add new knowledge and hypotheses for future research.

Acknowledgements

I wish to express my gratitude to all the people who have contributed to this work. In particular, I want to thank:

Gunilla Kjellby Wendt PhD, RPT and my tutor, for inviting me into this project a long time ago and supporting me to become a PhD student. We have had a long and crooked journey, but at last we have reached the goal! Thank you for standing by on the whole journey.

Roland Thomeé professor, RPT and my latest co-tutor, for positive support, sharing your scientific knowledge and most of all for believing in me. It has made a huge difference.

Ella Danielson professor and my co-tutor, it has been such a joy to learn from you. We have always had positive meetings when you have shared your vast knowledge and guided me most professionally in the field of qualitative research. And for all the support you have given me when I have needed it most.

Hans Christian Östgaard associate professor, co-author of the first article, for employing me in the project and thereafter assessing and including the patients in the studies and introducing me into science.

Mari Lundberg associate professor, RPT, co-author of the first article and my kinesiophobia mentor, for sharing your knowledge of kinesiophobia and your positive support.

Jón Karlsson professor and head of Section for Anesthesiology, Biomaterials, Orthopaedics and Otorhinolaryngology, the Sahlgrenska Academy at University of Gothenburg and the person who accepted

me as a PhD student. For friendly support and interest during my journey.

Helena Brisby professor and chairman at the Department of Orthopaedics, the Sahlgrenska Academy at University of Gothenburg for friendly support on my scientific journey.

Patrik Drevander, Sofia Fridén, Christina Grundén and Eva Fahlgren RPTs with credentials in MDT. Thank you for your professional treatment of the patients according to the structured physiotherapy treatment model and filling in all the sheets of paper.

Anders Björk, Linda Carlsson, Ole-Jörgen Ellefsen, Mia Gustafsson, Åse Hauta, Matilda Söderlund and Jenny Wingqvist Bergh, RPTs, for excellent and blinded distribution of questionnaires and testing the patients before and after treatment all the way to the two-year follow-up.

The orthopaedic surgeons and the staff at the Department of Orthopaedics at Sahlgrenska University Hospital, who helped me include patients.

Peter Nyberg for his work on collecting patients for the study at the Department for Orthopaedics, Södra Älvsborg Hospital in Borås. **Svante Ahlstrand** and **Daniel Björneroth**, RPTs, for assisting with the questionnaires to the patients operated on at Södra Älvsborg Hospital.

Björn Rydevik professor, for friendly help with the summary.

Åke Blixt and Olle Hägg PhDs for fruitful discussions during the planning of the studies.

Linda Johansson for outstanding assistance in academic guidance, practical matters and for always being kind and helpful in spite of all the possible and impossible questions.

Eva Beckung professor and head of the Department of Physiotherapy and Occupational Therapy at Sahlgrenska University Hospital and **Staffan Skarrie**, head of the Physiotherapy Department at Sahlgrenska University Hospital in Mölndal, for support, interest and providing me with the opportunity to carry on with my research.

My colleagues and dear friends at the Lundberg Laboratory Karin Larsson, Eva Runesson, Roy Tranberg, Roland Zügner, Ulla Thang, Elin Nilsson, Helena Barreto Henriksson, Cecilia Elam Edwén, and Annelie Brorsson for all the laughs around the scientific kitchen table and for support in both better and worse times.

Monika Fagevik-Olsén PhD and my supportive mentor on scientific matters.

Annelie Bilberg RPT, for inspiring lunches containing so much more than food, you are the next PhD in line, I wish you good luck!

Lars Degerfeldt RPT with a diploma exam and MDT teacher, for fruitful discussions about the structured physiotherapy treatment model before the studies started.

Gill Asplin, Jeanette Kliger and Yvonne Tizard for excellent revision of the English text.

Lena Kjäll and Eva Rodelius for verbatim transcription of the interviews.

Valter Sundh for statistical support.

Göte Norgren, Titti Strandberg and Jan-Ola Vestin RPTs, photographer and photographer's models, for letting me use your instructive photos in my thesis.

Anders Agetorp RPT, for letting me use your pictures in my thesis.

Maria Bäck PhD and RPT, for answering all my questions during the last period before the defence of my thesis.

The former "Satellite group" , **Kerstin Hagberg, Mari Lundberg, Annelie Gutke, Elisabeth Hansson, Pia Thomeé and Anna Danielsson**, you have all had your doctor's hat and ring for many years. Finally, it is my turn too! Thanks for qualitative discussions and good laughs when I started my life as a PhD student.

All my happy, positive and intelligent colleagues at the Physiotherapy Department at Sahlgrenska University Hospital in Mölndal, to all of you for support and positive exclamations!

My brothers, Magnus and Martin Limbäck for the past few years we have together taken care of our mother. I am so glad that we have managed so well. Thank you both. And on 12 April you must put on your dancing shoes!

Min mamma, Kerstin, och min avlidne pappa, Ingvar för att ni gav mig en trygg uppväxt. Tack också för att ni gav mig eget ansvar och därmed möjligheten att växa.

Simon, Nils and Signe our wonderful children, who grew up with medical science around the dinner table. Two of you are now studying at Chalmers, I wonder why? Thank you for reminding me at times what is significant in life. I love all three of you enormously! An extra thank you to Signe, who has made the extraordinary illustrations on the cover and the anatomic pictures in the book.

Erik my husband, first of all, for believing in me and supporting me in moments of despair, due to the scientific life. And for love, data support, layout of this thesis, being my favourite cook, my husband and friend.

All patients for generously participating in the studies.

The thesis was financially supported by grants from: The Health & Medical Care Committee of the Västra Götaland Region, the Local Research and Development Board for Gothenburg and Södra Bohuslän, the Renée Eander Foundation, the Swedish McKenzie Institute, the Doctor Felix Neubergh Foundation, Wilhelm & Martina Lundgren's Foundation of Science and Alice Swenzon's Foundation for Scientific Research.

References

Adams, M. A. and Roughley, P. J. (2006). What is intervertebral disc degeneration, and what causes it? *Spine*, 31(18):2151–61.

Adams, M. A., Stefanakis, M., and Dolan, P. (2010). Healing of a painful intervertebral disc should not be confused with reversing disc degeneration: implications for physical therapies for discogenic back pain. *Clinical biomechanics (Bristol, Avon)*, 25(10):961–71.

Aina, A., May, S., and Clare, H. (2004). The centralization phenomenon of spinal symptoms–a systematic review. *Manual Therapy*, 9(3):134–43.

Albert, H. B., Hauge, E., and Manniche, C. (2012). Centralization in patients with sciatica: are pain responses to repeated movement and positioning associated with outcome or types of disc lesions? *European Spine Journal*, 21(4):630–6.

Albert, H. B. and Manniche, C. (2012). The efficacy of systematic active conservative treatment for patients with severe sciatica: a single-blind, randomized, clinical, controlled trial. *Spine*, 37(7):531–42.

Allan, D. B. and Waddell, G. (1989). An historical perspective on low back pain and disability. *Acta Orthopaedica Scandinavica. Supplementum*, 234:1–23.

Antonovsky, A. (1991). *Hälsans mysterium*, volume 1. Bokförlaget Natur och Kultur, Finland, 1st edition.

Arpino, L., Iavarone, A., Parlato, C., and Moraci, A. (2004). Prognostic role of depression after lumbar disc surgery. *Neurological sciences*, 25(3):145–7.

Ashworth, J., Konstantinou, K., and Dunn, K. M. (2011). Prognostic factors in non-surgically treated sciatica: a systematic review. *BMC Musculoskeletal Disorders*, 12:208.

Atlas, S. J., Keller, R. B., Wu, Y. A., Deyo, R. A., and Singer, D. E. (2005). Long-term outcomes of surgical and nonsurgical management of sciatica secondary to a lumbar disc herniation: 10 year results from the maine lumbar spine study. *Spine*, 30(8):927–35.

Bandura, A. (2004). Swimming against the mainstream: the early years from chilly tributary to transformative mainstream. *Behaviour Research and Therapy*, 42(6):613–30.

Barke, A., Baudewig, J., Schmidt-Samoa, C., Dechent, P., and Kroner-Herwig, B. (2012). Neural correlates of fear of movement in high and low fear-avoidant chronic low back pain patients: an event-related fMRI study. *Pain*, 153(3):540–52.

Bergmark, A. (1989). Stability of the lumbar spine. A study in mechanical engineering. *Acta Orthopaedica Scandinavica. Supplementum*, 230:1–54.

Berthelot, J. M., Delecrin, J., Maugars, Y., and Passuti, N. (2007). Contribution of centralization phenomenon to the diagnosis, prognosis, and treatment of diskogenic low back pain. *Joint, bone, spine*, 74(4):319–23.

Björck-van Dijken, C., Fjellman-Wiklund, A., and Hildingsson, C. (2008). Low back pain, lifestyle factors and physical activity: a population based-study. *Journal of Rehabilitation Medicine*, 40(10):864–9.

Boersma, K. and Linton, S. J. (2006). Expectancy, fear and pain in the prediction of chronic pain and disability: a prospective analysis. *European Journal of Pain*, 10(6):551–7.

Bombardier, C. (2000). Outcome assessments in the evaluation of treatment of spinal disorders: summary and general recommendations. *Spine*, 25(24):3100–3.

Bono, C. M., Wisneski, R., and Garfin, S. R. (2006). Lumbar Disc Herniations. In Herkowitz, H. N., Garfin, S. R., Eismont, F. J., Bell, G. R., and Balderston, R. A., editors, *Rothman-Simeone The Spine*, volume II, chapter 59, pages 979–80. Saunders, Philadelphia, 5th edition.

Boos, N., Rieder, R., Schade, V., Spratt, K. F., Semmer, N., and Aebi, M. (1995). 1995 Volvo Award in Clinical Sciences. The diagnostic accuracy of magnetic resonance imaging, work perception, and psychosocial factors in identifying symptomatic disc herniations. *Spine*, 20(24):2613–25.

Brisby, H., Byröd, G., Olmarker, K., Miller, V. M., Aoki, Y., and Rydevik, B. (2000). Nitric oxide as a mediator of nucleus pulposus-induced effects on spinal nerve roots. *Journal of Orthopaedic Research*, 18(5):815–20.

Broetz, D., Burkard, S., and Weller, M. (2010). A prospective study of mechanical physiotherapy for lumbar disk prolapse: five year follow-up and final report. *NeuroRehabilitation*, 26(2):155–8.

Brötz, D., Kuker, W., Maschke, E., Wick, W., Dichgans, J., and Weller, M. (2003). A prospective trial of mechanical physiotherapy for lumbar disk prolapse. *Journal of Neurology*, 250(6):746–9.

Burström, K., Johannesson, M., and Diderichsen, F. (2001a). Health-related quality of life by disease and socio-economic group in the general population in Sweden. *Health policy*, 55(1):51–69.

Burström, K., Johannesson, M., and Diderichsen, F. (2001b). Swedish population health-related quality of life results using the EQ-5D. *Quality of Life Research*, 10(7):621–35.

Cakir, B., Schmidt, R., Reichel, H., and Käfer, W. (2009). Lumbar disk herniation: what are reliable criterions indicative for surgery? *Orthopedics*, 32(8):589.

Carr, A. J., Gibson, B., and Robinson, P. G. (2001). Measuring quality of life: Is quality of life determined by expectations or experience? *BMJ (Clinical Research Ed.)*, 322(7296):1240–3.

Carr, A. J. and Higginson, I. J. (2001). Are quality of life measures patient centred? *BMJ (Clinical research ed.)*, 322(7298):1357–60.

Chan, S. C., Ferguson, S. J., and Gantenbein-Ritter, B. (2011). The effects of dynamic loading on the intervertebral disc. *European Spine Journal*, 20(11):1796–812.

Cherkin, D. C., Deyo, R. A., Loeser, J. D., Bush, T., and Waddell, G. (1994). An international comparison of back surgery rates. *Spine*, 19(11):1201–6.

Clare, H. A., Adams, R., and Maher, C. G. (2004). A systematic review of efficacy of McKenzie therapy for spinal pain. *The Australian Journal of Physiotherapy*, 50(4):209–16.

Collins, S. L., Moore, R. A., and McQuay, H. J. (1997). The visual analogue pain intensity scale: what is moderate pain in millimetres? *Pain*, 72(1-2):95–7.

Coudeyre, E., Rannou, F., Tubach, F., Baron, G., Coriat, F., Brin, S., Revel, M., and Poiraudeau, S. (2006). General practitioners' fear-avoidance beliefs influence their management of patients with low back pain. *Pain*, 124(3):330–7.

Crombez, G., Vlaeyen, J. W., Heuts, P. H., and Lysens, R. (1999). Pain-related fear is more disabling than pain itself: evidence on the role of pain-related fear in chronic back pain disability. *Pain*, 80(1-2):329–39.

Das De, S., Vranceanu, A. M., and Ring, D. C. (2013). Contribution of kinesophobia and catastrophic thinking to upper-extremity-specific disability. *The Journal of Bone and Joint Surgery. American vol*, 95(1):76–81.

Dawson, A. P., Schluter, P. J., Hodges, P. W., Stewart, S., and Turner, C. (2011). Fear of movement, passive coping, manual handling, and severe or radiating pain increase the likelihood of sick leave due to low back pain. *Pain*, 152(7):1517–24.

Dedering, A. and Börjesson, T. (2012). Assessing fear-avoidance beliefs in patients with cervical radiculopathy. *Physiotherapy Research International*.

Delitto, A., George, S. Z., Van Dillen, L. R., Whitman, J. M., Sowa, G., Shekelle, P., Denninger, T. R., and Godges, J. J. (2012). Low back pain. *The Journal of Orthopaedic and Sports Physical Therapy*, 42(4):A1–57.

den Boer, J. J., Oostendorp, R. A., Beems, T., Munneke, M., and Evers, A. W. (2006a). Reduced work capacity after lumbar disc surgery: the role of cognitive-behavioral and work-related risk factors. *Pain*, 126(1-3):72–8.

den Boer, J. J., Oostendorp, R. A., Beems, T., Munneke, M., Oerlemans, M., and Evers, A. W. (2006b). A systematic review of bio-psychosocial risk factors for an unfavourable outcome after lumbar disc surgery. *European Spine Journal*, 15(5):527–36.

Domenech, J., Sanchis-Alfonso, V., Lopez, L., and Espejo, B. (2012). Influence of kinesiophobia and catastrophizing on pain and disability in anterior knee pain patients. *Knee Surgery, Sports Traumatology, Arthroscopy*, page [Epub ahead of print].

Donelson, R., Grant, W., Kamps, C., and Medcalf, R. (1991). Pain response to sagittal end-range spinal motion. A prospective, randomized, multicentered trial. *Spine*, 16(6 Suppl):S206–12.

Donelson, R., Silva, G., and Murphy, K. (1990). Centralization phenomenon. Its usefulness in evaluating and treating referred pain. *Spine*, 15(3):211–3.

Edmond, S. L., Werneke, M. W., and Hart, D. L. (2010). Association between centralization, depression, somatization, and disability among patients with non-specific low back pain. *The Journal of Orthopaedic and Sports Physical Therapy*, 40(12):801–10.

Estlander, A. M., Vanharanta, H., Moneta, G. B., and Kaivanto, K. (1994). Anthropometric variables, self-efficacy beliefs, and pain and disability ratings on the isokinetic performance of low back pain patients. *Spine*, 19(8):941–7.

Fairbank, J. C., Couper, J., Davies, J. B., and O'Brien, J. P. (1980). The oswestry low back pain disability questionnaire. *Physiotherapy*, 66(8):271–3.

Fairbank, J. C. and Pynsent, P. B. (2000). The Oswestry Disability Index. *Spine*, 25(22):2940–52; discussion 2952.

Fardon, D. F. and Milette, P. C. (2001). Nomenclature and classification of lumbar disc pathology. Recommendations of the Combined Task Forces of the North American Spine Society, American Society of Spine Radiology, and American Society of Neuroradiology. *Spine*, 26(5):E93–E113.

Feleus, A., van Dalen, T., Bierma-Zeinstra, S. M., Bernsen, R. M., Verhaar, J. A., Koes, B. W., and Miedema, H. S. (2007). Kinesiophobia in patients with non-traumatic arm, neck and shoulder complaints: a prospective cohort study in general practice. *BMC Musculoskeletal Disorders*, 8:117.

Funnell, M. M., Anderson, R. M., Arnold, M. S., Barr, P. A., Donnelly, M., Johnson, P. D., Taylor-Moon, D., and White, N. H. (1991). Empowerment: an idea whose time has come in diabetes education. *The Diabetes educator*, 17(1):37–41.

Furlan, A. D., Tomlinson, G., Jadad, A. A., and Bombardier, C. (2008). Methodological quality and homogeneity influenced agreement between randomized trials and nonrandomized studies of the same intervention for back pain. *Journal of clinical epidemiology*, 61(3):209–31.

Gadamer, H.-G. (1996). *The Enigma of Health*, volume 1. Polity Press in association with Blackwell Publishers Ltd, Oxford OX4 1JF, UK.

Garratt, A., Schmidt, L., Mackintosh, A., and Fitzpatrick, R. (2002). Quality of life measurement: bibliographic study of patient assessed health outcome measures. *BMJ (Clinical research ed.)*, 324(7351):1417.

Grönblad, M., Hupli, M., Wennerstrand, P., Järvinen, E., Lukinmaa, A., Kouri, J. P., and Karaharju, E. O. (1993). Intercorrelation and test-retest reliability of the Pain Disability Index (pdi) and the Oswestry Disability Questionnaire (ODQ) and their correlation with pain intensity in low back pain patients. *The Clinical Journal of Pain*, 9(3):189–95.

Hagins, M. and Lamberg, E. M. (2011). Individuals with low back pain breathe differently than healthy individuals during a lifting task. *The Journal of Orthopaedic and Sports Physical Therapy*, 41(3):141–8.

Hahne, A. J., Ford, J. J., Hinman, R. S., Taylor, N. F., Surkitt, L. D., Walters, A. G., and McMeeken, J. M. (2011). Outcomes and adverse events from physiotherapy functional restoration for lumbar disc herniation with associated radiculopathy. *Disability and Rehabilitation*, 33(17-18):1537–47.

Hahne, A. J., Ford, J. J., and McMeeken, J. M. (2010). Conservative management of lumbar disc herniation with associated radiculopathy: a systematic review. *Spine*, 35(11):E488–504.

Handa, T., Ishihara, H., Ohshima, H., Osada, R., Tsuji, H., and Obata, K. (1997). Effects of hydrostatic pressure on matrix synthesis and matrix metalloproteinase production in the human lumbar intervertebral disc. *Spine*, 22(10):1085–91.

Hansson, E. and Hansson, T. (2007). The cost-utility of lumbar disc herniation surgery. *European Spine Journal*, 16(3):329–37.

Hansson, E. K. and Hansson, T. H. (2005). The costs for persons sick-listed more than one month because of low back or neck problems. A two-year prospective study of Swedish patients. *European Spine Journal*, 14(4):337–45.

Harms-Ringdahl, K. (2012). How should we use the visual analogue scale (VAS) in rehabilitation outcomes? III: On the validation requirements for assessments using VAS with ratio properties. *Journal of Rehabilitation Medicine*, 44(9):801–2; discussion 803–4.

Heliövaara, M., Impivaara, O., Sievers, K., Melkas, T., Knekt, P., Korpi, J., and Aromaa, A. (1987). Lumbar disc syndrome in Finland. *Journal of Epidemiology and Community Health*, 41(3):251–8.

Hides, J. A., Jull, G. A., and Richardson, C. A. (2001). Long-term effects of specific stabilizing exercises for first-episode low back pain. *Spine*, 26(11):E243–8.

Hodges, P. W. (2000). The role of the motor system in spinal pain: implications for rehabilitation of the athlete following lower back pain. *Journal of Science and Medicine in Sport / Sports Medicine Australia*, 3(3):243–53.

Hodges, P. W., Moseley, G. L., Gabrielsson, A., and Gandevia, S. C. (2003). Experimental muscle pain changes feedforward postural responses of the trunk muscles. *Experimental Brain Research*, 151(2):262–71.

Hodges, P. W. and Richardson, C. A. (1999). Transversus abdominis and the superficial abdominal muscles are controlled independently in a postural task. *Neuroscience Letters*, 265(2):91–4.

Hoppenfeldt, S. (1976). *Physical examination of the spine and extremities*. Prentice-Hall, London, England.

Hoy, D., Bain, C., Williams, G., March, L., Brooks, P., Blyth, F., Woolf, A., Vos, T., and Buchbinder, R. (2012). A systematic review of the global prevalence of low back pain. *Arthritis and Rheumatism*, 64(6):2028–37.

Jacobs, W. C., van Tulder, M., Arts, M., Rubinstein, S. M., van Middelkoop, M., Ostelo, R., Verhagen, A., Koes, B., and Peul, W. C. (2011). Surgery versus conservative management of sciatica due to a lumbar herniated disc: a systematic review. *European Spine Journal*, 20(4):513–22.

Jansson, K. A., Németh, G., Granath, F., and Blomqvist, P. (2004). Surgery for herniation of a lumbar disc in Sweden between 1987 and 1999. An analysis of 27,576 operations. *Journal of Bone and Joint Surgery. British Volume*, 86(6):841–7.

Jensen, T. S., Albert, H. B., Sorensen, J. S., Manniche, C., and Leboeuf-Yde, C. (2007). Magnetic resonance imaging findings as predictors of clinical outcome in patients with sciatica receiving active conservative treatment. *Journal of Manipulative and Physiological Therapeutics*, 30(2):98–108.

Johansson, E. (1999). *Exercise-Based Physiotherapy Management of Patients with Persistent, Non-Specific Low Back Pain*. PhD-thesis, Uppsala University, Uppsala.

Kayama, S., Konno, S., Olmarker, K., Yabuki, S., and Kikuchi, S. (1996). Incision of the anulus fibrosus induces nerve root morphologic, vascular, and functional changes. An experimental study. *Spine*, 21(22):2539–43.

Kjellby-Wendt, G. and Styf, J. (1998). Early active training after lumbar discectomy. A prospective, randomized, and controlled study. *Spine*, 23(21):2345–51.

Koes, B. W., van Tulder, M. W., and Peul, W. C. (2007). Diagnosis and treatment of sciatica. *BMJ (Clinical research ed.)*, 334(7607):1313–7.

Koho, P., Orenius, T., Kautiainen, H., Haanpaa, M., Pohjolainen, T., and Hurri, H. (2011). Association of fear of movement and leisure-time physical activity among patients with chronic pain. *Journal of Rehabilitation Medicine*, 43(9):794–9.

Kongsted, A., Kent, P., Albert, H., Jensen, T. S., and Manniche, C. (2012). Patients with low back pain differ from those who also have leg pain or signs of nerve root involvement – a cross-sectional study. *BMC Musculoskeletal Disorders*, 13(1):236.

Konstantinou, K. and Dunn, K. M. (2008). Sciatica: review of epidemiological studies and prevalence estimates. *Spine*, 33(22):2464–72.

Kori, S. H., Miller, R. P., and Todd, D. D. (1990). Kinisophobia: A new view of chronic pain behavior. *Pain Management*, 3:35–43.

Krippendorff, K. (2012). *Content analysis: An introduction to its methodology*. Number 1. Sage Publications, Inc., Thounds Oaks, Ca, 3rd edition.

Lamberg, E. M. and Hagins, M. (2012). The effects of low back pain on natural breath control during a lowering task. *European Journal of Applied Physiology*, 112(10):3519–24.

Laslett, M., Oberg, B., Aprill, C. N., and McDonald, B. (2005). Centralization as a predictor of provocation discography results in chronic low back pain, and the influence of disability and distress on diagnostic power. *The Spine Journal : official journal of the North American Spine Society*, 5(4):370–80.

Linton, S. J., Vlaeyen, J., and Ostelo, R. (2002). The back pain beliefs of health care providers: are we fear-avoidant? *Journal of Occupational Rehabilitation*, 12(4):223–32.

Long, A., Donelson, R., and Fung, T. (2004). Does it matter which exercise? A randomized control trial of exercise for low back pain. *Spine*, 29(23):2593–602.

Long, A. L. (1995). The centralization phenomenon. Its usefulness as a predictor or outcome in conservative treatment of chronic low back pain (a pilot study). *Spine*, 20(23):2513–20; discussion 2521.

Luijsterburg, P. A., Verhagen, A. P., Ostelo, R. W., van Os, T. A., Peul, W. C., and Koes, B. W. (2007). Effectiveness of conservative treatments for the lumbosacral radicular syndrome: a systematic review. *European Spine Journal*, 16(7):881–99.

Lundberg, M. K., Styf, J., and Carlsson, S. G. (2004). A psychometric evaluation of the Tampa Scale for Kinesiophobia - from a physiotherapeutic perspective. *Physiotherapy Theory and Practice*, 20(2):121–33.

McKenzie, R. A. (1981). *The Lumbar Spine, Mechanical Diagosis and Therapy*. Spinal Publications Limited, Waikanae, New Zealand, 1st edition.

McKenzie, R. A. and May, S. (2003). *The Lumbar Spine: Mechanical Diagnosis & Therapy*, volume 1 and 2. Spinal Publications Limited, Waikanae, New Zealand, 2nd edition.

Mixter, W. J. and Barr, J. S. (1934). Rupture of the intervertebral disc with involvement of the spine canal. *New England Surgical Society*, 211(5):210–5.

Morgan-Hough, C. V. J., Jones, P. W., and Eisenstein, S. M. (2003). Primary and revision lumbar discectomy. A 16-year review from one centre. *Journal of Bone and Joint Surgery. British Volume*, 85(6):871–4.

Moustafa, I. M. and Diab, A. A. (2013). Extension traction treatment for patients with discogenic lumbosacral radiculopathy: a randomized controlled trial. *Clinical Rehabilitation*, 27(1):51–62.

Nachemson, A. L. (1993). Lumbar disc herniation–conclusions. *Acta Orthopaedica Scandinavica. Supplementum*, 251:49–50.

Olmarker, K., Nordborg, C., Larsson, K., and Rydevik, B. (1996). Ultrastructural changes in spinal nerve roots induced by autologous nucleus pulposus. *Spine*, 21(4):411–4.

Olmarker, K., Rydevik, B., and Nordborg, C. (1993). Autologous nucleus pulposus induces neurophysiologic and histologic changes in porcine cauda equina nerve roots. *Spine*, 18(11):1425–32.

Ostelo, R. W., Swinkels-Meewisse, I. J., Knol, D. L., Vlaeyen, J. W., and de Vet, H. C. (2007). Assessing pain and pain-related fear in acute low back pain: what is the smallest detectable change? *International Journal of Behavioral Medicine*, 14(4):242–8.

Ostelo, R. W. and Vlaeyen, J. W. (2008). Attitudes and beliefs of health care providers: extending the fear-avoidance model. *Pain*, 135(1-2):3–4.

Osterman, H., Seitsalo, S., Karppinen, J., and Malmivaara, A. (2006). Effectiveness of microdiscectomy for lumbar disc herniation: a randomized controlled trial with 2 years of follow-up. *Spine*, 31(21):2409–14.

Paatelma, M., Kilpikoski, S., Simonen, R., Heinonen, A., Alen, M., and Videman, T. (2008). Orthopaedic manual therapy, McKenzie method or advice only for low back pain in working adults: a randomized controlled trial with one year follow-up. *Journal of Rehabilitation Medicine*, 40(10):858–63.

Panjabi, M. M. (1992). The stabilizing system of the spine. Part I. Function, dysfunction, adaptation, and enhancement. *Journal of Spinal Disorders*, 5(4):383–9; discussion 397.

Patton, M. Q. (2002). *Qualitative research & evaluation methods*. Sage publications, Inc., Thousand Oaks, Ca, 3rd edition.

Pellino, T., Tluczek, A., Collins, M., Trimborn, S., Norwick, H., Engelke, Z. K., and Broad, J. (1998). Increasing self-efficacy through empowerment: preoperative education for orthopaedic patients. *Orthopedic Nursing*, 17(4):48–51, 54–9.

Perreault, K. (2008). Linking health promotion with physiotherapy for low back pain: a review. *Journal of Rehabilitation Medicine*, 40(6):401–9.

Peul, W. C., van den Hout, W. B., Brand, R., Thomeer, R. T., and Koes, B. W. (2008). Prolonged conservative care versus early surgery in patients with sciatica caused by lumbar disc herniation: two year results of a randomised controlled trial. *BMJ (Clinical research ed.)*, 336(7657):1355–8.

Picavet, H. S., Vlaeyen, J. W., and Schouten, J. S. (2002). Pain catastrophizing and kinesiophobia: predictors of chronic low back pain. *American Journal of Epidemiology*, 156(11):1028–34.

Pincus, T., Smeets, R. J. E. M., Simmonds, M. J., and Sullivan, M. J. L. (2010). The fear avoidance model disentangled: improving the clinical utility of the fear avoidance model. *The Clinical Journal of Pain*, 26(9):739–46.

Rabin, R. and de Charro, F. (2001). EQ-5D: a measure of health status from the EuroQol Group. *Annals of Medicine*, 33(5):337–43.

Rasmussen, C., Nielsen, G. L., Hansen, V. K., Jensen, O. K., and Schioettz-Christensen, B. (2005). Rates of lumbar disc surgery before and after implementation of multidisciplinary nonsurgical spine clinics. *Spine*, 30(21):2469–73.

Reneman, M. F., Jorritsma, W., Dijkstra, S. J., and Dijkstra, P. U. (2003). Relationship between kinesiophobia and performance in a functional capacity evaluation. *Journal of Occupational Rehabilitation*, 13(4):277–85.

Reneman, M. F., Schiphorts Preuper, H. R., Kleen, M., Geertzen, J. H. B., and Dijkstra, P. U. (2007). Are pain intensity and pain related fear related to functional capacity evaluation performances of patients with chronic low back pain? *Journal of Occupational Rehabilitation*, 17(2):247–58.

Rosén, M., Axelsson, S., and Lindblom, J. (2009). Observational studies versus rcts: what about socioeconomic factors? *Lancet*, 373(9680):2026.

Rydevik, B., Brown, M. D., and Lundborg, G. (1984). Pathoanatomy and pathophysiology of nerve root compression. *Spine*, 9(1):7–15.

Saal, J. A. and Saal, J. S. (1989). Nonoperative treatment of herniated lumbar intervertebral disc with radiculopathy. An outcome study. *Spine*, 14(4):431–7.

Saal, J. S., Saal, J. A., and Yurth, E. F. (1996). Nonoperative management of herniated cervical intervertebral disc with radiculopathy. *Spine*, 21(16):1877–83.

Scott, J. and Huskisson, E. C. (1976). Graphic representation of pain. *Pain*, 2(2):175–84.

Skytte, L., May, S., and Petersen, P. (2005). Centralization: its prognostic value in patients with referred symptoms and sciatica. *Spine*, 30(11):E293–9.

Stadnik, T. W., Lee, R. R., Coen, H. L., Neirynck, E. C., Buisseret, T. S., and Osteaux, M. J. (1998). Annular tears and disk herniation: prevalence and contrast enhancement on MR images in the absence of low back pain or sciatica. *Radiology*, 206(1):49–55.

Strömqvist, B., Jönsson, B., Fritzell, P., Hägg, O., Larsson, B. E., and Lind, B. (2001). The Swedish National Register for lumbar spine surgery: Swedish Society for Spinal Surgery. *Acta Orthopaedica Scandinavica*, 72(2):99–106.

Sullivan, M., Bishop, S., and Pivik, J. (1995). The Pain Catastrophizing Scale: Development and validation. *Psychological Assessment*, 7(4):524–32.

Takada, E., Takahashi, M., and Shimada, K. (2001). Natural history of lumbar disc hernia with radicular leg pain: Spontaneous MRI changes of the herniated mass and correlation with clinical outcome. *Journal of Orthopaedic Surgery (Hong Kong)*, 9(1):1–7.

Underwood, M. R., Harding, G., and Klaber Moffett, J. (2006). Patient perceptions of physical therapy within a trial for back pain treatments (UK BEAM) [ISRCTN32683578]. *Rheumatology (Oxford, England)*, 45(6):751–6.

Unlu, Z., Tasci, S., Tarhan, S., Pabuscu, Y., and Islak, S. (2008). Comparison of 3 physical therapy modalities for acute pain in lumbar disc herniation measured by clinical evaluation and magnetic resonance imaging. *Journal of Manipulative and Physiological Therapeutics*, 31(3):191–8.

van Til, J. A., Drossaert, C. H., Punter, R. A., and Ijzerman, M. J. (2010). The potential for shared decision-making and decision aids in rehabilitation medicine. *Journal of Rehabilitation Medicine*, 42(6):598–604.

Vlaeyen, J., Kole-Snijders, A., Rotteveel, A., Ruesink, R., and Heuts, P. (1995a). The role of fear of movement/(re)injury in pain disability. *Journal of Occupational Rehabilitation*, 5(4):235–51.

Vlaeyen, J. W., Kole-Snijders, A. M., Boeren, R. G., and van Eek, H. (1995b). Fear of movement/(re)injury in chronic low back pain and its relation to behavioral performance. *Pain*, 62(3):363–72.

Vlaeyen, J. W. S. and Linton, S. J. (2012). Fear-avoidance model of chronic musculoskeletal pain: 12 years on. *Pain*, 153(6):1144–7.

Von Korff, M. (1994). Studying the natural history of back pain. *Spine*, 19(18 Suppl):2041*S*–6*S*.

Vroomen, P. C., de Krom, M. C., Wilmink, J. T., Kester, A. D., and Knottnerus, J. A. (2002). Diagnostic value of history and physical examination in patients suspected of lumbosacral nerve root compression. *Journal of Neurology, Neurosurgery and Psychiatry*, 72(5):630–4.

Vucetic, N. and Svensson, O. (1996). Physical signs in lumbar disc hernia. *Clinical Orthopaedics and Related Research*, (333):192–201.

Weber, H. (1983). Lumbar disc herniation. a controlled, prospective study with ten years of observation. *Spine*, 8(2):131–40.

Weber, H. (1994). The natural history of disc herniation and the influence of intervention. *Spine*, 19(19):2234–8; discussion 2233.

Weber, H., Holme, I., and Amlie, E. (1993). The natural course of acute sciatica with nerve root symptoms in a double-blind placebo-controlled trial evaluating the effect of piroxicam. *Spine*, 18(11):1433–8.

Weinstein, J. N., Lurie, J. D., Tosteson, T. D., Skinner, J. S., Hanscom, B., Tosteson, A. N., Herkowitz, H., Fischgrund, J., Cammisa, F. P., Albert, T., and Deyo, R. A. (2006a). Surgical vs nonoperative treatment for lumbar disk herniation: the Spine Patient Outcomes Research Trial (SPORT) observational cohort. *JAMA*, 296(20):2451–9.

Weinstein, J. N., Lurie, J. D., Tosteson, T. D., Tosteson, A. N., Blood, E. A., Abdu, W. A., Herkowitz, H., Hilibrand, A., Albert, T., and Fischgrund, J. (2008). Surgical versus nonoperative treatment for lumbar disc herniation: four-year results for the Spine Patient Outcomes Research Trial (SPORT). *Spine*, 33(25):2789–800.

Weinstein, J. N., Tosteson, T. D., Lurie, J. D., Tosteson, A. N., Hanscom, B., Skinner, J. S., Abdu, W. A., Hilibrand, A. S., Boden, S. D., and Deyo, R. A. (2006b). Surgical vs nonoperative treatment for lumbar disk herniation: the Spine Patient Outcomes Research Trial (SPORT): a randomized trial. *JAMA*, 296(20):2441–50.

Werneke, M., Hart, D. L., and Cook, D. (1999). A descriptive study of the centralization phenomenon. A prospective analysis. *Spine*, 24(7):676–83.

Werneke, M. W., Hart, D. L., Resnik, L., Stratford, P. W., and Reyes, A. (2008). Centralization: prevalence and effect on treatment outcomes using a standardized operational definition and measurement method. *The Journal of Orthopaedic and Sports Physical Therapy*, 38(3):116–25.

White, A. A. and Panjabi, M. M. (1978). *Clinical Biomechanics of the Spine*. J. B. Lippincott Company, Philadelphia, Pa.

World Health Organisation (1948). Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, (Official Records of the World Health Organization, no. 2, p. 100).

Yilmaz, F., Yilmaz, A., Merdol, F., Parlar, D., Sahin, F., and Kuran, B. (2003). Efficacy of dynamic lumbar stabilization exercise in lumbar microdiscectomy. *Journal of Rehabilitation Medicine*, 35(4):163–7.

Zieger, M., Luppa, M., Matschinger, H., Meisel, H. J., Gunther, L., Meixensberger, J., Toussaint, R., Angermeyer, M. C., Konig, H. H., and Riedel-Heller, S. G. (2011). Affective, anxiety, and substance-related disorders in patients undergoing herniated disc surgery. *Social Psychiatry and Psychiatric Epidemiology*, 46(11):1181–90.

Zieger, M., Schwarz, R., Konig, H. H., Harter, M., and Riedel-Heller, S. G. (2010). Depression and anxiety in patients undergoing herniated disc surgery: relevant but underresearched - a systematic review. *Central European Neurosurgery*, 71(1):26–34.

Zung, W. W. (1965). A self-rating depression scale. *Archives of General Psychiatry*, 12:63–70.

Öberg, B., Enthoven, P., Kjellman, G., and Skargren, E. (2003). Back pain in primary care: a prospective cohort study of clinical outcome and healthcare consumption. *Advances in Physiotherapy*, 5(3):98.