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Low Back Pain

With Special Reference to Manual Therapy, Outcome and its Prognosis

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Abstract
Grunnesjö, M. 2011. Low Back Pain: With Special Reference to Manual Therapy, Outcome and its Prognosis. Acta Universitatis Upsaliensis. *Digital Comprehensive Summaries of Uppsala Dissertations from the Faculty of Medicine* 691. 79 pp. Uppsala. ISBN 978-91-554-8122-3.

Objectives. To assess outcome of manual therapy in addition to stay-active care in sub-acute low back pain patients and to investigate the predictive power of pain drawing sketch variables for return to work.

Materials and methods. The study was designed as a randomised controlled trial with a factorial design, and included 160 patients with acute or sub-acute low back pain allocated to one of the four treatment groups during 10 weeks. Group 1 received stay-active care only, Group 2 the same treatment as in Group 1 + muscle stretching, Group 3 the same treatment as in Group 2 plus manual therapy, and Group 4 the same treatment as Group 3 plus steroid injections. Outcome included pain intensity, pain extension, functional and health related quality of life variables and return to work.

Results. Pain intensity and disability rating improved faster in Groups 3 and 4 than in Groups 1 and 2 ($p<0.05$ and $p<0.05$). Also health related quality of life was affected by the treatments given; the more treatment options the better the effect (trend across the groups $p<0.05$). Pain extension as described on a pain drawing sketch decreased in all groups across the study period. The pain modality 'numbness' was the most painful one among patients with no pain radiation. Pain radiation according to the pain drawing sketch was the strongest predictor for return to work ($p=0.03$, Wald $\chi^2=4.56$).

Conclusions. The manual therapy concept used in this study reduced pain intensity and disability rating better than the stay active concept. The effects on health related quality of life were greater the larger the number of treatment modalities available. Pain drawing information was significantly correlated with pain and functional variables. Pain radiation according to the pain drawing adds significant information to the prediction of return to work.

Keywords: Low Back Pain, Manual therapy, Stay active care, Mobilisation, Manipulation, Pain drawing, Return to work, Prognosis, Disability rating, Pain

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To Ulf, Marcus, and Sophie

List of Papers

This thesis is based on the following papers, which are referred to in the text by their Roman numerals.

I Grunnesjö, M., Bogefeldt, J, Blomberg, S., Delaney, H., Svärdsudd, K. (2006) The course of pain drawings during a 10-week treatment period in patients with acute and sub-acute low back pain. *BMC Musculoskeletal disorders,* 7:65

II Grunnesjö, M.I., Bogefeldt, J.P., Svärdsudd, K.F., Blomberg, S.I.E. (2004) A randomized controlled clinical trial of stay-active care versus manual therapy in addition to stay-active care: Functional variables and pain. *Journal of manipulative and physiological therapeutics*, 27:431–441

III Grunnesjö, M.I., Bogefeldt, J.P., Blomberg, S.I.E., Strender, L-E., Svärdsudd, K.F. A randomized controlled trial of the effects of muscle stretching, manual therapy and steroid injections in addition to 'stay-active' care on health-related quality of life in acute and sub-acute low back pain. *Clinical rehabilitation* in press

IV Grunnesjö, M.I., Bogefeldt, J.P., Blomberg, S.I.E., Strender, L-E., Svärdsudd, K.F. The contribution of pain drawings in the prediction of return to work in patients with acute or sub-acute low back pain. Manuscript.

Contents

Abbreviations

95% CI	95% confidence intervals
DRI	Disability Rating Index
HR	Hazards Ratio
IASP	International Association for the Study of Pain
i.e.	id est (that is)
LBP	Low Back Pain
NSAID	Non-Steroid Anti-Inflammatory Drugs
PD	Pain Drawing
PDS	Pain Drawing Score
SBU	The Swedish Council on Technology Assessment in Health Care
SD	Standard deviation
VAS	Visual analogue scale

Prologue

My fascination for musculoskeletal function started at an early age, when I was active in athletics. When choosing a career, that fascination led me into the field of manual therapy and a doctor of napraphy degree [1]. As a doctor of naprapathy, focus of operandi lies in dysfunctions of the musculoskeletal system. Its fundament, i.e. that the system is malfunctioning due to muscle or joint impairment, appealed to me. Problem solving includes assessing the bodily assets with different manual therapies and matching home exercises to maintain the effect over time.

In practice, about half of the patients I met suffered from low back pain, of whom some could be helped, others not. That challenge started a search for answers in the literature, a far more daunting task than I had imagined. In the early 1990s there was no evidence for the effect of manual therapy on low back pain, or any other musculoskeletal pain. The Swedish Council of Technology Assessment (SBU) report from 1991 concluded that there was no evidence for effect of spinal manipulation on low back pain [2]. Still I saw in my everyday practice that patients with low back pain were benefitted from manual therapy, including spinal manipulation!

The lack of answers turned me some years later into research and Uppsala University, the latter because of their interest in scientific studies of manual therapy [3]. As a research student I had the opportunity to join a research group that was about to launch a new project, the 'Gotland Low Back Pain study', a randomised clinical trial in manual therapy on low back pain in a primary health care setting and on which material this thesis is based. My task was to aid in the finalisation of the data collection phase, participate in the intellectual work up of the data and publish the results. Thus, the 'Gotland Low Back Pain study' has for the last 12 years played a significant part of my life.

At the time of writing this thesis only moderate evidence for manual therapy on low back pain were at hand [4-6]. The bio-psychosocial explanation model [7, 8] had gained recognition and the challenge was rather to identify relevant subgroups to improve clinical outcome of low back pain in the individual [9-12]. The mechanisms behind the transition from acute to intermittent or chronic low back pain were not well established [13-15] and neither was the natural course of pain development in non-specific low back pain [16]. This thesis may provide some contributions in the search of knowledge in this field.

Introduction

The nature of pain

In the survival of humans the pain experience has been helpful throughout the history. The acute pain makes the individual conscious that tissue damage or possible tissue damage is in the doing. The warning system helps to prevent further damage and acute pain is often referred to as adaptive [14, 17]. The cause of pain can at times be elusive and even when the probable cause of pain has been identified there is no guarantee that the treatment will be successful. The factors pain, physical impairment and the level of disability have been described as related to each other, but the relationship has been reported as modest and varies according to the duration of symptoms and clinical subgroups [18]. In chronic pain the relationship between demonstrable physical impairment and the accompanying degree of functional incapacity or psychological distress have been reported as weak [19].

The complexity of pain comprises of the unpleasant sensation in a part or parts of the body, and that the unpleasantness turns pain into an emotional experience [17] that includes our previous memories of pain, how it was tackled and the result of it. It also includes our ability to adapt to the situation, the possibilities to adjust and to understand the changes of behaviour [20]. These gradual changes of behaviour have been suggested to be induced by several alterations in the brain function ending with a rearranged architecture of the brain and its functioning [14, 21].

To comprehend and successfully reduce pain most of the affected dimensions pain, attitudes and beliefs, psychological distress, illness behaviour and social environment, have to be targeted at the same time, Figure 1 [8]. Thus, the challenge of pain comprises of the subjective experience, which makes it unquestionable and thereby limits the ability to assess it with objective methods.

Pain definitions

According to the International Association for the Study of Pain (IASP), pain is defined as ‘An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage’ [22]. Acute pain is usually defined as pain since 6 weeks or less,

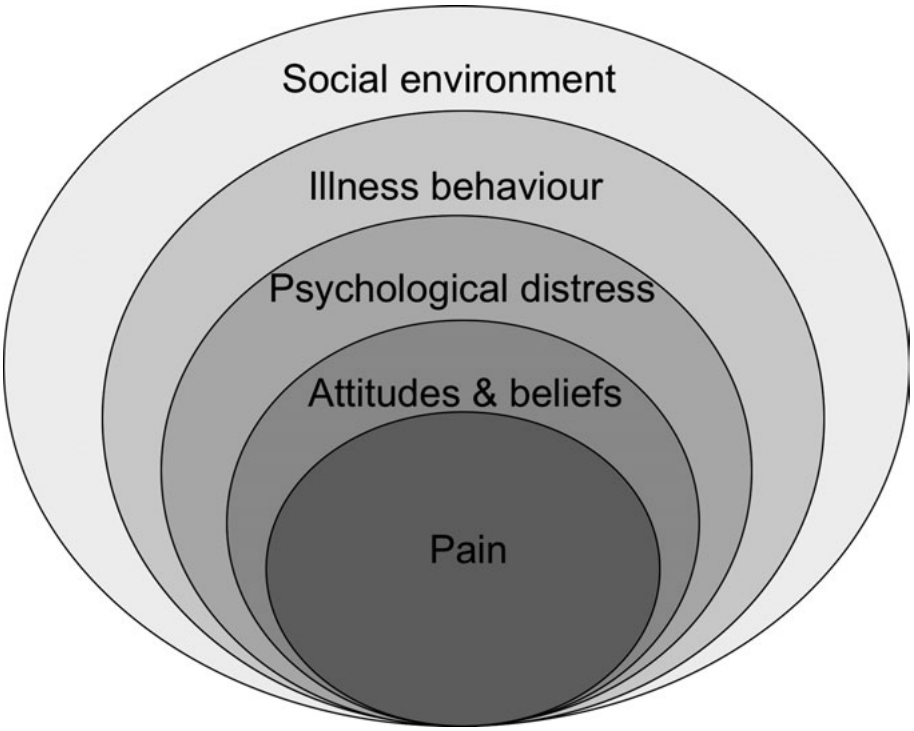


Figure 1. Factors affecting pain and pain reduction. Modified from Waddell et al. [8].

sub-acute pain as pain since more than 6 but less than 12 weeks, and chronic pain as pain lasting for 12 weeks or more [23].

Musculoskeletal pain is defined as pain originating from the musculoskeletal system. When the pain originates from the lower back to the gluteal fold it is usually defined as low back pain (LBP) [5]. Several other frequently used synonymous terms are lower back pain, low back disorders, back pain trouble, backache, low back syndrome and low back injury. To reflect the often unknown origin of low back pain in a specific patient, the term non-specific low back pain is often used and is used in this thesis.

Pain radiation to one or both legs is usually included in the low back pain concept. The anatomical border for pain radiation is commonly defined as pain radiating below the gluteal fold into one or both legs [24]. Sciatica is defined as pain radiating below the knee in the distribution area of the sciatic nerve [5]. Herniated disc is often defined as a herniation of the nucleus pulposus of an intervertebral disc through its fibrous outer covering, which may result in compression of adjacent nerve roots or other structures [5].

Neuropathic pain is commonly defined as pain arising as a direct consequence of a lesion or disease affecting the somatosensory system [25]. Neu-

rogenic pain and neuronal pain are usually used as synonyms to neuropathic pain.

Low back pain

Low back pain is normally of medically harmless character and most episodes (about 80%) ends within the first month [26-28]. The start of a low back pain episode could be the result of a trauma or have a spontaneous onset. The start could be gradual or acute, and relief is often received by treatment [29].

However, for some low back pain patients the episode has a longer duration and the mechanisms behind this transition are still largely unknown. The putative prognostic factors include social factors (not working, low job satisfaction and no current sports activity), psychological factors (distress) and biological factors (high age, obesity, female sex) or a previous history of low back pain [28, 30, 31]. Also for patients with a protracted low back pain course, including sciatic pain, the prognosis might be less favourable [32].

Low back pain tends to have an intermittent course [16, 28]. Prevalence levels range from less than 10% to more than 75%; the wide range might be attributable to the differences in methodological approaches such as duration and anatomic site [26, 33]. The Swedish point prevalence, which is in line with the European levels, has been reported as 18.2% for 17 to 67 year olds [34].

The natural course of acute low back pain implies a fairly sudden onset and then a gradual decline of the intensity of symptoms and its extension [16, 35]. One attempt to describe low back pain reduction is by the centralisation phenomenon [36]. McKenzie narrated a pain reduction over time from distal painful areas to a gradual centralisation of pain to its origin in the lower back. The centralisation phenomenon has been evaluated as reliable to examination and as a predictor of favourable treatment result [37-39].

The gradual decrease of symptoms has also been described in terms of the pain quality, i.e. pain modalities. This includes the perception that some pain modalities are more painful than others. The reported change of the pain quality over time has been described as a ‘pain modality shift’, a change from painful modalities to less painful ones [36]. The pain modalities have been sparsely studied. Four studies have reported pain modalities in low back pain patients, two as single measurements [40, 41] and two in chronic low back pain patients selected for surgery [42, 43]. In the latter studies a pain modality pattern could be distinguished, but the two reported patterns did not match each other. In one of the studies burning pain and frequent use of aching pain symbols indicated disc related pain [42]. In the other study, numbness was reported as the most painful one [43].

The pain drawing sketch

In 1949, Harold Palmer suggested that pain drawing sketches could be used to distinguish functional pain from organic pain [44]. The pain drawing sketch is a visual tool, a body contour of a human frontal and dorsal projection, in which the patient can express his or her pain using symbols to describe the pain experience both to quality and extent of area [45]. It allows the patient to describe the pain experience in an uncomplicated way, fairly independent from language, and its evaluation is easy learned. Thus, the method has gained interest and has become widely used in clinical practice as an assessment tool of patients' subjective pain.

Ransford et al. [46] found strong association between some of the psychological functioning profiles and certain pain drawing patterns. The impact of this study was global and the pain drawing assessment method was widely adopted and still is. During the following ten years there were several attempts to reproduce these findings, however less successful than in the original report [47-49]. The non-successful reproduction efforts and the difficulties to use the suggested assessment method triggered a development of different pain drawing assessment methods, both quantitative and qualitative ones.

Outcome measures in low back pain studies

Outcomes in low back pain studies have been measured in multiple ways, both overall and more detailed. Examples of overall outcomes are the frequency and number of episodes, the number and types of medical consultations, and return to work. Examples of more detailed outcome measures are pain intensity, disability and quality of life [50]. These outcomes appear to measure different aspects of low back pain recovery. In a study using overall as well as detailed outcomes, 99% returned to work, 75% still had impairment of activities of daily living, and more than 80% had symptoms or impaired functional performance [51].

In medically oriented trials, primary outcomes tend to be return to work, pain and disability-oriented outcomes, and more seldom quality of life oriented. Health related quality of life and background factors are rather used to describe the studied group and possibly to facilitate subgroups analysis [13, 52-54]. The outcome return to work has two main grades, at work or still on workers' compensation, but the worker's compensation situation might be a scale with gradual return to work. The gradual onset of return to work and different sick leave systems have led to difficulties comparing various study results [55, 56].

The pain measurement focuses on pain intensity by visual analogue scales (usually 100 millimetre VAS) or the Borg scale [57]. The patients are in-

structed to mark the experienced pain intensity during the last 24 hours or during last week on the scale. Thus, the pain intensity score reflects a global mean over the actual period. However, pain extension measures, i.e. measures of the size of the area where the pain is coming from, have not been used as outcome in any study. In a Medline search no randomised controlled studies on acute low back pain with the pain drawing sketch as primary outcome was found. The pain drawing sketch has been used on low back pain patients but rather to describe the patient group, classify the patients, correlate pain patterns with other outcome instruments or to predict outcomes, for example treatment or radiological examination.

There are several instruments available to evaluate self-reported physical functioning. Two frequently used scales are the Oswestry scale [58] and the Roland-Morris scale [59, 60]. The Disability Rating Index [61] used in this study has not been frequently used in low back pain studies but was chosen to facilitate the comparison of results with those from a previous study, performed in Säter, Sweden [62]. However, the three instruments are quite similar, and contain 12 to 16 visual analogue scales for the patient to grade various aspects of everyday functioning.

Global quality of life includes health but also marital status, financial income and housing situation [63]. Health related quality of life is usually defined as a broad range of human experiences related to the individual's overall wellbeing. It is idiosyncratic to the individual but intuitively meaningful and understandable to most people [64].

Health related quality of life may be measured with instruments, such as the Linton Score [65], the Euro Quality of life with five dimensions [66] and the Gothenburg Quality of Life (GQL) instrument [67]. The GQL instrument has been used in various settings, it is validated, found to be stable over time, found to be independent of diagnosis and treatment, and is simple to use and to interpret [67, 68].

Variables derived from the pain drawing sketch offer a number of additional potential outcome measures. However, the use of pain drawing variables as outcome measures in low back pain studies poses a number of problems. Although most suggested evaluations are easily learned, there is no standard for the number of pain areas, for how to assess the information on the pain drawing sketch and there is no generally accepted evaluation model. This lack of standard has contributed to a variety of number of areas being used, ranging from two (one frontal and one dorsal area) to 61,102 areas. Pain drawings with a large number of areas rely on computer assisted evaluation methods [69]. The number of areas poses problems of underestimation or overestimation of painful areas and thereby sensitivity problems regarding the clinical course. Thus, the number of areas is either chosen for the specific evaluation model or the specific study population [70].

The pain drawing sketch includes a variety of pain modalities for the patient to choose from when describing the pain experience. The Scandinavian

model as described by Uden [71] is frequently used with its six pain modalities ('cramps', 'pins and needles', 'numbness', 'burning', 'dull aching' and 'stabbing'). The pain drawing used in this study had seven pain modalities to describe the pain (the Scandinavian six plus 'stiffness').

The assessment methods may be 'qualitative', with processing of additional information that some patients add on the pain drawing outside the body contour, or 'quantitative' with no such processing of additional information [72, 73]. Both methods have been tested for validity [46, 72, 74-76] and reproducibility [45]. However, the quantitative method has also been found to be stable over time and it has low inter-rater variation [45, 69].

The variety of outcome measures leaves the result of a study difficult to compare with those of other studies. To address this dilemma consensus statements on what outcome measures to be used in studying low back pain have been proposed [13].

Low back pain treatment

The non-specific low back pain origin and the unidentified transition of pain development leave the process of understanding low back pain far from fully elucidated. This uncertainty is reflected in the vast number of available non-specific low back pain treatment methods.

There are numerous reviews on treatment methods. In the Cochrane Back Review Group database, 36 reviews on lumbar back pain studies were performed during 2002-2011 [77]. The use of non-steroidal drugs, the methods bed rest, exercises, acupuncture, multimodal rehabilitation and more recently spinal manipulation therapy were assessed [52, 78-82]. Non-steroidal drugs, acupuncture, spinal manipulation and active therapies such as multimodal rehabilitation and exercises were generally considered effective or moderately effective for acute and sub-acute low back pain, while passive monotherapies, such as bed rest, massage, ultrasound, electrotherapy, laser treatment and traction were not recommended since these therapies might increase illness behaviour and chronicity [83].

Thus, the treatment of low back pain poses a challenge. The abundant number of methods creates a scope for the therapist to use after his or her experience. The recommended management includes medical history and examination to rule out other conditions, information on the importance of staying active, judicious use of drugs, consideration of psychosocial situation and for selected patients laboratory tests and imaging tests [83, 84]. At the time of planning this study, the evidence for the effectiveness of the stay-active care was incomplete and its role in appropriate handling of low back pain was not established [2, 85].

Manual therapy includes several treatment tools, such as various soft tissue treatments, specific spinal mobilisation and spinal manipulation, often

supported with traction therapy [4, 86]. Soft tissue treatments include various types of massage, muscle stretching and soft tissue pressure, i.e. ligament-, muscle- or trigger point pressure [1, 87]. Manual therapies have in common that various diagnostic or treatment manoeuvres are used. Manual therapy is often combined with exercises, such as specific muscle stabilisation training in combination with specific muscle stretching.

The treatment manoeuvres are performed with a large variety of methods individual to the practitioner. The practitioners include doctors of chiropractic, doctors of naprapathy, doctors of osteopathy, and physicians and physiotherapists trained in manual therapy. Acceptance of the various professions as health care providers varies between countries. The treatment methods are classified as complementary or alternative medicine, even though some practitioners performing these methods belong to the ordinary healthcare system. In the following text sections the content and effect evidence of the treatments used in this thesis are presented.

Stay-active care

The basic management of low back pain, stay-active care, has strong to moderate evidence in non-specific acute low back pain [6, 27, 88]. It is noteworthy that patients with severe pain, or functional deficits, for instance patients with suspicion of fracture, tumour, neurological or an other severe disease, may be handled differently to this concept [89]. Stay-active care has three main components; to explain the generally favourable prognosis, to stress the importance of staying active and to provide effective self-care options [5, 8]. Patients with non-specific acute low back pain generally experience substantial improvement in the first weeks after onset [27, 28]. Stating the medically harmless nature of the condition and the adverse effects of inactivity and sick leave increase the chances of a positive outcome [88, 90]. Finally, the stay-active care includes self-care with evidence-based activities to reduce pain. The self-care advice are often included in handout booklets [91] or more recently, available on Internet web sites, for instance the Swedish website www.1177.se.

Muscle stretching

The support for a positive effect of muscle stretching as a single treatment was weak at the time of the design of this study. A recent Medline search for muscle stretching studies resulted in only two studies published during the last two decades, one in chronic low back pain and one in acute neck pain [92, 93]. Still another study under progress has been announced where the effect of muscle stretching will be compared with that of yoga [94].

However, numerous studies of the effect of muscle stretching in combination with exercise for low back pain have been published. In a recent

Cochrane review on the effect of exercise [95], the support of exercise, including muscle stretching, remains moderate as far as reducing recurrences of low back pain is concerned [96].

Thus, the distinction of the effect of exercise from that of muscle stretching is difficult, but studies on exercise therapy without muscle stretching or studies with muscle stretching as an add-on to exercises may be indicative. For instance, exercise was found to affect pain more effectively when muscle stretching was added in chronic low back pain treatment [97]. Also, home exercises including muscle stretching were more effective than non-steroid anti-inflammatory drugs (NSAID) in chronic low back pain treatment [98].

Spinal manual treatment

In 2004, a Cochrane review concluded that there was no evidence that spinal manipulation was superior to any other standard treatment for acute or chronic low back pain [99]. However, since then an American and a European clinical guideline have been published [5, 83], both concluding that there is good evidence for spinal manipulation treatment of acute low back pain in adults. As regards sub-acute low back pain, spinal manipulation or mobilisation therapy was considered effective based on moderately strong evidence [4].

Manual treatment has also been reported effective in adults 65 years and older [100]. However, the scientific support for spinal manual treatment of chronic low back pain is weaker. In the European clinical guideline short periods of spinal manual treatment might be considered for these patients [101]. The management of chronic low back pain emphasises that no single intervention component is likely to be effective, but rather a combination of several components.

Steroid injections

A Medline search for the effects of steroid injections in low back pain resulted in 220 articles, of which the majority were dealing with epidural or disc injections in patients with radicular symptoms or prolapsed discs. Steroid injections in addition to manual therapy were not used as experimental treatment in any study of acute or sub-acute low back pain before the present and the Säter study [102]. However, the effect of steroid injections as mono-therapy was probably limited to a short period of time, one to two weeks. After three months there was no difference to placebo [103].

The Cochrane review from 2008 on the effect of injections, based on 18 diverse studies of epidural-, facets- or local injection sites and with a variety of injected drugs (including steroids), found that pooling of studies was not possible [104]. They concluded that the effect of injections as mono-therapy

was insufficient for sub-acute or chronic low back pain, but opted for the possibility that specific injection types might be effective for subgroups of patients.

However, more recently published results in chronic low back pain patients indicate some positive effect of local injections. Due to pain relief only for a short period of time, i.e. three weeks, the suggested method was concluded suitable as second line treatment [105]. Moreover, nerve blockades with or without steroids, in the lumbar facet joints have been reported as effective pain reducers for 6 weeks or more [106, 107].

Problems in the study of low back pain treatment

Despite a great deal of scientific effort in the past decades, most of the treatment for low back pain is based on the therapists experience and not on evidence [108]. The quality of several guidelines from 1992 to 2002 has been criticised and considered not sufficient, due to methodological flaws like incomplete description of targeted population or not explicitly considering all main outcomes when formulating the therapeutic recommendations [109, 110]. The overall argument was that there were far too many unanswered questions not to conclude that most studied low back pain treatments were ineffective or at the best marginally effective.

Since then the number of clinical guidelines has increased both on national and international consensus levels. The quality of these recent guidelines has been considered much improved in terms of validity but external peer review was still missing [111]. Two recent clinical guidelines found moderate evidence that manual therapies reduce pain and disability in acute and sub-acute low back pain [4, 83].

The difficulty of applying a study design fit for the heterogeneous patient group remains; the bio-psychosocial treatment model may describe the complexity of this group [8]. The problem may be addressed in several ways, all with their strengths and shortcomings. A possible solution might be to apply standardised brief pain-management regime or manual treatment to all patients regardless of low back pain presentation. This strategy might obscure the potential effectiveness of targeted treatments to patients that are more likely to benefit from a specific treatment.

A second possible solution might be to use large studies in order to allow sub-grouping of patients with homogenous characteristics in order to show effects of various specific treatment tools [108, 112]. However, beside the needed study size, sub-grouping is still not well supported by data, so far they rely on untested theories, are poorly validated and are not replicated in other studies [9, 113].

A third possible solution might be to use a study model close to the clinical situation with a ‘toolbox’ to be used after the therapist’s knowledge, i.e.

a pragmatic method combined with a factorial design [114]. According to this method a list of specific potential treatments (toolbox) are created for each study group from which the therapist might chose the most relevant ones for an individual patient. By adding available treatments from one group toolbox to the next, the effects of added treatments might be tested. This strategy reduces the flexibility to pinpoint the most effective treatment item *per see* but will provide scientific evidence for the effect of the various added treatment components.

The Gotland Low Back Pain study

The Gotland Low Back Pain study was initially launched to evaluate the results of the Säter study [115]. Like the Säter study it was designed with a pragmatic treatment approach, but in addition it had a factorial design in order to test the effects of muscle stretching, manual therapy and specific steroid injections. Thus, except for the overall task to evaluate previous results, the Gotland Low Back Pain study was designed to provide evidence for effective treatment modalities of sub-acute non-specific low back pain.

Aims

The aims of this thesis were to evaluate the effect of manual treatment and to investigate the pain drawing sketch as an outcome measure and predictive aid in low back pain patients. The specific aims were:

- To investigate if perceived pain and disability are associated with the pain modalities used in the pain drawing sketch.

- To evaluate the effects on pain intensity score and disability index of manual therapy including steroid injections added to stay-active care and muscle stretching.

- To evaluate the effects on health related quality of life of the additions of muscle stretching, manual therapy and steroid injections to stay-active care.

- To test the hypothesis that pain drawing information contributes to the prediction of return to work.

Study population and methods

The study was performed from January 1994 to December 1998; the effective recruitment period was 32 months. The study was conducted in the province of Gotland, Sweden, an island in the Baltic Sea with 58,000 residents at the time. The recruitment population segment consisted of the 19,000 persons who were 20-55 years of age. Only patients with symptoms severe enough to motivate seeing a doctor were potential recruitment patients.

Study design

The study was a prospective randomised controlled trial with pragmatic approach. A factorial design was used, which enables the evaluation of two or more experimental interventions not only separately but also in combination and against a control group [114]. There were four treatment groups, two reference treatments (Groups 1 and 2) and two experimental treatments (Groups 3 and 4), Figure 2. In Papers I and IV all patients were assessed as a cohort. In Paper II the two experimental treatment groups were compared with the two reference treatment groups, and in Paper III a four-group comparison was done, analysing effects of added treatments.

Study sampling

All patients with acute or sub-acute low back pain that provisionally fulfilled the inclusion criteria were referred by Gotland general practitioners (GP) at primary health care centres and by physicians at Visby Hospital. In addition, to secure an unselected study population, the local National Insurance Office referred all patients filing sick-leave applications for low back pain. In Sweden, the National Social Insurance Offices (a government agent) handle all sick leaves with duration of two weeks or more. The recruiting physician met all patients, performed a physical examination, and made the final assessment whether or not they fulfilled the inclusion criteria. These were:

- Acute or sub-acute perceived low back pain with or without pain radiating to one or both legs, not requiring acute surgical or rheuma-

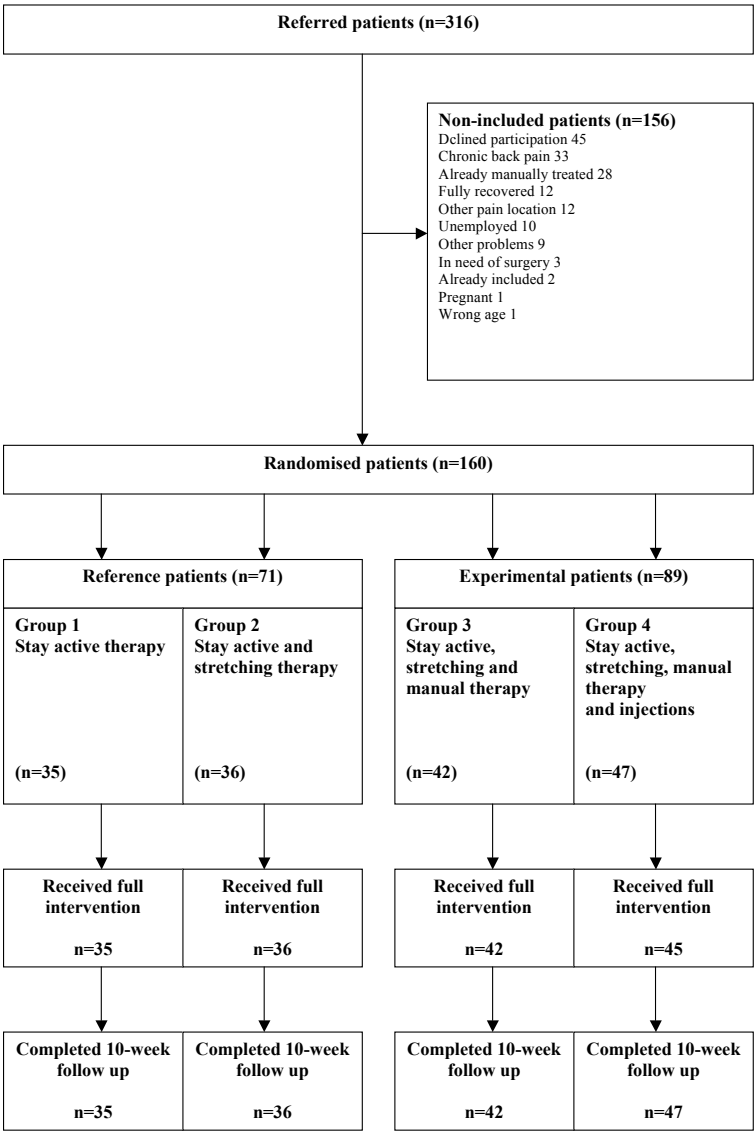


Figure 2. Flow chart of the study population.

tologic care. Patients with demonstrated or suspected herniated discs were included if surgery was not indicated as assessed by the recruiting physician. Low back pain was required to be the dominating

symptom but patients with other musculoskeletal symptoms, not requiring treatment, were allowed.

- Symptom duration of 3 months or less proceeded by at least 2 months of relative freedom from symptoms.

- Consent to treatment and follow-up for 10 weeks.

- Agreement not to consult therapists other than those participating in the study during the treatment period.

- Employed and with no threat of job loss.

- Born in Sweden and articulate enough not to jeopardise the verbal contact with the physicians and/or the physiotherapists.

- Absence of other conditions or circumstances that might jeopardise completion of treatment and follow-up, such as pregnancy, malignant tumours, etcetera.

- No previous treatment of current complaints with specific mobilisation or manipulation.

- No previous participation in the present study.

Of the 316 patients who were referred to the study, 111 did not fulfil the inclusion criteria and 45 declined participation. The remaining 160 patients were entered in the study. The most common reasons for failing to fulfil the inclusion criteria were too long symptom duration (33 patients), previous manual treatment for the current acute low back pain episode (28 patients) and spontaneous recovery before the study start (12 patients), Figure 2.

Patients who fulfilled the inclusion criteria received standardised information concerning the study and those who gave informed consent to participation were included. When the patients had responded to questionnaires and undergone a physical examination, he or she was randomly allocated to one of the treatment groups by the study monitor. A weighted randomisation procedure was used, aiming at random allocation of 45% of the patients to the reference therapy groups and 55% to the experimental therapy groups. Sealed pre-prepared envelopes with group assignment derived from a random number table were used. The envelopes were inaccessible to anyone but the monitor. The Research Ethics Committee of the Faculty of Medicine at Uppsala University approved the study.

Treatments

The treatment was provided individually, in groups, or both. The treatment protocol was not standardised, but in conformity with the pragmatic approach a list of allowed treatment modalities, specific for each group, was used. The physicians and physiotherapists chose after clinical assessment, according to need of the individual patient, the treatment modalities to use from the group specific treatment list. The available treatment modalities and treatment contents in the groups are presented in Table 1. Moreover, the physicians were instructed to certify as short periods of sick leave as possible at each consultation and prescribe drugs when indicated.

Reference therapy

Two orthopaedic surgeons at Visby Hospital and 8 physiotherapists treated the two reference group patients. The basic management strategy in all treatment groups was stay-active care, as described by Waddell [8] and evaluated by Indahl [85], Torstensen [116, 117] and Malmivaara [118]. It includes information of the generally favourable prognosis of the condition, the adverse effect of inactivity and sick leave, and encourages patients to take part in physical and other activities to stay fit [88, 90]. The used operant-conditioning behavioural approach [86] was consistent with official recommendations for low back pain treatment in Sweden [6]. The reference therapy was similar to the pragmatic approach to low back pain as evaluated by Lindström et al. [119, 120].

Group 1 was treated with stay-active care only. However, since patients with demonstrated or suspected herniated discs were admitted to the study, non-specific traction was allowed in Group 1. In Group 2 muscle stretching or matching home exercises or both were added to the stay-active care [121, 122]. Forty-one per cent of the patients did actually receive muscle stretching at the clinic or as home exercise.

Experimental therapy

Two GPs based at primary health care centres in Visby and 9 physiotherapists treated the experimental group. During two months before the study, the GPs and the physiotherapists in the experimental treatment team received basic training for 12 days, corresponding to the basic course in manual therapy ‘step 1’. In addition, the two GPs completed their examinations for the ‘step 2’ level thirteen months after the study had started. Two of the physiotherapists began their ‘step 2’ course one year after the study started and graduated six months before the end of the study period.

Table 1. Treatment content in the two groups.

	Reference therapy		Experimental therapy			
	Physiotherapist		Physician		Physiotherapist	
	%	95% CI	%	95% CI	%	95% CI
Mobilisation/manipulation						
Sacroiliac mobilisation	—		72.7	63.2-82.2	50.6	39.7-61.4
Lumbar mobilisation	—		75.0	65.8-84.2	45.9	35.1-56.7
Lumbar manipulation (thrust techniques)	—		19.3	10.9-27.7	4.7	0.1-9.3
Thoracic mobilisation/ manipulation	—		8.0	2.2-13.7	10.6	3.9-17.3
Cervical mobilisation	—		2.3	–0.9-5.4	4.7	0.1-9.3
Muscle stretching/treatment						
Muscle stretching	80.6*	67.0-94.1	52.3	41.6-62.9	88.2	81.2-95.2
Home exercises for						
muscle stretching	78.4*	64.5-92.3	29.5	19.8-39.3	69.4	59.4-79.4
specific mobilisation	—		6.8	1.4-12.	30.6	20.6-40.6
Massage/Soft tissue treatments	7.5	1.0-13.9	14.8	7.2-22.	15.3	7.5-23.1
Deep frictions	—		3.4	–0.5-7.3	8.2	2.3-14.2
Steroid injections/ligament stretching						
Sacroparacoccygeal structures						
stretching	—		9.1	3.0-15.2	1.2	–1.2-3.5
steroid injections	—		4.3†	1.7-10.2	—	
Piriformis/gl. med./min.						
steroid injections	—		21.3†	9.1-33.4	—	
Other steroid injections	—		17.0†	5.9-28.2	—	
Traction						
Autotraction	—		2.3	–0.9-5.4	30.6	20.6-40.6
Nonspecific traction	46.3	34.0-58.5	—		—	
Physical training						
Low back pain school training	1.5	–1.5-4.5	0		0	
Medical training therapy	9.0	1.9-16.0	1.1	–1.1-3.4	16.5	8.4-24.5
Other back exercises	—		3.4	–0.5-7.3	12.9	5.7-20.2
Sequential training	19.4	9.7-29.1	0		0	
Plunge-bath training	6.0	1.5-11.8	1.1	–1.1-3.4	4.7	0.1-9.3
Active movement therapy	34.3	22.7-46.0	0		0	
Active back exercises	58.2	46.1-70.3	0		0	
Relaxation training	13.4	5.1-21.8	0		0	
Body awareness training	9.1	2.0-16.2	0		0	
Postural exercises	25.4	14.7-36.1	0		0	
Ergonomic advice	74.6	63.9-85.3	0		0	
Heat and different electric treatment						
Ultrasonic waves	19.4	9.7-29.1	0		0	
TNS	49.3	37.0-61.5	0		0	
Heat (steam-pack)	11.9	4.0-19.9	0		0	
Electric stimulation	1.5	–1.5-4.5	0		0	
Corsets						
Pelvic corset (CAMP)	—		3.4	–0.5-7.3	8.2	2.3-14.2
Corset	3.0	–1.2-7.2	1.1	–1.1-3.4	1.2	–1.2-3.5

TNS, Transcutaneous nerve stimulation

*Data for the reference subgroup in which muscle stretching was allowed (51%). The frequency of stretching in the entire reference group was 41%.

†Data for the experimental group in which steroid injections were allowed (52%).

In the first experimental group (Group 3) manual therapy was added to the stay-active care and the muscle stretching and matching home exercises or both given to Group 2. The origin of Swedish manual therapy is the classical osteopathic techniques [123] and the continental tradition [124, 125].

These techniques as well as specific 'locking techniques' have been further developed in Scandinavia [121, 122, 126] and they formed an important part of the experimental treatment. Diagnostic items according to the Muscular Energy Technique (MET) [127] are incorporated in the physical examination. An essential therapeutic manoeuvre is mobilisation for pelvic dysfunctions according to Kubis [128], with the addition of an Evjent and Hamberg locking technique and a strictly applied MET procedure in the treatment situation. Thus, the manoeuvre has become gentle.

All patients in Group 3 were treated with specific mobilisation or lumbar thrust techniques (manipulation) or both by the two physicians. In addition, the physiotherapists treated 67% of the experimental patients with specific mobilisation or manipulation. Manual traction in the lumbar region and auto traction [129, 130] was also added to the group specific treatment list.

In the second experimental therapy group (Group 4) steroid injections, in case of specific findings, were added to the group specific treatment list of Group 3. Steroids were often given in combination with 'needling' [124] and local anaesthetics. After parasacrococcygeal injections, the soft tissues were also stretched per rectum ad modum Midttun [131, 132]. A total of 19 injections were given to 17 patients, two patients receiving two injections each.

Treatment intensity

The waiting-time for physiotherapy was significantly shorter in the experimental groups ($p<0.0001$), the patients in Group 1 had to wait for 8.6 days (95% C.I. 6.8-10.4), Group 2 for 10.6 days (95% CI 8.9-12.3), Group 3 for 5.0 days (95% CI 3.4-6.6) and those in Group 4 for 7.0 days (95% CI 5.5-8.6). Treatment intensity data are given in Table 2. Physiotherapy was offered to all patients in this study. However, mainly due to complete recovery after randomisation 11 patients did not see a physiotherapist; four patients in Group 1, one patient in Group 2, two patients in Group 3 and four patients in Group 4.

Data collection

Data on patient characteristics, i.e. demographic and socioeconomic data, previous low back pain infirmity, treatment before study start and symptom duration at the beginning of the study were obtained by questionnaires on location. Initial outcome measures were also recorded at baseline using

Table 2. Treatment intensity during the study period.

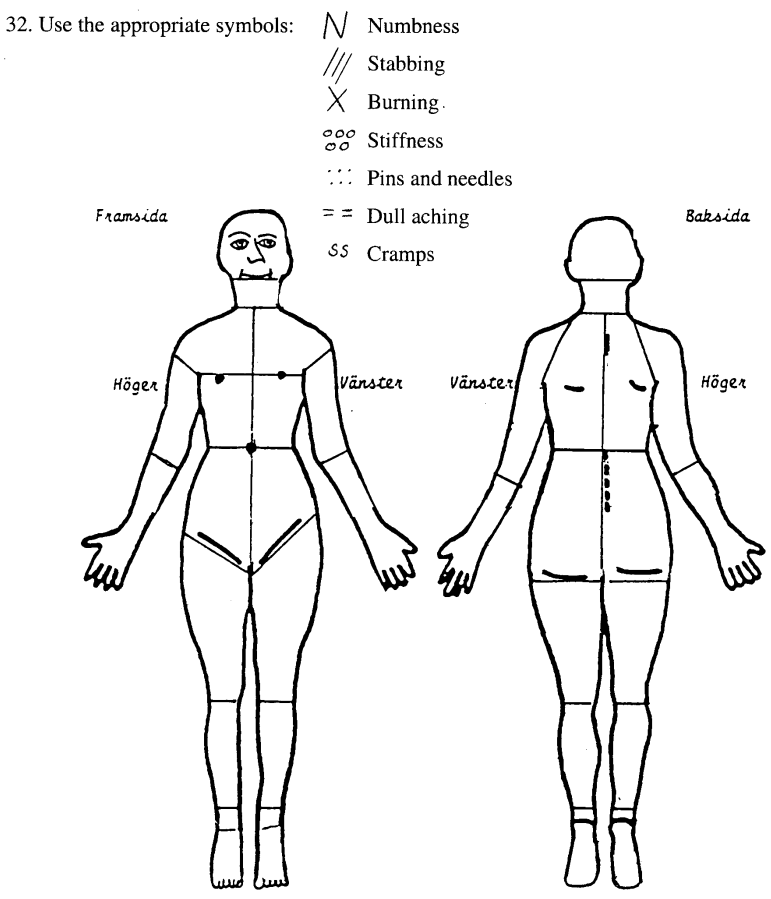
	Group 1 (Stay-active)		**Group 2** (Stay-active and muscle stretching)		**Group 3** (Stay-active, stretching and manual therapy)		**Group 4** (Stay-active, stretching, manual therapy and steroid injections)		
	M	SD	M	SD	M	SD	M	SD	p
Physicians									
Appointments	2.2	0.8	2.1	0.8	2.8	1.0	2.6	1.1	<0.05
Active treatment sessions	0	-	0	-	2.5	1.1	2.5	1.1	
Telephone contacts	0.4	0.7	0.7	0.9	0.6	0.8	0.5	0.6	n.s.
Physiotherapist									
Appointments	5.8	4.1	6.3	5.7	6.3	3.7	5.3	4.3	n.s.
Individual sessions	5.0	3.5	6.0	5.7	5.8	3.4	5.1	4.1	
Group sessions	0.8	2.2	0.3	1.5	0.5	1.5	0.2	1.0	

M=mean, SD=standard deviation.

questionnaires on location. Follow-up outcome measurement data were obtained using postal questionnaires after 5 and 10 weeks of treatment. Information on number of treatments, treatment content, diagnoses, the prescription of diagnostic imaging, and medication was obtained by questionnaire from the treating staff in all groups at 5 and 10-week follow-up.

The recruiting physician performed an initial physical examination in all patients at baseline, including a general physical examination and a standardised neurological examination, out of which items reflecting pain affection behaviour, pain radiation and reflex disturbances were used for Paper IV. A spreadsheet showing the 66 combinations of the various physical examination items was produced (Appendix). Based on this information, a doctor of naprapathy (MG) and a general practitioner, specialised in orthopaedic medicine (JB), created a clinical indication score for nerve root involvement, classified as score 0-4. However, score 3 and 4 were infrequent and were therefore amalgamated into score 2, and the final classification was "weak indication" (=0), "intermediately strong indication" (=1) or "strong indication" (=2). Differences in opinion were few and were discussed until consensus was reached.

Pain intensity scores and 15 disability rating variables were measured with visual analogue scales, 100 millimetres (mm) long and ranging from no pain or disability (=0 mm) to maximum pain or disability (=100 mm). Twelve of the 15 disability rating variables form the Disability Rating Index instrument, validity as well as reliability tested [61]. The remaining three items, 'lying still', 'car-driving or car-riding', and 'getting up from sitting', have been used previously [62] and they provide additional daily activities to



Figur 3. The pain drawing sketch with its 34 anatomical areas, and the seven pain modalities and their symbols.

the Disability Rating Index. Furthermore, drugs consumed were asked for in the questionnaire.

The pain drawing sketch contained 34 anatomical areas, Figure 3. The patients were instructed to describe their pain intensity and quality in each of these areas by markings with seven pain modality symbols (numbness, stabbing, burning, stiffness, pins and needles, dull aching, and cramps). The pain drawing score (PDS) [45] was assessed as the mean number of areas with at least one mark (range 0 to 34). The degree of pain radiation to the legs was classified as no radiation, i.e. pain confined to the lower back/buttock area,

or radiation to the leg, which was defined as pain in the lower back/buttock and in at least one area in the leg, frontal or dorsal side. The number of pain modalities used in each area, the 'area score', was also assessed [71, 133]. Only patients with no marks above waistline were assessed for the dominating pain modality in all 16 areas below waistline. All marks were recorded by modality and ranked for dominance by the same observer.

Health related quality of life was assessed with the Gothenburg Quality of Life Instrument [67, 68]. For this report the Complaint score and the Well-being subscales were used. The instrument is validated and found independent of diagnosis or treatment [134-136]. In the Complaint score the respondents were asked: 'Have you been troubled by any of the following symptoms during the last 3 months?', followed by a list of 30 general symptoms with response alternatives 'yes' or 'no' for each symptom. The Complaint score is the sum of yes-answers. In the Well-being subscales, twelve items (work situation, family situation, hearing, eyesight, memory, physical fitness, appetite, energy, mood, patience, self confidence, sleep, and perceived health) were listed and the responses were given on 100 millimetre visual analogue scales ranging from 'very bad' (=0) to 'excellent, could not be better' (=100). The items used in paper III were patience, energy, mood, family situation, perceived health, and sleep.

At the time of the study sick leave was reported to the Social Insurance Agency that paid the compensation, except for the first two weeks, which were reported to and paid by the employers without always being reported to the Social Insurance Agency. Sick leave periods of up to seven days could be self-certified by the patient. Beginning with the second week, a sick-listing certificate issued by a physician was required. Sick leave information from two months before inclusion until two years after start of treatment was obtained from the Social Insurance Agency, from medical records, from the questionnaires filled out by the physicians and from patient diaries. Baseline for the sick leave analyses was set to the day of the first appointment with the treating physician in the study. The information included first and last day of each sick leave period, diagnosis and extent (25, 50, 75 or 100% sick leave).

Information on return to work, available for all 160 patients, was based on the sick leave information. The day of return to work was defined as the first day after conclusion of the initial sick leave period. The initial sick leave period was regarded as concluded if followed by a sick leave free period of at least one week followed by no more sick leave until end of follow-up, or followed by a sick leave period shorter than the preceding sick leave free one. If these criteria were not fulfilled the new sick leave period was regarded part of the initial one, and the criteria check was repeated at the end of each period until they were fulfilled or until end of follow-up, whatever came first.

Masking and parallel treatment

All information on outcome was kept inaccessible to anyone but the study monitor and was thus masked, or blinded, to the treatment staff. Information on contamination by parallel treatment provided by external therapists was obtained at the 10-week follow-up by questionnaire and was also asked for and reported by the participating physicians and physiotherapists.

Statistical considerations

Data was analysed with the JMP version 4 [137] and the Statistical Analysis System (SAS) version 9.2 [138] software. Summary statistics, such as means and measures of dispersion, were computed using standard parametric methods. Crude differences regarding continuous data were tested using Student's t-test or analysis of variance, and regarding nominal or ordinal data were tested with chi-square test. Only two-tailed tests were used. P-values less than 5% were considered to indicate statistical significance. The intention-to-treat concept was followed in all calculations of group effects. Two patients did not return the 10-week questionnaire and partial non-responses were minimal, the total data loss was less than 1%.

Considerations particular to Paper I

The study population was analysed as a cohort. Pain modality distribution was calculated across the study period, i.e. using all three time points (baseline, 5 and 10 weeks) as one. The pain modality considered dominant in the low back pain area was defined as the most frequently used pain modality in the left and right lower back/buttock areas together. The 'pain drawing score' and the 'area score' were computed with regression-based analysis of variance. The analyses of association were done with standard least square analyses and one-way analysis of variance with pain intensity score or disability rating index, respectively, as dependent variables and pain drawing score as the independent variable at 0, 5 and 10 weeks and for the whole period. In the latter analysis the data from the various time points were stacked. The results from the separate time points and the overall period were consistent.

The regression surface in Figure 5 was constructed using multivariate linear regression technique with pain intensity score or disability rating index as dependent variable and the seven pain modalities and pain radiation as independent variables. The analysis was performed on the 436 pain drawings with marks only below waistline, among the 480 possible ones across the study period, to eliminate the possibility of influence on pain intensity score and disability index from painful sites above the waistline. The analy-

sis was done twice, first on the 287 pain drawings with no pain radiation and then a second time on the 149 pain drawings with pain radiation.

Considerations particular to Paper II

Pain intensity score and disability rating index were used as outcome in the two-group comparison, reference therapy (Group 1 and 2) versus experimental therapy (Group 3 and 4). The analyses of outcomes, change of the outcome variables (pain intensity score and disability rating scores) from baseline to the end of the treatment period was analysed in the two treatment groups by regression-based analysis of variance.

Considerations particular to Paper III

The Well-being variables and Complaint Score were used as outcome in the four-group comparison. The effects on outcome of the treatment given were computed in two ways. First crude effects were computed as the outcome difference between baseline and 10-week levels in linear regression with difference as the dependent variable and group number as the independent. Then effects adjusted for the potential influence of variables other than the treatment variables were computed. These other potential outcome affecting variables (covariates) were age, sex, body mass index, smoking habits, and low back pain history during the two years preceding baseline. Moreover, there were initial differences between the groups in the outcome variables, in some instances favouring one group, in other instances other groups. To adjust for this potential bias, the initial measurement of the outcome under study was included as an additional covariate in the analyses.

To keep the statistical power as high as possible, the adjusted analyses were based not only on the baseline and the 10-week measurements, but also on all available measurements (baseline, 5-week, and 10-week). Use of all three measurements considerably reduces the probability of positive (or negative) effects by chance alone. For this purpose multiple linear regression was used with time dependent updated outcome across the follow-up period as the dependent variable, and the group variable and all covariates as the independent variables, with backward elimination of non-significant covariates. In addition, least square means (and confidence intervals) of the updated outcome variables across follow-up time by treatment group and adjusted for remaining significant covariates were computed (a standard option in the SAS software).

The Complaint score may be regarded as a continuous scale, while the Well-being variables basically are ordinal, even though the scale range 0-100 may be regarded as a continuous scale. Moreover, the variables were reasonably symmetrically distributed. Therefore the results from multiple ordinal logistic (with the 100-step scale converted to a 10-step scale) was

compared, with those of multiple linear regression technique (with the 100-step scale). The results were very similar. Therefore the results from the multiple linear regressions were used, since this procedure may be expected to be generally better known.

Considerations particular to Paper IV

The analyses were performed in two steps. First, screening bivariate proportional hazards regression analyses (Cox's analyses) of variables possibly associated with return to work (candidate variables) were performed, with return to work and time of return to work as the dependent variables, and the potential predictors as independent variable. In the second step, multivariate proportional hazards regression analyses were performed accordingly to find independent predictors of return to work.

Potential predictors were pain intensity score, pain drawing score, pain radiation according to pain drawing and clinical indication score of nerve root involvement. The analyses were performed as time dependent analyses regarding pain intensity, pain drawing score and pain radiation according to pain drawing, but not for the clinical indication score that was measured only at baseline. The analyses were performed either as updated predictor levels at 5 or 10-week follow-up until the time of return to work, or as mean values of the predictors until return to work. The two procedures gave essentially similar results. For the sake of simplicity the latter was used. Variables potentially affecting outcome other than the potential predictors were age, sex, cigarette smoking, educational level, similar complaints last two years, sick spell duration, body mass index and treatment group (covariates).

P-values less than 0.10 were used for the preliminary candidate screening analyses and $p<0.05$ were used for the final model analyses.

Results

Baseline characteristics are presented in Table 3. The patients were on average 41 years old (SD 8.5), 70 (44%) patients were women, and 71 (44%) patients were cigarette smokers. The average duration of the current episode was 27.3 days (SD 26.0) with a median duration of 16 days. At baseline 110 (68.8%) patients and at start of treatment 99 (62%) patients were on sick leave and 134 (84%) patients had experienced similar low back pain in the past two years. None of the group differences was statistically significant. More than one third had previously undergone x-ray examinations due to low back pain infirmity; ten patients had been admitted to hospital due to low back pain, four of who had undergone back surgery. Herniated disc was suspected during the study in 17 (19.1%) patients and verified during the study in 10 (11.2%) patients in the two experimental groups; in the two reference groups the corresponding numbers were 16 (22.5%) and 4 (5.6%) patients.

The pain drawing course (Paper I)

At baseline, the proportion of patients with marked areas below waistline ranged from 85.6% in the left lower back/buttock area to 3.1% in the right dorsal foot area, Table 4. The left side generally had a higher proportion of marked areas than the right side. In all areas but the frontal side of the lower leg and foot there was a large drop in the proportion of patients with marked areas during the first five weeks, on average 34.5 per cent units, and then a more moderate decrease during the next five weeks, on average 6.0 per cent units. The pattern was similar in all treatment groups. At baseline the pain drawing score was 3.7 for all areas (range 1-14) and 3.6 for the 16 areas below waistline (range 0-12). During the first five weeks this score dropped by approximately 33% and then remained stable (range 0-10). At baseline 70.9% of the patients had pain radiating to the knee and 38.6% to the lower leg. At the 10-week follow-up the corresponding frequencies were 24.1% and 22.2%.

The mean number of pain modalities, the ‘area score’, is shown in Table 5. At baseline the ‘area score’ ranged from 1.79 in the lower left back/buttock to 0.03 in the dorsal side of the right foot. The mean number of used pain modalities decreased over the 10-week period, but most of the

Table 3. Patient characteristics at baseline.

	Group 1 (Stay-active)			**Group 2** (Stay-active and muscle stretching)			**Group 3** (Stay-active, stretching and manual therapy)			**Group 4** (Stay-active, stretching, manual therapy and steroid injections)		
	n	mean or %	SD	n	mean or %	SD	n	mean or %	SD	n	mean or %	SD
Numbers	35			36			42			47		
Age, years		41.8	8.3		40.3	8.2		42.1	8.9		41.1	8.7
Women, %	13	37.1		12	33.3		20	47.6		25	53.2	
Body mass index, kg/m^2		24.6	3.4		25.8	4.8		25.9	4.2		24.5	2.8
Cigarette smokers, %	16	45.7		15	41.7		18	42.9		22	46.8	
Compulsory school only, %	10	28.6		11	30.6		13	31.0		13	27.7	
Mild chronic complaints last two years, %	27	77.1		32	88.9		37	88.1		38	80.8	
Current episode of low back pain												
Duration, days		25.5	26.9		35.1	26.8		24.6	21.5		25.1	27.9
On sick leave at baseline, %	27	77.1		20	55.6		29	69.0		34	72.3	
Return to work possible, %	17	48.6		26	72.2		28	66.7		29	61.7	
Low belief in activity, %	15	42.9		23	63.9		19	45.2		25	53.2	
Pain Score		51.4	22.1		57.6	21.0		59.6	20.9		48.1	21.8
Difficulties falling asleep, %	18	51.4		15	41.7		16	38.1		31	67.4	
Pain disturbed sleep, %	27	77.1		24	66.7		27	64.3		33	70.2	

n=numbers, SD=standard deviation

Table 4. Pain drawing characteristics at baseline, 5 and 10 weeks of follow-up.

	Baseline		At 5 weeks		At 10 weeks	
	Mean or %	95% CI	Mean or %	95% CI	Mean or %	95% CI
N	160		160		158	
Proportion of areas marked, %						
Dorsal side						
Lower back/buttock left	85.6	78.7-89.7	64.4	56.7-71.4	58.8	51.0-66.1
Lower back/buttock right	78.1	71.1-83.8	68.1	60.6-74.8	59.4	51.6-66.7
Thigh back, left side	38.1	31.0-45.8	16.2	11.3-22.7	15.6	10.8-22.0
Thigh back, right side	33.1	26.3-40.7	12.5	8.2-18.5	10.6	6.7-16.4
Lower leg back, left side	19.4	14.0-26.2	9.4	5.8-14.9	11.2	7.2-17.1
Lower leg back, right side	15.0	10.3-21.3	7.5	4.3-12.6	8.1	4.8-13.4
Plantar area left side	10.6	6.7-16.4	6.2	3.4-11.1	8.1	4.8-13.4
Plantar area right side	6.2	3.4-11.1	3.1	1.3-7.1	4.4	2.1-8.7
Frontal side						
Lower abdomen, left side	8.1	4.8-13.4	5.6	3.0-10.3	4.4	2.1-8.7
Lower abdomen, right side	8.1	4.8-13.4	3.7	1.7-7.9	3.7	1.7-7.9
Thigh front, left side	16.2	11.3-22.7	8.1	4.8-13.4	7.5	4.3-12.7
Thigh front, right side	15.6	10.8-22.0	6.2	3.4-11.1	5.6	3.0-10.3
Lower leg front, left side	6.9	3.9-11.9	6.2	3.4-11.1	6.9	3.9-11.9
Lower leg front, right side	4.4	2.1-8.7	3.1	1.3-7.1	4.4	2.1-8.7
Dorsal foot, left side	8.7	5.3-14.2	5.6	3.0-10.3	5.0	2.6-9.6
Dorsal foot, right side	3.1	1.3-7,1	2.5	1.0-6.3	1.9	0.6-5.4
All other areas	5.6	3.0-10.3	12.5	8.2-18.5	9.4	5.8-14.9
Mean number of areas marked						
Areas above waistline	0.1	0.03-0.17	0.3	0.15-0.45	0.26	0.11-0.42
Areas below waistline	3.6	3.3-3.8	2.3	2.0-2.6	2.2	1.8-2.5
All areas	3.7	3.4-4.0	2.6	2.3-2.9	2.4	2.0-2.8
Radiation, any degree, %						
Pain in lower back/buttock	100.0	97.6-100.0	83.5	77.0-88.5	72.8	65.4-79.1
Pain radiating to the thigh	70.9	63.4-77.4	32.9	26.1-40.6	24.1	18.1-31.3
Pain radiating to lower leg	38.6	31.4-46.4	22.2	16.4-29.2	22.2	16.4-29.2

95% CI=95% confidence intervals.

reduction, on average 46.2%, occurred during the first half of the period. There was also a shift of dominating pain modality prevalence in the lower back/buttock areas during the follow-up, Figure 4. Stabbing pain decreased from 66.9% at baseline to 27.2% at 10 weeks follow-up and 'no marks' increased from 1% to 27%.

Pain drawings, pain intensity and functional variables (Paper I)

There was an association between, on the one hand, mean number of areas marked, i.e. the pain drawing score, and pain intensity score during the previous week ($r= 0.39$, $p<0.0001$) and the disability rating index ($r=0.40$, $p<0.0001$) on the other across the study period. Pain radiation was present in 149 (34.2%) of the 436 pain drawings with no marks above the waistline.

Table 5. Number of modalities, the 'area score', reported in the sixteen lower areas, at baseline, 5 and 10 weeks of follow-up.

	Number of modalities used					
	Baseline		At 5 weeks		At 10 weeks	
	Mean	95% CI	Mean	95% CI	Mean	95% CI
N	160		160		158	
Dorsal side						
Lower back/buttock left	1.79	1.63-1.95	1.02	0.87-1.17	0.91	0.76-1.06
Lower back/buttock right	1.61	1.43-1.78	1.01	0.88-1.15	0.92	0.78-1.07
Thigh back, left side	0.57	0.43-0.70	0.27	0.16-0.38	0.25	0.14-0.36
Thigh back, right side	0.48	0.36-0.61	0.17	0.09-0.24	0.14	0.07-0.21
Lower leg back, left side	0.27	0.18-0.37	0.14	0.06-0.21	0.17	0.08-0.27
Lower leg back, right side	0.22	0.14-0.31	0.09	0.04-0.14	0.11	0.05-0.17
Plantar area left side	0.14	0.07-0.20	0.10	0.04-0.16	0.10	0.04-0.16
Plantar area right side	0.08	0.03-0.13	0.05	0.01-0.10	0.06	0.01-0.10
Frontal side						
Lower abdomen, left side	0.11	0.05-0.18	0.08	0.02-0.14	0.07	0.01-0.13
Lower abdomen, right side	0.12	0.05-0.20	0.06	0.01-0.11	0.06	0.01-0.11
Thigh front, left side	0.24	0.15-0.34	0.12	0.05-0.19	0.14	0.05-0.24
Thigh front, right side	0.21	0.13-0.28	0.09	0.03-0.16	0.09	0.02-0.15
Lower leg front, left side	0.12	0.05-0.20	0.07	0.03-0.12	0.10	0.03-0.17
Lower leg front, right side	0.05	0.02-0.08	0.04	0.01-0.07	0.04	0.01-0.08
Dorsal foot, left side	0.13	0.05-0.21	0.07	0.02-0.13	0.07	0.02-0.13
Dorsal foot, right side	0.03	0.01-0.06	0.04	0.00-0.08	0.02	0.00-0.04
All other areas	0.13	0.03-0.23	0.38	0.17-0.58	0.39	0.13-0.65

95% CI=95% confidence intervals

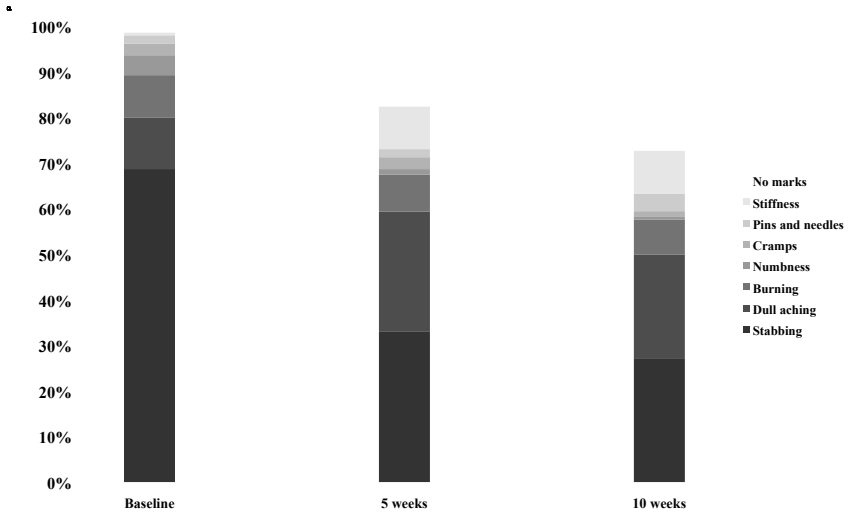


Figure 4. Distribution of pain modalities in the lower back/buttocks area at baseline and after 5 and 10 weeks of follow-up.

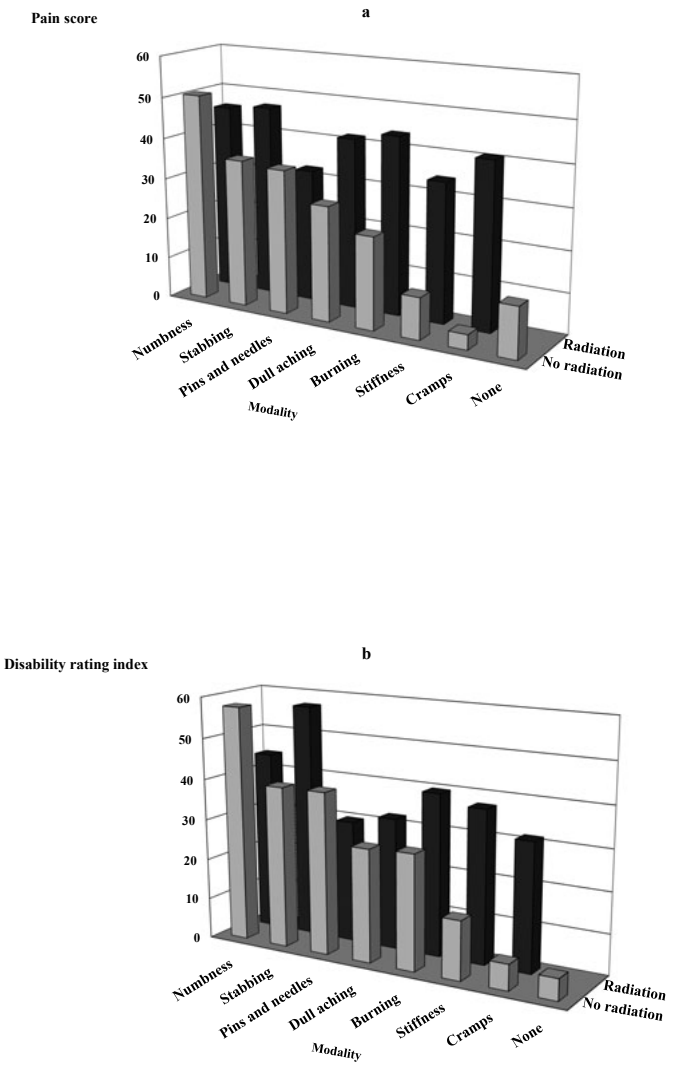


Figure 5. Mean pain intensity score (a) and mean disability rating index (b) in groups according to dominating pain modality and pain radiation, among patients with marks only below the waistline across the 10 week period.

Among the latter, 'stabbing pain' was the most frequently used dominating pain modality (45.6%) followed by 'dull aching' (30.2%), 'stiffness'

(12.1%), ‘burning’ (6.0%), ‘numbness’ (2.7%), ‘pins and needles’ (2.0%) and finally ‘cramps’ (1.4%).

Among the pain drawing sketches with no pain radiation, there were no significant differences in pain intensity score or disability rating index between the various pain modalities at baseline ($p=0.25$ for the whole model). Over the study period strong associations between the pain modalities and the pain intensity score or the disability rating index emerged ($p<0.0001$ for the whole model at 5 and at 10 weeks). In Figure 5 the average pain intensity score and disability rating index per modality across the 10-week period is displayed. The pain modality ‘numbness’ was associated with both the highest pain intensity score and highest disability rating index, followed by ‘pins and needles’ and ‘stabbing’. The pain modalities ‘stiffness’ and ‘cramps’ were associated with the least pain and least disability. For the pain drawing sketches with pain radiation the differences were smaller and more inconsistent than in the non-radiation group.

Pain and disability variables (Paper II)

Pain variables are shown in Table 6. The scores for pain intensity during the last 24 hours and pain intensity during the last week were fairly similar in the two groups at baseline. They decreased significantly over time in all groups but there were no significant differences between the groups. The variables measuring pain intensity or the effect of pain in various situations all improved significantly during the treatment period in both groups, but there were no significant differences in rate of decrease between the groups.

However, since the experimental groups tended to be somewhat more affected than the reference groups by low back pain at baseline but less so at 5 and 10 weeks, an adjustment for the initial differences in outcome variables, verified herniated disc and differences in age and sex distribution was made. After this adjustment the experimental groups had a faster rate of decrease for pain intensity last week than the reference groups ($p<0.05$) and a faster decrease of pain intensity during the last 24 hours after 5 weeks of follow-up ($p<0.05$) but not at 10 weeks of follow-up. For all other pain variables the rate of decrease tended to be non-significantly faster in the experimental groups than in the reference groups, except for waking up with back pain, where the non-significant rates tended to be reversed.

The use of painkillers or non-steroid anti-inflammatory drugs decreased as well in the groups but there were no significant differences in decrease rate between the groups. The most frequently used painkillers at baseline were light analgesics and antipyretics (53.8%), light opoids (41.9%), non-

Table 6. Pain variables in the two groups at baseline, at 5 weeks and at 10 weeks respectively. These variables were measured on a visual analogue scale 100 mm long, where 0 mm means no pain and 100 mm the worst possible pain or by answering a yes or no question. p value refers to test of difference in pain reduction over 10 weeks between reference and experimental therapy groups

	Baseline				At 5 weeks				At 10 weeks				p after adjust-ments
	Reference therapy		Experimental therapy		Reference therapy		Experimental therapy		Reference therapy		Experimental therapy		
	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	
Pain intensity last 24 hours, mm	52.2	46.7-57.8	54.7	49.8-59.6	29.7	23.3-35.2	20.8	16.0-25.7	21.1	16.2-26.0	16.2	11.8-20.6	n.s.*
Pain intensity last week, mm	54.5	49.4-59.7	53.5	49.0-58.1	36.1	30.6-42.7	29.0	24.1-33.9	27.5	22.3-32.8	19.5	14.8-24.2	<0.05
Pain at rest, %	69.0	58.0-80.0	69.7	59.9-79.4	28.2	17.4-38.9	23.6	14.6-32.6	25.7	15.2-36.2	19.5	11.0-28.0	n.s.
Pain influencing leisure time negatively, %	60.6	48.9-72.2	70.8	61.1-80.4	32.4	21.2-43.6	28.1	18.6-37.6	25.4	15.0-35.7	16.1	8.0-23.4	n.s.
Difficulties falling asleep due to back pain, %	46.5	34.6-58.4	53.4	42.8-64.0	22.5	12.6-32.5	14.6	7.1-22.1	11.3	3.7-18.8	5.8	0.8-10.7	n.s.
Waking up with back pain, %	71.8	61.1-82.6	67.4	57.5-77.3	34.3	22.9-45.7	27.0	17.6-36.4	22.9	12.8-32.9	23.3	14.1-32.4	n.s.
Morning stiffness, %	81.7	72.5-90.9	74.2	64.9-83.4	67.6	56.4-78.8	62.9	52.7-73.1	64.8	53.4-76.2	52.9	42.2-63.6	n.s.
Time to relief of morning stiffness, minutes	91.3	53.0-129.6	71.0	35.1-107.0	58.9	46.2-71.5	50.6	38.9-62.3	58.1	38.7-77.4	52.3	38.1-66.5	n.s.
Taking painkillers or NSAIDs, %	60.6	48.9-72.2	67.4	57.5-77.3	32.4	21.2-43.6	32.6	22.7-42.5	25.4	15.0-35.7	18.4	10.1-26.7	n.s.

*= $p<0.05$ at 5 weeks follow-up

Table 7. Mean disability measures in the two groups at baseline, at 5 weeks and at 10 weeks respectively.

	Baseline				At 5 weeks				At 10 weeks				p
	Reference therapy		Experimental therapy		Reference therapy		Experimental therapy		Reference therapy		Experimental therapy		
	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	
'Heavy' disability rating index	70.0	65.3-74.8	78.3	74.0-82.5	45.0	37.9-52.1	39.3	32.9-45.7	37.8	31.1-44.6	29.9	23.9-35.9	<0.01
Heavy physical work	75.6	70.5-80.7	81.8	77.2-86.3	49.0	41.3-56.8	43.2	36.2-50.2	43.0	35.6-50.5	31.9	25.2-38.5	
Lifting heavy objects	80.0	75.5-84.4	84.9	81.0-88.9	55.7	47.6-63.8	47.4	40.1-54.7	51.1	43.1-59.2	39.1	32.0-46.2	
Participating in exercise/sports	62.1	55.8-68.3	75.1	69.5-80.7	38.7	31.3-46.1	34.0	27.5-40.5	30.7	23.8-37.6	26.3	20.2-32.5	
Running	62.6	55.7-69.4	71.2	65.1-77.3	37.2	29.7-44.6	31.4	24.6-38.1	27.1	20.6-33.7	23.7	17.8-29.6	
'Less heavy' disability rating index	45.4	40.6-50.2	50.3	46.0-54.6	27.2	22.5-31.9	21.2	17.0-25.4	20.7	16.4-25.0	16.6	12.8-20.5	<0.05
Dressing (without help)	41.0	34.1-48.0	46.0	39.8-52.2	24.0	18.7-29.3	15.4	10.7-20.1	18.8	14.1-23.6	12.3	8.0-16.6	
Outdoor walks	36.4	29.8-43.0	44.3	38.4-50.2	22.5	17.0-27.9	16.7	11.9-21.6	18.1	13.3-22.8	13.9	9.6-18.2	
Climbing stairs	41.4	35.2-47.6	43.2	37.7-48.7	23.3	18.3-28.2	16.0	11.6-20.4	18.2	13.8-22.6	13.8	9.8-17.8	
Sitting for a longer time	56.3	49.7-62.8	57.4	51.6-63.3	40.2	33.7-46.8	30.0	24.0-35.9	31.8	25.5-38.2	23.5	17.7-29.2	
Standing bent over a sink	57.2	50.3-64.1	58.9	52.7-65.0	33.8	27.2-40.5	28.4	22.4-34.3	25.5	19.5-31.4	22.3	16.9-27.6	
Carrying a bag	41.7	34.9-48.5	49.2	43.1-55.3	25.1	19.4-30.8	24.7	19.6-29.9	20.8	15.8-25.9	16.8	12.2-21.4	
Making a bed	56.1	49.0-63.1	62.5	56.2-68.8	31.7	25.4-38.1	26.4	20.7-32.0	23.9	18.0-29.8	21.5	16.2-26.7	
Light physical work	40.8	34.1-47.5	50.1	44.2-56.1	23.0	17.8-28.2	17.6	12.9-22.2	19.4	14.9-24.0	12.9	8.7-17.0	
Lying still	32.0	25.1-39.0	38.4	32.1-44.6	20.6	15.3-25.9	16.9	12.2-21.6	15.4	10.6-20.1	12.7	8.4-17.0	
Car driving/car riding	44.4	37.1-51.6	50.2	43.7-56.7	26.6	20.7-32.5	18.4	13.1-23.7	17.2	12.3-22.1	15.7	11.3-20.2	
Getting up from sitting	52.3	46.0-58.6	53.1	47.4-58.7	31.6	26.0-37.1	22.3	17.3-27.2	23.3	18.6-28.1	16.0	11.7-20.3	
Mean all disability rating variables	52.0	47.4-56.6	57.8	53.7-61.8	31.9	26.8-37.0	25.8	21.2-30.4	25.0	20.2-29.7	20.1	15.9-24.3	<0.05

p value refers to test of difference in disability rating over 10 weeks between reference and experimental therapy groups.

steroid anti-inflammatory drugs (21.4%) and muscle relaxants (12.5%). At 10 weeks follow-up the most frequently used painkillers were light analgesics and antipyretics (15.2%), light opoids (12.7%), non-steroid anti-inflammatory drugs (12.0%) and muscle relaxants (3.8%).

The fifteen disability rating variables are shown in Table 7. At baseline the experimental groups tended to have higher scores than the reference groups in all fifteen variables. However, at 5 and 10 weeks the experimental groups tended to have lower scores than the reference groups in all variables. The rate of improvement was significantly faster in the experimental groups than in the reference groups for disability rating index, including 12 variables, ($p<0.05$) and all 15 variables ($p<0.05$). The same was true for the 'heavy' variables ($p<0.01$) as well as for 'less heavy' ($p<0.05$).

Levels for all fifteen disability rating score variables at baseline, 5 and 10 weeks adjusted for the initial differences in outcome variables, for differences in verified herniated disc, and for age and sex distribution are shown in Figure 6. At baseline, all levels were set to 100%. The levels, expressed as percentages of the initial value, decreased in all groups, but the experimental groups had consistently lower levels than the reference groups for all variables at 5 as well as at 10 weeks of follow-up.

Health related quality of life (Paper III)

Crude outcome data at baseline, 5 and 10-week follow-up are displayed in Table 8. The Well-being score increased across time in all groups, and so did all the sub-scales except for a few in Group 1. Complaint score decreased systematically across time in all groups. The change from baseline to 10-week follow-up was significant across all groups ($p<0.0001$ to 0.02) except for mood and family situation. However, the differences in change between groups were all insignificant except for patience ($p=0.02$).

Since the starting levels for the scales differed between the groups, a multivariate analysis was performed adjusted for differences in starting levels. Outcome adjusted for the covariates (age, sex, body mass index, smoking habits, low back pain history during the last two years, and initial outcome differences) are shown in Table 9 as treatment group specific mean levels of the outcome variables across the study period. The total Well-being score increased consistently across the treatment groups ($p=0.02$), and so did the items patience score ($p=0.005$), energy ($p=0.02$), mood ($p=0.03$), and family situation ($p=0.04$). For the items perceived health, and sleep and for Complaint score there were similar but non-significant trends.

Figure 6. Adjusted levels of 15 disability measures in the experimental and reference groups at baseline (a), 5 weeks (b) and 10 weeks (c) expressed as percentages of the group means at baseline. The baseline values were set to 100% and 0% indicates complete improvement.

Table 8. Crude outcome data at baseline and at 10-week follow up of quality of life variables in the four treatment groups.

	Group 1 (Stay-active)			**Group 2** (Stay-active and muscle stretching)			**Group 3** (Stay-active, stretching and manual therapy)			**Group 4** (Stay-active, stretching, manual therapy and steroid injections)			
	Base-line	5 weeks	10 weeks	Base-line	5 weeks	10 weeks	Base-line	5 weeks	10 weeks	Base-line	5 weeks	10 weeks	
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	p
Well-being score (mm VAS)	65.8 (17.7)	68.9 (15.8)	68.0 (18.2)	67.4 (14.4)	72.4 (14.8)	76.7 (15.9)	69.1 (14.1)	73.9 (13.9)	77.3 (15.5)	66.6 (15.8)	73.9 (15.8)	76.4 (16.2)	0.03
Patience	65.1 (21.0)	64.7 (21.0)	61.9 (24.3)	64.3 (20.0)	68.4 (21.7)	74.1 (21.8)	66.0 (23.0)	70.6 (23.4)	74.3 (23.7)	63.8 (22.8)	71.0 (20.8)	74.5 (20.8)	0.02
Energy	66.9 (23.3)	62.8 (21.0)	65.2 (22.7)	67.1 (20.8)	69.3 (18.0)	75.0 (17.6)	70.7 (21.6)	71.3 (19.5)	74.5 (20.7)	67.1 (20.8)	70.9 (20.4)	73.4 (20.6)	0.26
Mood	69.4 (20.8)	71.2 (21.4)	66.0 (25.4)	71.1 (20.1)	72.2 (18.9)	77.3 (18.5)	74.8 (18.5)	75.2 (17.1)	78.2 (19.6)	69.0 (20.4)	76.1 (19.2)	75.3 (19.9)	0.14
Family situation	79.3 (23.1)	78.4 (18.8)	76.1 (22.0)	85.2 (14.7)	84.5 (14.1)	81.8 (19.3)	84.0 (17.7)	83.6 (16.9)	85.4 (15.3)	83.5 (19.1)	84.4 (17.9)	83.9 (19.0)	0.21
Perceived health	52.3 (27.4)	64.1 (21.3)	66.9 (22.1)	50.6 (20.3	66.8 (19.7)	71.9 (23.6)	51.3 (26.7)	66.9 (22.7)	71.2 (23.8)	51.7 (25.4)	67.4 (23.0)	74.2 (21.6)	0.30
Sleep	61.9 (27.0)	72.4 (20.8)	71.6 (20.7)	66.4 (26.6)	73.1 (23.2)	80.0 (19.2)	67.9 (29.7)	75.8 (23.6)	80.0 (21.7)	64.2 (28.0)	73.8 (22.5)	77.1 (21.2)	0.66
Complaint score	9.9 (4.7)	8.3 (6.0)	7.3 (5.6)	9.6 (4.4)	7.5 (4.9)	7.4 (5.6)	9.5 (5.2)	7.1 (4.9)	6.8 (5.0)	8.9 (3.9)	6.7 (4.6)	5.8 (4.2)	0.58

p value refers to differences between groups at 10-week follow up.

Table 9. Multivariate analysis of well-being in the four groups when the baseline differences were considered.

	Group 1 (Stay-active)		**Group 2** (Stay-active and muscle stretching)		**Group 3** (Stay-active, stretching and manual therapy)		**Group 4** (Stay-active, stretching, manual therapy and steroid injections)		p
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Well-being score (mm VAS)	68.4	12.5	72.1	12.4	72.3	12.4	72.7	12.5	0.02
Patience	63.7	16.7	69.2	16.7	69.5	16.7	70.3	16.8	0.005
Energy	65.7	15.1	71.1	15.1	70.4	15.1	71.0	15.2	0.02
Mood	70.0	15.6	73.6	15.6	73.8	15.6	74.6	15.6	0.03
Family situation	80.4	13.5	82.4	13.5	83.7	13.4	83.7	13.5	0.04
Perceived health	60.7	21.8	63.5	21.8	63.2	21.7	64.2	21.9	0.26
Sleep	70.5	18.5	72.4	18.5	73.0	18.4	72.2	18.6	0.48
Complaint score	8.1	3.5	8.0	3.5	7.7	3.4	7.6	3.5	0.19

The possible outcome affecting variables age, sex, body mass index, smoking habits, low back pain history during the two years preceding baseline, duration of current episode, low belief in activity, belief in return to work, and actual return to work were included as covariates in the analysis.

Table 10. Physical examination findings at baseline.

	N	%
Severe observed pain influence	4	2.5
Pain radiation according to physical examination		
To uni/bilateral leg from flexion	129	80.6
To uni/bilateral leg from extension	109	68.1
Positive straight leg raising test (SLR)	43	26.9
Pathological reflex or other test		
Patellar, uni- or bilateral	17	10.6
Achilles, uni- or bilateral	21	13.1
Greater toe extension test, uni- or bilateral	27	16.9
Clinical indication score for nerve root involvement		
Weak indication (score 0)	99	61.9
Intermediately strong indication (score 1)	40	25.0
Strong indication (score 2)	21	13.1

Clinical indication score (Paper IV)

The physical examination findings used to construct the clinical indication score for nerve root involvement are summarised in Table 10. Few patients had observable severe pain, pain radiation was common, and pathological reflexes appeared in 11-17% of the cases. More than half were classified as having a weak indication for nerve root involvement, a quarter an intermediately strong indication and 13% had a strong indication of nerve root involvement.

Effect on return to work (Paper IV)

Bivariate analyses of pain intensity score, pain drawing score, pain radiation according to the pain drawing, clinical indication score, and the covariates were performed to identify variables affecting return to work, Table 11. When the analyses were restricted to baseline measures, clinical indication score was the only significant determinant for return to work. When updated measurements were used also pain radiation according to pain drawing sketches was a significant determinant.

Table 11. Effects on return to work over time, 105 days.

	HR	95% CI	Wald	p
Baseline measurements				
Age	0.998	0.98-1.02	0.07	0.80
Women	0.90	0.65-1.25	0.40	0.53
Education	1.07	0.94-1.22	1.07	0.30
Body mass index	1.00	0.999-1.00	0.91	0.34
Smoking	0.89	0.64-1.23	0.50	0.48
Treatment group	1.08	0.93-1.25	1.00	0.32
Sick spell duration at baseline	1.00	0.99-1.00	1.01	0.31
Similar complaints last two years	0.88	0.57-1.34	0.38	0.54
Clinical indication score for nerve root involvement	0.78	0.62-0.99	4.17	0.04
Pain radiation according to pain drawing	0.86	0.73-1.02	2.95	0.09
Pain Drawing Score below waistline	0.92	0.83-1.02	2.49	0.11
Pain score	0.99	0.99-1.01	0.08	0.77
Updated measurements				
Pain radiation according to pain drawing	0.82	0.68-0.98	4.55	0.03
Pain Drawing Score below waistline	0.95	0.86-1.04	1.23	0.27
Pain intensity score	1.00	1.00-1.01	1.02	0.31

HR=Hazard Ratio, 95% CI=95% confidence intervals, Wald=Wald Chi Square test.

The effects across time of the two significant variables are shown in Figure 7. For pain radiation according to pain drawing, return to work was on average 15 per cent units higher for those with no radiation as compared to those with radiation below the knee. For clinical indication score, those with a weak indication score had 20% higher return to work than those with a strong indication score.

Clinical indication score and updated pain radiation according to the pain drawing sketch were then tested against each other in a multivariate analysis with backward elimination of the non-significant variable. Pain radiation according to the pain drawing was somewhat stronger than clinical indication score ($p<0.04$ versus $p<0.20$). The effects of the two variables together are shown in Table 12. Among patients with a radiation below the knee and a strong indication score, 84% returned to work within 105 days versus 97% among those with no radiation and a weak indication score.

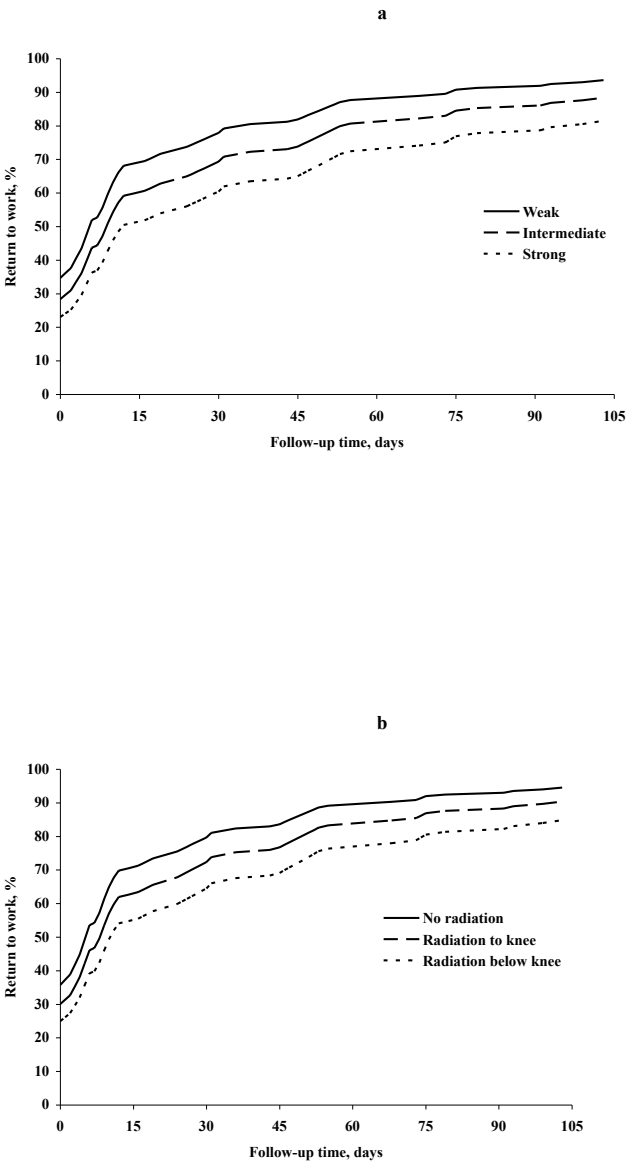


Figure 7. Return to work over time according to clinical indication score (a) and pain radiation according to pain drawing (b).

Table 12. Effect of pain radiation according to pain drawing and clinical indication score for nerve root involvement on return to work (%).

	Clinical indication score		
	Weak	Intermediate	Strong
Pain radiation			
None, %	96.7	94.5	91.4
To thigh, %	94.9	91.9	88.1
Below knee,%	92.5	88.8	84.3

Discussion

Pain as described on a pain drawing sketch was improved over time, an improvement that mainly occurred during the first half of the study period. Pain intensity and disability were associated with the pain modalities used in the pain drawing. In pain drawing sketches with no pain radiation some pain modalities were associated with higher pain intensity score and disability rating index than others, a finding that became more evident over time. For the pain drawing sketches with pain radiation, the differences were smaller and less consistent than for those with no radiation.

Manual therapy including steroid injections in addition to stay-active care and muscle stretching reduced pain as measured by pain intensity score and pain killer usage better than the reference treatment, stay-active care including muscle stretching. Also the disability rating index was improved to a larger extent by the experimental treatment as compared with the reference treatment.

Health related quality of life measures were improved across time in the treatment groups. The greatest improvement tended to occur from Group 1 to Group 2, i.e. when 'muscle stretching' was added to the stay-active care. Further but more modest improvements occurred in Group 3 and Group 4, i.e. when 'manual therapy' or 'manual therapy and steroid injection' were added.

Pain drawing sketch information added valuable significant precision to the prediction of return to work better than that of clinical assessment only.

Methodological issues

The strengths of the study include that the study population was population based. All patients with low back pain seeking medical attention or receiving sick leave compensation in the area were assessed regarding inclusion in the study. The study population is therefore most certainly representative for this type of low back patients.

The methods used were all well established and evaluated. The visual analogue scale has been used for decades, as has the Disability Rating Index instrument [61]. The three variables added to the Disability Rating Index instrument did not affect the results. Pain drawings have been used as a de-

scriptive tool and evaluated in numerous trials [45, 72, 76, 139]. The same, blinded observer assessed all pain drawings. The Well-being and Complaint score subscales of the Gothenburg Quality of Life Instrument [67, 68] have also been evaluated and been concluded as an valid and reliable outcome measure [68].

The analyses were based on the intention-to-treat approach, although the data loss attributable to dropout was minimal and there was minimal partial non-response (minimal missing data in returned questionnaires and pain drawings). State of the art data analysis techniques were used. Sick leave at baseline was based on patient questionnaire data, while return to work in Paper IV was based on official data including diagnosis, and date of onset and end of sick-leave periods. The official data were more suitable for the analysis of return to work. In Paper IV three of the four prediction variables were updated with the findings at 5 and 10 weeks until return to work, the exception being the physical examination done at baseline by the same recruiting physician. The 105 days long follow-up period was chosen to allow for equally long follow-up periods after baseline, the 5 and 10-week examination.

All study groups received about the same amount of active treatment. It was given according to need from a toolbox of treatment modalities specific for that particular treatment group. Normally, the effects of individual treatment modalities cannot be evaluated, but in this study a factorial design was used, with successively added treatment modalities, allowing for evaluation of the effects of added modalities. However, a four-group study design reduces the statistical power of any study, even when a factorial design is used. To compensate, the outcome variables were based on all measurements from baseline to the end of the study period. As a result, the power to detect differences between the study groups in the Well-being variables was satisfactory. Moreover, all initial differences between the groups were taken into account.

The study was designed with no placebo treatment to keep adherence to the study protocol as high as possible and to allow testing of the effects of the various treatment additions. Instead, an active treatment, the stay-active care, was used as the basic, standard treatment, as suggested by others [8, 85, 86, 117]. In this way placebo effects were avoided.

The study weaknesses include that the study was done on a fairly small geographical area, which limited the number of eligible patients and the study sample. However the setting included one Social Insurance Agency office handling all the sick leave compensations, one hospital, and a strict protocol for referral for health care on the mainland. The setting probably reduced the chances for data loss and contaminating treatment.

A potential confounder in this study could be the shorter waiting-time for appointments with the physiotherapists, favouring the experimental groups.

However, the four days longer waiting-time for physiotherapy is an unlikely explanation for the differences in outcome at 5 and 10 weeks. To address the potential confounding of uneven waiting time for treatment, the baseline for sick leave analyses in Paper IV was set to the day of first appointment with the treating physician in the study.

Another study limitation was the fact that steroid injections were given sparsely (only 17 patients out of 47 received at least one injection) and at an early stage of the treatment period. Furthermore, owing to the short follow-up period, the effects on the health related quality of life measures in Paper III might have been underestimated, since the health related life quality changes may be expected to occur after the low back pain symptoms diminished substantially [140].

The clinical examination score, used in Paper IV, was done after the study ended by two clinically well-trained persons. The procedure has the drawback of being done not by the treating physician after the study was concluded. On the other hand the scoring was done for another report, by two observers blinded for patient identification, which the treating physician would not have been, and the number of observers and the consensus procedure used minimised observer bias. All things considered, there is no reason to believe that the data would be biased to such an extent that the results are affected.

The course of pain drawing sketch variables (Paper I)

To assess the pain drawing sketches the pain drawing score was used, a frequently used method first described in 1986 by Margolis [45], and later used in numerous studies as an instrument to measure low back pain. Originally, the pain drawing score was based on anatomical regions within the body contour and on weights to compensate for the difference in area size. However, Margolis and others have suggested that the weights are unnecessary, since the raw scores correlate closely with the weighted ones (r=0.97-0.99) [41, 72].

Several studies on the validity and reproducibility of pain drawing sketches have been published. The instrument is validity and reproducibility tested [75, 141], stable over time [72], and has low inter-rater variability [45, 69]. Validity regarding pain, function and some psychological instruments is high [74, 141]. Some authors questioned the reliability of the pain drawing sketch [69, 72, 141], while others found the scoring system to have an acceptable reliability even with untrained observers [45].

Among pain drawing sketch variants available that proposed by Margolis was chosen, containing 43 areas all within the body contour. However, the anatomical areas size and numbers were moderated for this study to a total

of 34 areas since the lower half of the body had a higher impact and the area regions were more relevant for the purposes of our study. This method allows the pain to be scored using clinically reported pain patterns [70] and it is easy to use. Since the patients in the present study were all suffering from low back pain, the 16 areas of the lower half of the body were of particular interest. Therefore, both the overall score and the 16 areas score below the waistline were reported.

The pain drawing sketches were completed in the same way at all three measurement occasions. Two pain drawing patterns were prominent: the left side dominated the drawings, and there was a more substantial rate of improvement during the first period than the second. The left side domination has not previously been reported, and therefore remains to be replicated in other studies. The improvement manifested itself as fewer marked areas, fewer marks in the areas, fewer used modalities and more proximal marking, i.e. fewer marks in the leg areas. The early improvement may be attributable to the fact that the majority of treatments were given in the first half of the 10-week treatment period. The effects are seen in association with the treatment. The faster change in the first 5 weeks was also evident in the 'pain modality shift'.

The 'pain modality shift' as described by McKenzie [36], was seen in the low back/buttock area. The initially frequent modalities 'numbness' and 'stabbing' shifted to 'stiffness' and 'no marks' over time. There are some reports on the distribution of pain modalities in different regions [40, 41]. However, they are based on a single measurement, making it difficult to deduce a 'pain modality shift' or the average speed at which the shift occurs.

In the present report there was a strong association ($p<0.0001$) between pain intensity score, functional score and pain drawing score. These results are in line with the literature both for the disability rating [74, 75, 142] and the pain intensity score [74, 133, 142]. No other studies on the possible association between various pain modalities and the grade of pain radiation on the pain drawing and pain intensity score or disability rating were found. Furthermore, to compensate for the fact that pain intensity score and disability rating index are global estimates; the association with the dominating leg pain modalities was analysed only in patients with all marks below waistline. The present study population had quite a homogenous pain drawing pattern, with the majority of marks below the waistline. Also, both the pain intensity score and the disability rating index were low for patients with no marks in the lower back/buttock areas.

Among patients who had no pain radiation there was a clear change towards fewer pain modalities and an emerging difference between modalities in pain intensity score and disability index during the course of the study. This was not found among those who had pain radiation, a finding not described elsewhere to our knowledge. A possible explanation might be that

since various pain modalities communicate with the brain through different type of nerve fibres [143, 144], patients who use a number of modalities to describe their pain might have difficulties in grading the sensations, and the addition of pain radiation makes the distinction between pain modalities too complex [6]. The difficulty to rate complex pain in a small area and to rate radiating pain with different pain modalities in different areas might be even more difficult, because other factors such as psychological coping strategies are likely to contribute to the rating [145]. Also, there could be a minor change in choice of pain modality, a change that is too small to distinguish in this relatively small sample. However, if that is the case, one might ask whether such a minor change is clinically relevant.

The results from this paper emphasise that the pain drawing sketch should be part of the clinical practice when assessing sub-acute low back pain, as recommended in the pain analysis of chronic pain [19]. Pain drawing information of the different pain modalities adds vital information, i.e. the patients describing pain modalities that are more painful should be subjected to a thorough medical investigation. The recognition that sub-acute low back pain patients with radiating pain are less likely to be able to rank the pain modalities needs further investigation, since radiating leg pain is described as a significant predictor to develop chronic back pain [15]. Also, the possibility to differentiate patient categories that benefit from early treatment or extended examination by pain drawing patterns and choice of pain modality requires further investigation.

Pain and disability variables (Paper II)

During the period 1987 to 2003 some twelve randomised clinical trials on manual therapy versus various reference treatments in low back pain patients were published. A variety of study designs and treatment methods were used which makes the comparison of results between trials difficult. In five studies the treatment was given as a single tool treatment [146-150] and in seven trials a pragmatic approach was used [62, 151-156]. The manual therapy was more effective than the reference treatment in all the single tool trials and in five of the pragmatic approach trials [62, 151, 153-155]. Thus, the results of the present study are in line with these earlier studies, and the present guidelines for acute and sub-acute non-specific low back pain [4, 5, 83, 84]. However, despite these mainly positive results, several guidelines were, in the early 2000s, criticised and considered not sufficient due to methodological flaws [109]. Due to these shortcomings there were considered to be far too many unanswered questions to not conclude that most studied low back pain treatments were ineffective or at the best marginally effective and that the choice of treatment had to be based on the therapist's experience [108].

Today, the quality of recent guidelines has been considered much improved methodologically [111]. Among the overshadowing problems remains the heterogenic patient group creating a methodological study challenge [83, 108]. Most clinical trials in other fields are performed as single tool trials where one specific treatment is compared with another one. It is claimed to be the most unbiased method to evaluate specific treatment effects [157]. However, during the 1990s the pragmatic approach became more common, not least in drug trials where the study drugs may be combined with other specified drugs if the treatment goal is not achieved. [158]

The pragmatic treatment approach provides an opportunity to use the most suitable treatment option from a specified list in each of the treatment groups to address the heterogeneous non-specific aetiology. The treatment situation is from this point of view closer to a clinical situation than the single tool trial. The criticism against the pragmatic approach is mainly based on the potentially confounding effect caused by the number of treatment modalities. The possibility to evaluate the effect of separate treatment modalities is diminished by the pragmatic design unless a factorial design is used [114], as in the present study. This dilemma could also be addressed by creating subgroups within large studies in order to find matching problem characteristics. The study model has been described as the 'Holy Grail' of low back pain research [9]. These studies aim at creating large enough homogenous characteristics subgroups to enable the success of different treatment tools [108, 112].

However, the model has several weaknesses. One compelling weakness is that primary care practitioners believe in subgroups and that they can identify what type of patients are in the various subgroups. But when this belief was assessed among primary care practitioners there was no consensus on what to include defining a subgroup [159]. Another study weakness includes that the poorly validated study model so far remains unreplicated in other studies [9, 113].

Moreover, the strive for causal homogeneous patient groups, i.e. having the same pathoanatomical cause of pain, may not imply treatment responsiveness. Different subgroups based on causal mechanisms may not guarantee that the patients within each subgroup will develop a similar symptom course over time and respond to given treatment in a similar way [9]. For instance several psychological factors have been shown to predict patient outcome, but these factors cannot be assumed to select patients for specific treatments [113, 160].

Thus, the classification systems that form the base of subgroup methodology has to be further developed before general alterations of non-specific low back pain study methods could be done. This task has been considered a high priority consensus goal [29]. Until that is done the continued search for valid screening tools of low back pain diagnostics and treatments will be

needed [10]. Moreover, the research has also been developed for the last two decades with evidence-based medicine, using structured abstracts, summarising of high relevance and methodology in secondary papers and the Cochrane Collaboration [161].

Health related quality of life (Paper III)

The muscle stretching addition had the largest observed additional impact on the outcome, i.e. the health related quality of life measurements improved the most between Group 1 and Group 2. The continued addition of treatment modalities, i.e. manual therapy and manual therapy with steroid injections, did affect the outcome further positively but the additional improvement (between Groups 2 and 3 and between Groups 3 and 4) was much smaller than between Groups 1 and 2. However, the size of the additional effects may be assumed to depend on the order in which additional treatment modalities are introduced. This phenomenon is seen in multivariate analyses, where the additional effects of independent variables depend on the order of introduction.

This assumption is further supported by results from other clinical trials. Brennan et al. used subgroups to compare treatment effects in three groups, one of which corresponded to our treatment Group 2 and one of the other to our Group 3 [162]. They found an additional effect between the subgroups in the two groups that got the optimum treatment of approximately the same magnitude as between our Groups 1 and 2. However, there is a major difference between the studies. While Brennan used subgroups to test which treatment approach that was optimal in their groups the present study had a pragmatic approach, where the physicians or physiotherapists were free to choose the optimal treatment from a group specific treatment list for each patient, creating an individual subgrouping. However, we abstained from subgroup analyses since they are questionable in randomised trials if not defined at the time of randomisation.

The Well-being subscale includes a number of potential outcomes some of which, considering the study hypothesis, were regarded as irrelevant, for instance work situation (only 50 were at work at baseline), eyesight, hearing, etcetera. Others were regarded as relevant or highly relevant. It was expected that patience, energy, and mood would be affected. However, it was a surprise that perceived health and sleep would not be significantly influenced by the treatment, although there was an inconclusive tendency towards an effect in each of these variables.

The absence of difference between the groups in terms of Complaint score was another surprise. The treatment may have affected the musculoskeletal symptoms, but the effect on the total Complaint score appears to be

approximately the same in all groups. One possible reason might be that it was affected primarily by the stay-active approach, another that the Complaint score improvement reflects the natural course of the condition. However, there is limited evidence that behavioural approaches as a compliment to ongoing physiotherapy is more effective in patients who have elevated fear-avoidance, i.e. avoidance of certain physical activities for fear that they will cause back pain, than if the approach is only physiotherapeutic [163].

A few other studies of low back pain have used health related quality of life as outcome measure. In the study reported by Underwood et al., 1,334 primary care patients with sub-acute or chronic low back pain were randomised to an exercise programme only, spinal manipulation package, combined treatment, or 'best care' in general practice (control group), receiving fairly intensive treatment for 12 weeks [160]. The combination group had the best quality of life outcome after three months, followed by the group receiving the spinal manipulation package, the exercise programme group, and the control group. After one year the results were approximately the same. Goldby et al. compared manual therapy with stay-active care and found a large positive effect on health related quality of life in the manual therapy group [164].

Niemistö et al. randomised 204 chronic low back pain patients into two groups, best primary health care, or spinal manipulation and exercises with low intensity (a total of four times during four weeks). They found an effect on pain and disability but not on health related quality of life [165]. Nor did Hay et al., who randomised 402 primary health care patients to a pain management programme (stay-active care and exercise) or manual therapy [166]. There are two additional studies with health related quality of life outcome, one showing an effect [167], the other no effect [168]. However, in both studies compliance with the treatment was only moderate, which makes the results difficult to interpret.

The characteristics of successful manual therapy trials with health related quality of life outcome include study populations with sub-acute low back pain. Patients with chronic low back pain may require a different treatment approach. Furthermore, the treatment intensity was high enough in the successful studies, while it was modest or low in the non-successful ones. The treatment intensity in the present study was high enough to make a difference, eight to nine appointments over the 10-week study period. The third characteristic was the choice of outcome measures. The successful studies all used fairly simple health related quality of life instruments, such as the Gothenburg Quality of Life Instrument used in this study, Euro Quality of life with five dimensions (EQ-5D), and the physical subscale of Fear Avoidance Beliefs Questionnaire (FABQ).

Pain drawing prediction (Paper IV)

To standardize the results of a physical examination including a neurological status into a clinical examination score is difficult. Despite the vast number of suggested low back pain classification systems the results have been disappointing, none of the suggested systems has gained international recognition [145, 169]. The classification efforts have been one-dimensional with either bio-medical or psychosocial focus. The bio-medical classification systems mix different types of variables such as age and gender with the result from various questionnaires (for example the Oswestry low back pain questionnaire) and different physical examination manoeuvres and their results [170]. This circumstance combined with a tendency that cultural settings (attitudes, beliefs and interactions in society) might have impact on the natural history of low back pain, offer one explanation to why the clinical examination standardisation still is missing [145]. The results of the present paper suggest a possibility to use the pain drawing as a bridge in this dilemma. The studied pain drawing assessment model with pain radiation update was promising and may add precision to the effort of identifying determinants of clinical examination.

Measuring return to work poses another challenge with no gold standard [171, 172], for various reasons specific from country to country and the complexity of the benefit system [173-175]. However, a Swedish review found limited scientific evidence of the effect of sick listing in relation to low back pain, no matter whether register data or self-reported data were used [55]. The way of calculating return to work used in this report has been used previously [176].

Conclusions

Perceived pain intensity and disability were associated with the pain modalities used in the pain drawing sketch. The pain drawing sketches with no pain radiation changed over time with fewer pain modalities, and a strong association between the pain modalities and the pain intensity score or the disability rating index emerged. This was not found among those with pain radiation.

The manual therapy concept was more effective than the standardised but optimised stay-active care in acute and sub-acute low back pain patients, regarding pain reduction and improvement of everyday function. In spite of the fact that the mechanism by which the effect is mediated is still unknown, the results are sufficiently convincing for the method to be used as one of several treatment options in patients with acute and sub-acute low back pain.

The effects on health related quality of life were greater the larger the number of treatment modalities available. The stay-active treatment group, with the most restricted number of modalities, had the most modest health related quality of life improvement, while Group 4 with the most generous choice of treatment modalities, had the greatest improvement in health related quality of life.

When determining return to work with baseline data the score based on clinical examination data appear to be the best. But, when using updated measures pain radiation according to the pain drawing sketch contributed significantly to the prediction of return to work. However, more research and standardisation is needed to assess the value of the determinants.

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Appendix

Clinical examination findings and Clinical indication score. Test result: empty boxes=negative, 1=possibly positive, 2=definitely positive.

Clinical indication score	Radiation right leg		Radiation left leg		Patellar reflex		Achilles reflex		Greater toe reflex		Straight leg raising test	
	exten-sion	flexion	exten-sion	flexion	right	left	right	left	right	left	right	left
0												
0												**1**
0											**1**	
0											**1**	**1**
0										**1**		
0									**1**	**1**		
0					**1**	**1**	**1**	**1**				
0					**2**	**2**						
0										**1**	**1**	**1**
0			**1**									
0	**1**											
0	**1**										**1**	**1**
0				**1**								
0				**1**							**1**	
0				**1**							**1**	
0			**1**	**1**						**1**		
0			**1**	**1**	**1**	**1**	**1**	**1**				
0			**1**	**1**							**1**	**1**
0	**1**		**1**	**1**								
0	**1**		**1**	**1**			**1**					
0		**1**										
0		**1**								**1**		
0		**1**									**1**	
0		**1**	**1**									

Clinical indication score	Radiation right leg		Radiation left leg		Patellar reflex		Achilles reflex		Greater toe reflex		Straight leg raising test	
	exten-sion	flexion	exten-sion	flexion	right	left	right	left	right	left	right	left
0		**1**	**1**									
0	**1**	**1**								**1**		
0		**1**		**1**								
0		**1**		**1**						**1**		
0	**1**	**1**	**1**	**1**								
0	**1**	**1**	**1**	**1**						**1**		
0	**1**	**1**	**1**	**1**	**1**	**1**						
1										**1**	**1**	**1**
1					**1**	**1**	**1**	**1**			**1**	**1**
1	**1**		**1**									
1	**1**		**1**								**1**	
1				**1**	**2**					**1**		
1			**1**	**1**								
1			**1**	**1**								**1**
1	**1**	**1**										
1	**1**	**1**							**1**			
1	**1**	**1**									**1**	
1	**1**	**1**									**1**	**1**
1	**1**	**1**	**1**					**2**				
1		**1**	**1**	**1**			**2**	**2**				
1	**1**	**1**	**1**	**1**			**1**		**1**			**1**
1	**1**	**1**	**1**	**1**						**1**	**1**	**1**
1	**1**	**1**	**1**	**1**					**1**		**1**	**1**
2					**2**	**2**	**2**	**2**				
2			**1**	**1**						**1**		**1**
2			**1**	**1**				**2**			**1**	**1**

Clinical indication score	Radiation right leg		Radiation left leg		Patellar reflex		Achilles reflex		Greater toe reflex		Straight leg raising test	
	exten-sion	flexion	exten-sion	flexion	right	left	right	left	right	left	right	left
2	**1**		**1**	**1**								**1**
2		**1**					**2**	**2**				
2	**1**	**1**							**1**		**1**	
2	**1**	**1**	**1**		**2**	**2**				**1**	**1**	
3						**2**						**1**
3					**2**	**2**	**2**				**1**	
3			**1**					**2**		**1**		**1**
3				**1**		**2**				**1**	**1**	**1**
3			**1**	**1**				**2**				**1**
3	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**				
4				**1**				**2**				**1**
4				**1**				**2**		**1**		**1**
4			**1**	**1**				**2**		**1**		**1**
4		**1**					**2**				**1**	
4	**1**	**1**			**2**						**1**	
4	**1**	**1**			**2**				**1**		**1**	

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