BACK TO ONESELF

– Sensory Motor Learning –
applied in patients with nonspecific chronic low back pain

Christina Schön-Ohlsson

UNIVERSITY OF GOTHENBURG

Department of Clinical Neuroscience and Rehabilitation
Institute of Neuroscience and Physiology
Sahlgrenska Academy, University of Gothenburg
Sweden
2010

ISBN 978 – 91 – 628 – 7959 – 4

Printed by Intellecta Infolog AB, Göteborg, Sweden, 2009
Photo on front page by Rosalie O'Conner www.rosalieoconner.com
Images by Elin Fälthammar elin@falthammar.com
Text design by R o u n d a b o u t

ABSTRACT

Back pain is an endemic problem affecting one in five adults every year. Even though only 10 % of all cases of back pain become chronic it is one of the largest health problems in industrialized societies. The term nonspecific chronic low back pain (NSCLBP) refers to cases in which neither the persistent pain symptoms nor the related physical dysfunction are related to structural impairment or disease. NSCLBP accounts for 80 % of cases of chronic low back pain.

The overall purpose of this thesis was to generate knowledge in order to evaluate the Sensory Motor Learning (SML) intervention when applied in patients with NSCLBP. To achieve the purpose the conceptual framework behind the SML intervention was outlined and the investigation implemented through four separate studies.

Patients with NSCLBP who previously had not been helped by any treatment and who were not expected to be helped by spinal surgery participated in the studies.

Study I investigated if the optoelectronic Posturo-Locomotion-Manipulation (PLM) test was a valid and reliable measurement tool, able to objectively assess the quality of a dynamic goal directed action in freely moving patients with NSCLBP. Study II evaluated how the SML intervention influenced movement capacity in patients with NSCLBP as assessed by the PLM test. Study III used individual interviews to evaluate how the SML intervention influenced the patients regarding their subjective, cognitive perspectives. Study IV was designed as a qualitative randomized clinical trial using focus groups to compare how two comparable groups of NSCLBP patients expressed their experiences from two different interventions based on different conceptual frameworks; SML and exercise therapy (ET).

The result showed the PLM test to be a valid and reliable outcome measure. Compared with an age and gender matched control group without back pain, the NSCLBP patients' performance was significantly less efficient before the SML intervention. After the intervention there were no differences between the movement capacity of the patient group and the control group. The results were maintained after one year. The patients described that they had learned to reduce pain, to diminish psychological distress and to improve physical ability. Major differences were indentified when comparing how the two patient groups with NSCLBP experienced SML and ET. The patients in the SML group expressed that they had learned to trust in themselves and now felt able to handle their low back pain themselves. This was in contrast to the patients in the ET group who expressed insecurity and dependence on advice from back-pain experts.

Based on the results; a hypothesis was generated stating that SML– an embodied, empathic, therapeutic approach to health behaviour change - enables patients with NSCLBP to increase control over back pain and promotes health by guiding them – back to oneself – implying that patients learn to rely on themselves and their bodily awareness. The hypothesis was based on the fact that the patients' felt able to handle their low back pain themselves and their subjectively experienced positive physical and psychological changes coincided with objectively assessed improvements in movement capacity.

Key words: Chronic nonspecific low back pain, Sensory Motor Learning, SML, Posturo-Locomotion-Manipulation (PLM) test, Qualitative method, Focus group study, Health promotion, Feldenkrais method, Exercise therapy.

ABBREVIATIONS

ATM	Awareness Through Movement
ET	Exercise Therapy
FI	Functional Integration
FM	Feldenkrais Method
GMP	Global Movement Pattern
ICF	World Health Classification on Functioning, Disability and Health (WHO 2001)
KSP	Karolinska Scale of Personality
MG	Movement Gestalt
NSCLBP	Nonspecific Chronic Low Back Pain
PLM test	Posturo - Locomotion – Manipulation test
PT	Physical Therapy/ Therapist
RoM	Joint range of motion
SF 36	The 36-item Short Form Health Survey
SML	Sensory Motor Learning
TIPPA	Test Instrument Physical Performance Ability
WHO	World Health Organisation

LIST OF PAPERS

This thesis is based on the following studies, which will be referred to in the text by their Roman numerals. Reprints of published papers were made with the kind permission from the publishers.

I. Schön-Ohlsson Christina, Willén Jan, Johnels Bo. Optoelectronic movement analysis to measure motor performance in patients with chronic low back pain: test of reliability. J Rehabil Med 2006;38(6):360-7.

II. Schön-Ohlsson Christina, Willén Jan, Johnels Bo. Sensory motor learning in patients with chronic low back pain: a prospective pilot study using optoelectronic movement analysis. Spine 2005;30(17):E509-16.

III. Schön-Ohlsson Christina, Willén Jan, Räisänen Christine, Johnels Bo, Willén Carin. Rehabilitation of patients with nonspecific chronic low back pain: a qualitative study of patients' experiences of Sensory Motor Learning intervention. Manuscript submitted.

IV. Schön-Ohlsson Christina, Willén Jan, Rydén Lisbeth, Willén Carin, Hane Monica. Using focus groups to compare how patients with nonspecific chronic low back pain express their experiences of sensory motor learning and exercise therapy interventions; a randomized, qualitative study. Manuscript.

Dare to do right!
Dare to speak the truth!
You have a duty that
no one else can fulfill!

Do even the smallest duty well
and when the day is ended
you will have nothing to regret,
no time will have been lost and
you will feel content and happy!

To Christina from Kindergarten teacher

CONTENTS

INTRODUCTION

Back pain is an endemic problem affecting one in five adults every year. Even though only 10 % of all cases of back pain become chronic it is one of the largest health problems in industrialized societies. The term nonspecific chronic low back pain (NSCLBP) refers to cases in which neither the persistent pain symptoms nor the related physical dysfunction are related to structural impairment or disease. Nonspecific spinal disorders are categorized as chronic if they occur episodically within a six month period or last for more than three months. They are usually accompanied by other musculoskeletal pains, bodily complaints, psychological distress and amplified dysfunctional cognition and pain behaviour. NSCLBP accounts for 80 % of the chronic low back pain cases [1-4]

In 2000 'The Swedish Council on Technology Assessment in Health Care' (SBU) published an extensive review on the scientific evidence of causes, diagnosis and treatment of back pain. A group of international experts had gone through 25 000 articles and selected around 2000 studies on back and neck pain of the highest scientific quality. In the conclusions it was stated that back pain and its consequences are not isolated physical problems but are associated with stress, worry and anxiety. The patient's own perceptions of and ability to manage the problem can have decisive impact on the transition from acute to more chronic pain. Many treatment methods are currently used but there is little scientific evidence about their benefits. According to the Swedish SBU report, progressive resumption of activities of daily living and back programs combining muscle strength- and stretch training plus aerobic fitness are recommended as effective treatment for the reduction of disability and improvement of physical function, in patients with NSCLBP [3].

Despite the fact that several clinical practice guidelines had been developed for the management of low back pain, it was concluded that the overall quality was disappointing [1-3]. Therefore in 2006, the European Commission COST B13 program published the European guidelines for the management of low back pain, including guidelines for NSCLBP. In conclusion it was stated that the few therapies that may be recommended for patients with NSCLBP have only modest effects due to the heterogeneous and multidimensional nature of the underlying problem. According to the guidelines Exercise Therapy (ET) together with cognitive behavioural intervention are the most promising interventions for this group of patients, even though the "active ingredient" in ET programs is largely unknown. ET encompasses a heterogeneous group of interventions that vary in type, intensity, frequency and duration of exercise and the setting in which it is provided. The primary aim is to engage patients to increase their amount of general physical activity, to strengthen muscles and increase joints flexibility in order to improve physical capacity level [2, 5, 6].

A systematic review conducted within the framework of the Cochrane Collaboration found that ET is slightly effective at decreasing pain and improving function and is at least as effective as other conservative interventions for patients with NSCLBP. The ET program should be individually designed, the performance supervised and adherence encouraged to achieve a high amount of exercise. Moreover, stretching exercises should be included in the program to reduce pain as well as muscle-strengthening exercises to improve function [6-8]

Protective pain behaviour

It has been shown that patients with NSCLBP have dysfunctional postures, habituated restricted movement repertoires, reduced kinesthesia and impaired proprioception [9-13] .

Several studies confirm that sensory motor disturbances are found frequently in patients with chronic pain [14-16]. From a clinical perspective the relationship between chronic pain and movement related disabilities is unambiguous. Disabilities in patients with NSCLBP may be related to an earlier acute injury or may be the result of long time disuse or as a consequence of physical or psychological overload. Little is known, however, about how nonspecific pain related neuromusculoskeletal disabilities occur and how humans learn to control and optimize their movements. The answer lies in the interface of neuroscience, kinesiology, neurophysiology, psychology, biomechanics and clinical sciences [17-20].

It has been suggested that protective pain behaviour may underlie the maladaptive movements and the motor control impairments in patients with chronic low back pain [21]. Protective pain behaviour implies any action that is intended to reduce the probability of further injury, minimize the experience of pain or promote recovery from injury [22]. Back pain may influence anticipatory postural compensation during a movement that involves the spine, plus the increased activation of deep muscle structures might reflect a protective mechanism aimed at minimizing movement associated with an increase in pain [23]. Individuals engage in behaviours such as holding or guarding the part of the body where pain is being perceived and they perform actions in a rigid or halting manner to minimize movements that cause pain [22-24].

There are indications that emotional factors related to fear of pain play a significant role in the degree of protective behaviour individuals will display when experiencing pain. Consistent research findings corroborate that individuals suffering from NSCLBP develop fear-avoidance strategies, pain-related disability and generally negative affect [25]. Fear of pain has been defined as a highly specific negative emotional reaction to pain eliciting stimuli involving a high degree of mobilization for avoidance behaviour [26]. Individuals who score high on measures of fear of pain are

less active, have reduced range of motion, are prone to discontinuing activities that are associated with pain and avoid activities that they expect will be associated with pain [24, 27, 28].

From a short term perspective, such unconsciously restrictive movement habits can be seen as a physiologically beneficial coping strategy that protects against further overload and/or injury. Kinaesthetic perception, however, becomes less differentiated when action is restricted [14, 29, 30]. This implies that after some time, the patient with NSCLBP will no longer perceive his or her movements as precisely as before. This will reduce the ability to co-ordinate the fine-tuned, complex movements of the spine and a vicious circle is initiated with pain being the patient's only noticeable sign.

When referring to the above, NSCLBP seem to present one of the most challenging aspects of rehabilitation since no underlying disease or anatomical source of pain can explain the patients' severe pain symptoms, physical disabilities and/or psychological distress. Moreover, in patients with NSCLB there is no concurrent disease or pathophysiological process, which can progress and possibly bias the outcome of a potentially efficient intervention.

The author of this thesis had the objective of developing a comprehensive intervention aimed at the rehabilitation of patients with NSCLBP. It was intended that the intervention would address the whole person and therefore it was named Sensory Motor Learning (SML).

AIMS

The overall purpose of this thesis was to generate knowledge by evaluating the Sensory Motor Learning (SML) intervention when applied in patients with nonspecific chronic low back pain (NSCLBP). To achieve the purpose the conceptual framework behind the SML intervention was outlined and the investigation implemented through four separate studies with the following aims:

Study I:

The aim of study I was to investigate if the optoelectronic Posturo-Locomotion-Manipulation (PLM) test was a valid and reliable measurement tool, able to assess dynamic movement capacity objectively in freely moving patients with NSCLBP.

Study II:

The aim of study II was to evaluate how the SML intervention influenced movement capacity in patients with NSCLBP.

Study III:

The aim of study III was to evaluate how the SML intervention influenced a group of patients with NSCLBP with regard to their subjective cognitive perspectives.

Study IV:

The aim of study IV was to compare how patients with NSCLBP express their experiences from two interventions that are based on different conceptual frameworks; SML and exercise therapy (ET) interventions.

Design

To achieve the various aims of the four studies, multiple methodological approaches were required. In study I and II the data collection was computer-based and the time taken for the entire PLM test movement and for its three phases; postural (P), locomotion (L) and Manipulation (M) were calculated and statistically analysed. There was also an attempt to measure to what degree the postural motor program was integrated with gait and arm dexterity into an efficient movement by the calculation of a simultaneity index (SI). In study III two individual interviews with each patient were audio recorded, transcribed and the content was analysed using a systematic 7-step iterative procedure. Study IV was designed as a qualitative randomized clinical

trial using focus groups to compare how patients with NSCLBP expressed their experiences regarding the two different interventions.

An overview of the research design is given in Table I.

Table 1

Study	I	II	III	IV
Design	Assessment of PLM-test's validity and reliability	Assessment of movement capacity before, after and 1 year after SML	Individual interviews to assess how patients perceive and interpret SML	Focus groups discussions to compare how patients express experiences of SML and ET
Setting	Movement laboratory	Movement laboratory	SML intervention clinic	Neutral conference room
Data collection	Computer based measurements of time	Computer based measurements of time	Audio recorded, transcribed individual interviews	Audio recorded, transcribed focus group discussions
Participants	Patients with NSCLBP and control group	Patients with NSCLBP and control group	Patients with NSCLBP	Patients with NSCLBP
Analysis	Descriptive and non-parametric statistics	Descriptive and non-parametric statistics	Qualitative content analysis of cognitive individual interviews	Qualitative discursive analysis of focus group discussions

THE CONCEPTUAL FRAMEWORK behind Sensory Motor Learning (SML) intervention

The author of this thesis started developing the Sensory Motor Learning (SML) intervention in the mid 1990s as she was responsible for a project named "To learn with the body and evolve as a human being; the movement school – Awareness through movement". Her idea was to start her developmental work by assessing the outcomes of the Feldenkrais method (FM); Awareness Through Movement (ATM) lessons [31], offered to patients with nonspecific chronic pain-related disabilities, who had not been helped by conventional physical therapy.

Approximately 50 patients with medical diagnoses such as Fibromyalgia, Chronic low back pain and Whiplash injury took part in the project. The evaluations were performed by final term physical therapy students and resulted in five graduate research methodology projects. The patients' sense of coherence (SOC) was assessed using a questionnaire developed by Antonovsky [32]. The West Haven Yale Multidimensional Pain Inventory (MPI) was used to assess multiple pain dimensions [33]. To investigate the qualitatively different ways in which the patients experienced the intervention, two separate interview studies were performed. To assess the patients' movement capacity, the Body Awareness Scale (BAS test) [34] and the Resource Oriented body investigation (ROK) [35], were used. The results indicated that the patients' SOC improved [36] and their pain intensity decreased [37]. The patients experienced positive physical and psychological changes, which resulted in a more positive self image and coincided with marked improvements in well-being and daily life capability [38-40].

There were several methodological limitations to these pilot studies. We could not find a valid outcome measure to assess the patients' movement capacity. Major objections were directed towards the lack of control groups. The unusual idea of including patients with various medical diagnoses in the same intervention was questioned.

Against the background of what the author had learned from these pilot projects and through advanced, theoretical and applied courses in FM [41-45] and studies in Psychosynthesis [46-48] and Motivational Interviewing (MI) [49, 50], a conceptual framework was outlined. Three phenomena were assumed to play a decisive role in the SML intervention comprising an efficient intervention aimed at patients with NSCLBP, even though its major influence came from FM. The conceptual framework is outlined below and the text is divided into three parts.

Part one discusses what constitutes an efficient movement pattern and how inefficient movement patterns can be observed and therapeutically addressed trough the

FM. Part two discusses the process of change and describes how the NSCLBP symptoms can be explained and made meaningful and understandable so that the dejected patient can replace the locus of control onto himself and find the motivation to persist. Part three describes what distinguishes the complex and dynamic therapeutic relation between the SML teacher and the patient, including the practical FM skills the SML teacher needs to master in order to guide the patient to discover ways that may lead him/her out of the self imposed protective pain behaviour.

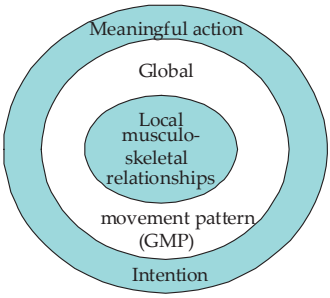
Movement patterns

From the perspective of an observer, an individual's movement pattern is defined by the observed relations between the bodily parts of the individual while in movement. Each daily life activity comprises a defined number of Global Movement Patterns (GMP) [51]. The concept "Global" (G) is used to emphasize that the whole body is involved, from the head to the toes, when an action is performed in the most efficient way. The "most efficient way" refers to a situation when the transmission of forces through the skeleton is mono vectored and the distribution of movements along involved joints is congruent with the size of these joints.

The quality of each GMP is created by the individual's nervous system during the act of moving. Every GMP comprises several movements and each movement addresses specific musculoskeletal relationships. As the degree of freedom in the human body is very large there are many possibilities regarding how each movement at the level of the specific musculoskeletal relationships inherent in a GMP is created. As the human musculoskeletal structure is identical in every non impaired individual, in theory the innate movement possibilities are known. Moreover, the ideal ensuing Movement Gestalt (MG) of perfectly performed GMP can be anticipated and the inefficient GMP observed and recognized. The MG refers to the whole body configuration that constitutes the resulting observed "image" of an individual's body in motion. When observing the MG of an individual whose action is comprised by ideal GMP, one gets an embodied impression of beauty and lightness. The GMP that gives rise to the "ideal" MG encompasses the most efficient performance.

This implies that each action can be performed in many, more or less inefficient, ways. The defining factors are decided both by the situational local sensory - motor - skeletal status and by situational environmental constraints. In the absence of environmental constraints the efficiency of an action is only determined by the individual's use of self, which in its turn is dependent on the kinaesthetic transparency of the individual's bodily self image.

Figure 1 illustrates how the same action can be performed in various ways.



The action is the same for all three individuals in the photo. They are sitting on the floor, turning left. Each individuals' GMP is mirrored by the movement gestalt (MG), created by the local musculoskeletal relationships at every joint. Observing the MG's of the three persons one discovers differences at almost every musculoskeletal connection; toes, feet, knees, hips, pelvis, lumbar spine, thoracic spine, neck , shoulder girdle, elbows and hands.

Figure 1. The photo demonstrates how each person tends to act in accordance with his/her habituated bodily self-image.

It can be quite easy to detect distinctive differences subjectively in the way two individuals perform the same action. To measure the quality of an action, in order to compare the movement patterns of different individuals, or the same individual at different occasions, a reliable observation system is needed. A valid outcome measure must be able to capture the essential distinguishing GMP of a specified action and monitor its inherent movements as an integrated whole, i.e. an entity comprised of interdependent parts working together.

The FM is based on the innate human capacity for lifelong development and growth. The client is encouraged to update his/her movement repertoire by choosing to manifest what is kinaesthetically perceived as the easiest way instead of unconsciously performing any intention in the habitual way. This implies to consider an individual's inefficiently performed (eventually painful) actions from the perspective of the GMP and avoid the futile problem perspective. Freeing self imposed behavioural limitations, whether produced because of pain or not, is not only supposed to pro-

duce more efficient movements but also significant relief of muscular strain and reduce eventual pain.

The FM lessons aims at guiding the patient to organize himself functionally to move with minimum effort and maximum efficiency, not through muscular strength, but through increased kinaesthetic awareness of self, resulting in better body alignment and more efficient actions. There is a sensory correlation so that optimal actions feel effortless, whereas inefficient actions feel effortful [52]. The FM uses two modes; Functional Integration (FI) lessons and Awareness through Movement (ATM) lessons [53]

An FI lesson comprises a hands-on, non-invasive and interactive approach. What occurs is the direct result of the interaction between the teacher and the client. The teacher uses what he/she feels and sees to guide the client to a more diverse, whole, and well-organized use of self. The teacher addresses the client's self image through the local musculoskeletal relationships of a specific GMP; first carefully exploring the structural characteristics of the client and then (nonverbally, hands-on) posing questions in relation to perceived free movement directions. Depending on the teacher's felt sense of the client's structural flexibility he/she also may (nonverbally, hands-on) propose alternative movement directions, without ever imposing change.

ATM lessons comprise a series of guided movement sequences, through which clients are led verbally, either in groups or individually. Clients are encouraged to move slowly and gently, usually lying down or sitting (some standing), with an emphasis on reducing effort and developing awareness. The teacher addresses the self image of the clients by suggesting that they explore specified local musculoskeletal relationships inherent in a selected GMP and belonging to a specified meaningful action (Figure 1). This implies that the clients' attention is directed to areas of self that may not be the ones to which he/she usually pays attention. The aim is to bring about a more complete sense of what the client is doing and how he/she is doing it. Having identified these characteristics means having found a way to study the own habituated movement patterns and thereby the method to change them.

The process of change

What are clearly and comprehensibly outlined in the method named Motivational Interviewing (MI) [49, 50] are inherent, but hidden and unspoken, principles of the FM. This implies honouring the patients' autonomy, listening with empathy, resisting the righting reflex, understanding and exploring the patient's own motivations, developing discrepancy, avoiding argumentation, rolling with resistance and empowering the patient by encouraging hope and optimism. The MI method is presented and used as a verbal method but in SML the MI principles are followed both in the verbal ATM mode and in the nonverbal FI, FM mode.

All emotions are, in essence, impulses to act and Edmund Jacobsen was the first to develop an evidence-based self-observational technique aimed at kinaesthetic awareness of the tension level of bodily musculature. He demonstrated that the action potentials in muscles vary in a predictable way with mental activity and especially with feelings of tension [54]. The intimate bond between emotions, thoughts and movements often seem obvious to patients; with fear the body tends to freeze and sadness brings significant loss of muscular strength. Moreover, that bodily movements reveal the thoughts and intentions of people more truly than do words, which may be untrue, is not controversial [55]. In addition to experience-based discussions on the relationship between emotions and bodily movement patterns, Figure 2 may be used to describe these complex relationships to the patient and explain how pain, strain and being out of balance can be created as a result of self induced protective pain behaviour.

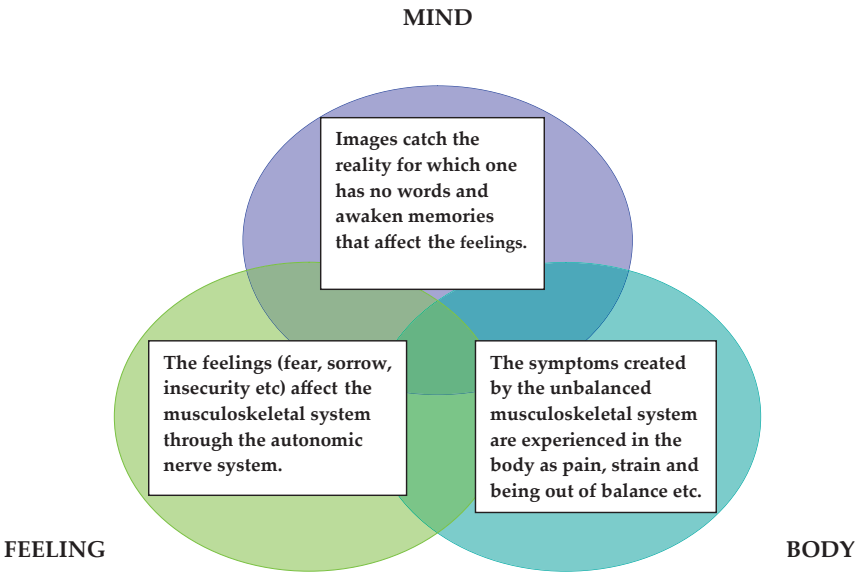


Figure 2. Illustration of a hypothesis stating how protective pain behaviour is being created through the circular relationship between mind, body and feelings leading to a less transparent self image.

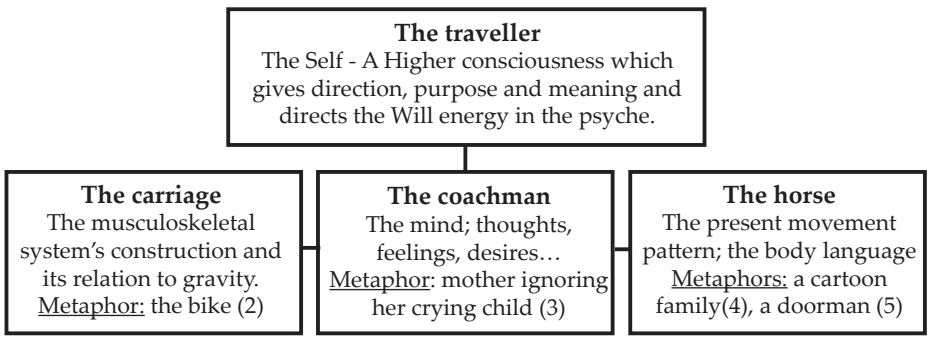
Information, however, rarely leads to profound change. It was Albert Einstein who said that imagination is more important than knowledge if one needs to look at old problems from a new angle. This implies that in order for change to happen the emotional and sensory motives are more important than the cognitive ones. In the SML intervention selected metaphors are used to mobilize patients' creative potential and

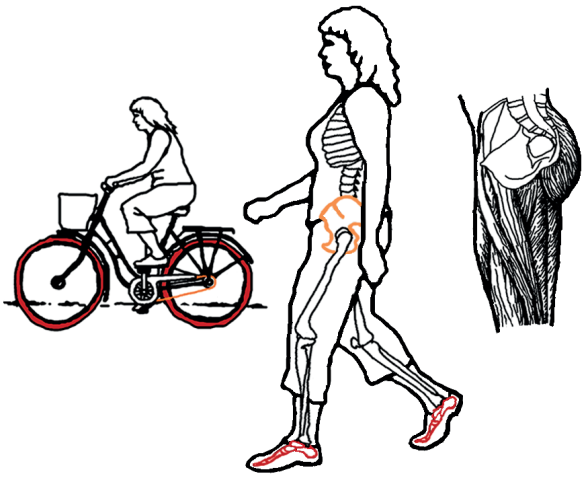
imaginative representations and to illustrate how ingrained habits and emotional reactions tend to limit efficient action.

This part of SML has been influenced by Psychosynthesis, a therapeutic approach, which uses imagery and metaphorical language to explore the unconscious and expand self awareness [46-48]. It seems as if this kind of imagery constitutes an important part of the SML intervention as a majority of patients say that the imagery helped them make sense of and see the meaning in earlier unexplained experiences and painful events. The embodied, emotional self may help a person to see the meaning or significance of something and apprehend its implications [56].

The metaphors nr 1 - 5 on the next pages are a few examples of the many that were created, in cooperation with patients, during SML lessons in response to their non-specific pain related disabilities. Metaphor nr 1 has been found to be a useful illustration of the relationship between self, mind and physical body, which helped the patients recognize the horse, carriage, coachman and traveller within themselves.

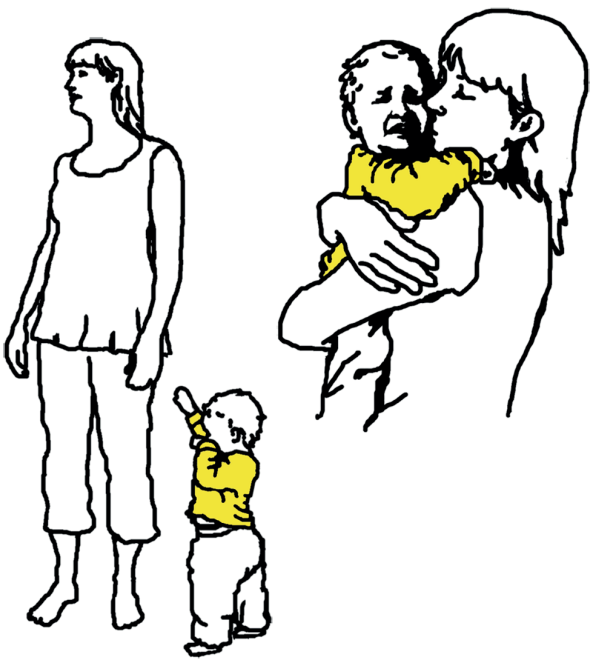
1. The horse, carriage and coachman





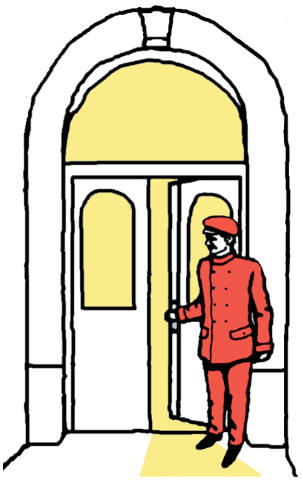
2. The bike;
a metaphor for the efficient construction of the human muscular skeletal system; able to perform many activities for example the complex activity called walking. The tyres of the bike mirror the feet, both of which function best when they are full of bounce. The construction of the bicycle chain and the wheel hub mirror the functional anatomy of the spinal pelvic muscular system. They both function at their best when there is free transmission of force through the system. This can be accomplished only if there is no mechanical obstacle or muscular constraints. The bicycle handlebars mirror the shoulder girdle, both being constructed to move easily with very little strain.

3. A mother ignoring her crying child;
a metaphor for a localized pain, which risks becoming chronic. The image, in which a crying child seeks attention from a busy mother, illustrates how a local pain or discomfort seeks attention from an occupied mind. If the mother ignores the crying child for long enough the child may finally stop crying but, instead, become depressed. If the mother learns how to increase her self-awareness, however, then her self-understanding, her self- acceptance and her self-mastery will increase and in this way will enable her to console her child (her distressed inner self).



4. A cartoon family;
a metaphor for a spinal system with reduced function due to inefficient transmission of forces caused by an uneven distribution of movements along the spine. If the distribution of movements had been ideal in relation to the functional anatomy of the human spine there would have been more motion, especially in the thoracic part of the spine (the husband would be more moveable) and less motion in the lumbar part (the woman would relax a little to ease the muscular strain).

5. An anxious doorman holding on to doors;
a metaphor for situations in which some muscles habitually hold and thus hinder movements in some vertebral joints, forcing other muscles to work too hard and too much. If the pain related fear can be reduced; however, the doorman will be able to open and close the doors in a more reliable way.



The therapeutic relationship

The relation between the SML teacher and her patient is of same character as between a FM method teacher and his/her student and it may best be characterised as empathic. The basic aspect of empathy is an awareness, an understanding, a knowledge of another's state, condition or consciousness. Many researchers, in the field of neuroscience [56-61] and in psychology [62-64], consider empathy as embodied understanding, which means that empathy provides the empathizer with some kind of knowledge. Empathy can be viewed as the capacity by which one person obtains knowledge of the subjective side of another person.

In the empathetic position the intention is to meet and see the patient from his/her position. The focus of attention is directed towards the SML teacher's own bodily felt sense while observing the patient's MG. The information the SML therapist obtains while sensing/observing the MG of the moving patient is indispensable for determining what strategy to suggest the patient to try out.

The primary question the SML teacher asks herself while observing a patient moving, or with her hands exploring the patient's structural characteristics is; "how may this person experience herself (her bodily self image) so that she is "forced" to use herself in the way she does (the observed MG) and perceive the enclosed pain related symptoms?" – Or put differently; "which are the unconscious bodily constraints that this person habitually and thus unconsciously enacts thereby causing the observed symptoms and the self imposed limitations in her use of herself?" Often, what is most obvious to the observing SML teacher is totally hidden to the patient; she can not kinesthetically perceive how she moves.

The answers that emerge intuitively from these implicitly posed questions gives rise to ideas to try. The SML teacher's task is to guide the patient to discover kinesthetically how she is unconsciously and habitually using unnecessary muscular tensions. Once she has found how she does this she can stop doing it and a way out of the self imposed protective pain behavior has been found. Freeing self imposed protective pain behaviour is supposed to produce significant relief of muscular strain and reduce pain.

The character of the relationship between the SML teacher and the patient leads to a researching partnership. This relationship implies that the outcome of the intervention is not predictable. This will inevitably influence not only what the patient learns but also the patient's locus of control and his/her self efficacy.

Conclusion

Three phenomena were assumed to play a decisive role for the SML intervention comprising an efficient intervention in cases of NSCLBP:

1. *The quality of the individual patient's movement patterns*; an individual's movement patterns are considered efficient when the individual can coordinate the movements inherent in the actual GMP into a smooth whole body action. Protective pain behaviour is supposed to give rise to restrictive, inefficient movement patterns, which in turn produce negative muscular strain and pain. To investigate if the SML intervention can guide a patient with NSCLBP to free himself from protective pain behaviour and enact more efficient patterns of movement requires a valid and reliable outcome measure. This method must be able to capture the essential distinguishing GMP of a specified action and monitor the movements as an integrated whole, i.e. an entity comprised of interdependent parts working together.

2. *The principles and pertinent approaches to be followed to induce an efficient process of health behaviour change;* to evaluate how meaningful the patient finds persisting in the SML intervention can only be assessed through interviews, performed and analysed in accordance with appropriate qualitative research methodology.

3. *The efficiency of the therapeutic relationship inherent in the SML intervention;* if the character of the relationship between the patient and the SML teacher has been of decisive importance or not can not be assessed by asking the patient directly. By using a focus group the questions can be asked indirectly and if the discussions are performed and analysed in accordance with appropriate qualitative research methodology the answer can be found.

MATERIALS AND METHODS

Ethics

The studies were approved by the Ethics Committee of the Faculty of Medicine at the University of Gothenburg. The ethical principles for the humanities and social sciences regarding openness, consent, confidentiality and autonomy were followed.

Setting and participants

Patients with nonspecific chronic low back pain (NSCLBP), who had not been helped by any treatment and who, despite degenerative changes in the lower lumbar spine, were not expected to benefit from spinal surgery were selected by two orthopaedic spine surgeons in the Department of Orthopaedics, Sahlgrenska University Hospital, Gothenburg, Sweden. The patients had been referred to the Department of Orthopedics by primary care physicians.

Inclusion criteria were:

- Swedish speaking patients of both sexes, aged 25-65 years
- Severe low back pain, with a duration of more than one year
- Degenerative changes in the lower lumbar spine with at least a decrease in disc height of 50% or more at 1-2 levels, seen on plain radiographs.
- Physical therapy treatments of any kind had proven unsuccessful.

Exclusion criteria were:

- Other pathologies e.g. disc herniations or spinal stenosis were excluded using computed tomography (CT), and/or magnetic resonance imaging (MRI).
- Specific radiological findings such as spondylolisthesis, signs of spinal stenosis, disabling arthritic joints, fractures, infection, inflammatory processes or neoplasm.
- Psychiatric illness.

The responsible spine surgeon informed his/her patient about the study.

Participation in study I, II and III implied:

- participation, for up to 12 months, in an intervention focusing on Sensory Motor Learning (SML)
- to attend a movement laboratory for objective, optoelectronic assessments of the performance of a simple physical task of daily life several times before and after the SML intervention,
- to be interviewed during the first part of the intervention and after its conclusion.

Control group

- In study I and II age- and gender matched volunteers with no back pain history were recruited as control subjects. Their occupations and fitness level varied. None of them was extremely well trained or had physical defects. They were asked to attend a movement laboratory for objective, optoelectronic assessments of the performance of a simple physical task of daily life 9 times. The measurements took around 30 minutes and were performed once a week for three weeks, on three occasions with 1 year in between. The volunteers were reimbursed for travel expenses.

Participation in study IV implied:

- filling in two self- report inventories on subjective health before intervention
- an extensive and careful examination of physical ability profile by an experienced physical therapist before the intervention
- participation in individualized physical therapy intervention for 6 up to 12 months, after being randomized to either:
    1. individualized, supervised exercise therapy (ET) or
    2. physical therapy with focus on sensory-motor learning (SML)
- participation in a focus group conversation after completion of the allocated intervention

All patients received written information about the study and were asked if they wanted to participate. All questioned chose to take part and gave informed consent.

Randomization procedure

While being supervised by an independent PT, the patient picked one envelope from a stack of 40 identical, glued envelopes, which were placed in a locked box. Twenty of these envelopes contained a letter referring the patient to a clinic specializing in ET and twenty of the envelopes containing a letter referring the patient to a clinic specializing in SML.

An overview of all the included patients' age, gender and years of severe back pain plus those of the control subjects are outlined in Table II and III.

Interventions

The patients were encouraged to come to the allocated intervention at least every two weeks, but the individual schedule was adjusted always to the patient's situation at work and at home. It was decided that the maximum time in the intervention would be 12 months.

In study IV the intervention was considered completed if the responsible physical therapist judged that a patient had participated regularly for 6 months or longer. The

decision was based on the assumption that this was the minimum amount of time needed to achieve a lasting health related change of any kind.

Table II. Patients included in study I, II and III and control subjects in study I and II.

Age at inclusion		Gender: F= Female M = Male		Years of severe NSCLBP before inclusion		Low back surgery before inclusion	
Patient N=12	Control N=12	Patient N=12	Control N=12	Patient N=12	Control N=12	Patient N=12	Control N=12
(1) 39	39	F	M	3	0	no	no
(2) 40	42	F	F	4	0	no	no
(3) 52	61	F	F	4	0	yes	no
(4) 45	52	M	M	16	0	no	no
(5) 42	43	F	F	6	0	no	no
(6) 26	20	F	F	4	0	no	no
(7) 42	48	M	M	13	0	no	no
(8) 44	51	M	M	10	0	no	no
(9) 32	17	M	M	9	0	yes	no
(10) 34	17	M	M	5	0	no	no
(11) 44	46	F	F	20	0	yes	no
(12) 61	84	F	F	14	0	yes	no
Mean: 42 Median: 42	Mean: 43 Median: 44	F (N=7) M (N=5)	F (N=6) M (N=6)	Mean: 9 Median: 8	Mean: 0 Median: 0	No (N=8) Yes (N=4)	No (N=12) Yes(N =0)

Table III: Patients included in study IV; Exercise therapy (ET), Sensory-motor learning = SML

Included patients:	ET group N = 20	SML group N = 20
Age at inclusion	Mean: 41.1 59 max 25 min	Mean: 42.5 57 max 28 min
Gender: F= Female M = Male	F (N = 12) M (N =8)	F (N = 14) M (N = 6)
Years of severe NSCLBP before inclusion	Mean: 7,5 20 max 2 min	Mean: 7,0 20 max 1 min
Low back surgery before inclusion	N = 4	N = 8

Sensory Motor learning (SML) lessons

The SML lessons were provided by one of two experienced physical therapists who were both trained Feldenkrais teachers [53], with more than 5 years experience.

The intent was to create an environment that felt safe enough for the patients to focus on kinaesthetic self-awareness and not on the instructor. The following three strategies were used:

1. The patients were taught the basic principles of 'focusing', i.e. learning to become aware of very subtle and vague internal bodily signals/motions, termed 'felt sense'. As a patient learns how to 'focus' on the 'felt sense' of self, the SML movement explorations become more tangible and easier to work with [65, 66].
2. The patients were guided to notice the slightest movements in their bodies; to feel how breathing rhythms moved through the body; to explore the body's imprint on the floor when they were lying down and thus discover how each slight motion influenced the shape of their skeletal structure. These subtle explorations were aimed at identifying the gap between an intention to move and the body's execution of the intent. Being able to identify this gap meant that they found a way to study their own habituated movement strategies and thus the means to change them [42, 67]
3. A number of mental images were used to illustrate how ingrained habits and emotional reactions restrain efficient action and helped the patients make sense of the 'felt sense' of self and of experiences from the movement explorations. The metaphors used by the SML theacher as she described body states were meant to mobilize the patients' creative potential and imaginative thoughts. The overall aim was that the patients should acquire a strategy for dealing with back pain, physical disability and psychological distress in the future [48, 68-70]

Supervised Exercise Therapy sessions (ET)

Based on extensive and careful physical examination, the individually designed ET programs were composed by one of two physical therapists; both with extensive knowledge and more than 5 years experience working with ET. Most often the program included stabilizing, strengthening and stretching exercises to promote musculoskeletal, neuromuscular and circulatory functions. Training equipment was used only if it made the patient's performance more efficient. Each patient's performance was always supervised by one of the physical therapists and the program was modified when needed. Symptomatic pain relieving treatments such as acupuncture or hot- or ice-packs were never used.

Measurements overview

- In study I and II the patients' and the control subjects' movement capacity was assessed using the objective, optoelectronic Posturo-Locomotion-Manual (PLM) test. The measurements were performed at three occasions; the first occasion before the SML intervention, the second directly after the SML intervention and the third at one year after the conclusion of the SML intervention. At each test occasion the PLM test was assessed three times at three consecutive visits to the movement laboratory with one week intervals.

- In study III two interviews with each patient were performed to evaluate how the SML intervention influenced the patients as regarded from their subjective cognitive perspectives. All interviews were audio recorded and transcribed verbatim.

- The patients also completed a questionnaire on subjective health (constructed by the researchers) aimed as an introduction to the one year post SML intervention follow-up assessment by the responsible orthopaedic spine surgeon.

- In study IV two questionnaires on subjective health and one the extensive instrument to assess profile of physical ability were chosen to control comparability between the two randomized groups; ET and SML. The questionnaires were the Karolinska Scales of personality (KSP) and the Short Form 36 Health Survey (SF – 36). The Test Instrument for Profile of Physical Ability (TIPPA) was chosen to assess physical ability profile.

- Focus group discussions were performed to compare how the patients expressed their experiences from two different interventions that are based on different conceptual frameworks; SML and exercise therapy (ET).

Quantitative measurements

The Posturo-Locomotion-Manual (PLM) test

The PLM-test uses an optoelectronic measurement system to record the dynamic performance of a simple goal-directed physical activity during a timed test. Seven spherical markers (5 cm diameter) covered with infrared light-reflective tape were placed on defined parts of the subject's body; the head, one shoulder, one arm, one hip, both legs and on a small object. The position of the markers in 2-D space was recorded every 20 milliseconds by the optoelectronic system, which had an infrared flashlight.

To perform the PLM-test the subject was asked to move repeatedly the small (500 grams) object with a convenient handle, from a clearly marked starting place on the

floor, to a stand located at chin level, 1.5 meters in front of the starting place. Thus the body had to carry out postural changes (bending down to take the handle and rising again) (the P-phase), locomotion (walking forward) (the L-phase) and a targeted arm movement (placing the object on the stand) (the M-phase) (Figure 3).

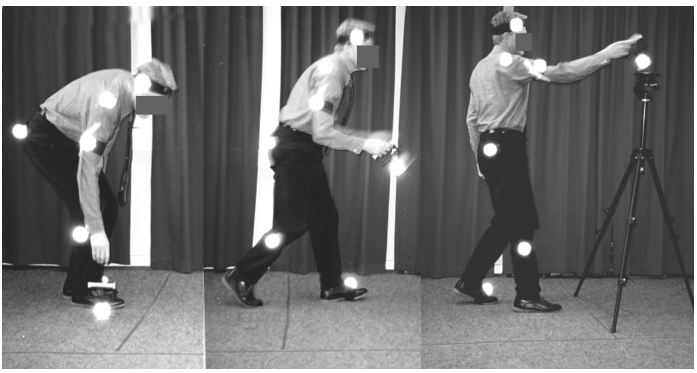


Figure 3. The Posturo-Locomotion-Manual (PLM) test. The freely moving subject is instructed to transport an object as quickly as possible from floor to stand.

The PLM phases (P-, L and M-phases) were identified by the software by calculating the velocity profiles of the markers placed on the body. The PLM phases have in common starting from zero velocity, reaching a maximum velocity and then decelerating to standstill, i.e. they are monophasic. As every measurement system provides an inherent noise in the signal a "zero level" cannot be identified. Instead a minimum value of the velocity was set to identify the movement start of each specific PLM-phase and in an analogous manner the end point of the phase was set to when the velocity was less than a specific value. These parameters, included in the PLM software, have been found previously to be stable for all measurements.

The computer software inspected the velocity profiles of the markers placed on the subject and on the handle of the object and calculated the movements of the body in two-dimensional space while the subject moved forward. The return movement to the starting place was not recorded (Figure 4 A).

Three movement phases: The P-phase was derived from the velocity profile of the marker on the head and measured the time spent to elevate the body, from the moment the object is gripped, until the body is fully straightened. The L-phase is a measure of the time spent for locomotion, which was determined by assessing the movements of the markers on the legs. The M-phase is a measure of the time spent for the forward aiming arm movement, placing the handle on the stand. The M-phase was derived from the markers on the hip, the shoulder and the arm by inspection of the angular velocity between the arm and the trunk (Figure 4 A and B).

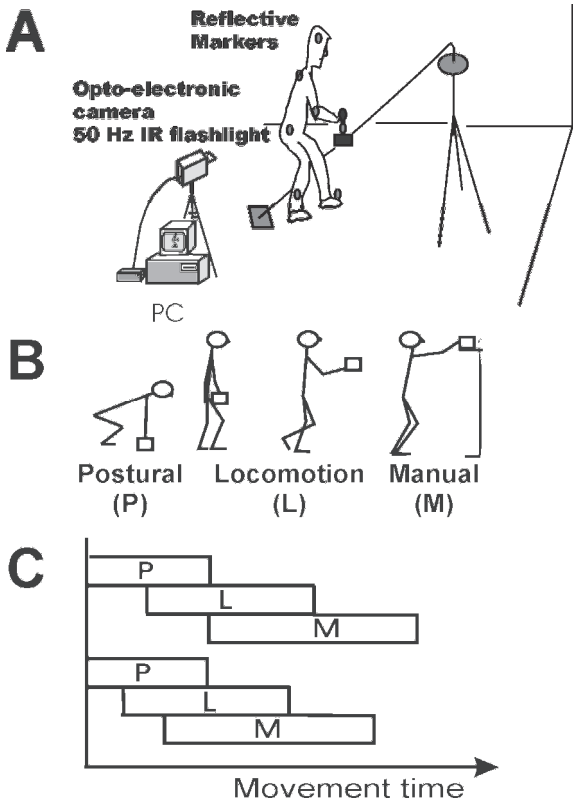


Figure 4. Set-up of the Posturo-Locomotion-Manual test.

A. The body movements are recorded using an optoelectronic camera and infra-red reflective markers. B. The time for raising the body (P), locomotion (L) and arm movement (M) are calculated. C. Decreased movement time (MT) can be accomplished by an increase in simultaneity of the postural (P), locomotor (L) and manual (M) phases. The simultaneity index (SI) reflects this association.

Movement time (MT) was identified from the velocity profiles of the marker placed on the handle of the object by calculating the mean time spent for 3 consecutive forward movements of the object from its starting position on the floor to the stand.

The degree by which, in action, the P-, L- and M-phases are performed simultaneously is calculated and defined as the simultaneity index (SI). SI = (P + L + M) / MT (Figure 4 C).

The most efficient way to move the object quickly from the floor to the shelf is by transporting the object along a straight line. The dextrous human body unconsciously follows this demand by initiating the different movement phases (P-, L- and M- phases) with a degree of simultaneity as high as possible. In a healthy person, this appears to give the impression of a smoothly performed, well-integrated, whole body movement.

To assess the degree by which, in action, the 3 different P-, L- and M- phases were integrated into one single movement, a Simultaneity Index (SI) was derived from the following formula: SI = (P + L + M) / MT. An improved simultaneity of the PLM phases is reflected by an increase of the Simultaneity Index (SI). This means that SI will increase if the gait (L-phase) and/or arm movement (M- phase) is initiated earlier during the PLM test action. Increasing the simultaneity will speed up the movement task without the need for increased muscle work (Figure 4 C).

Data collection procedure: A trained laboratory assistant performed the PLM tests in a clinical movement laboratory at the Sahlgrenska university hospital in Gothenburg. The subject to be tested was instructed to stand at the marked starting place with the object on the floor beside him /her. At a start command, the subject was asked to grip the object, move forward as quickly as possible and place the object on the stand (Figure 3).

To perform any action as fast as possible one has to accelerate from a standstill. To reach maximal speed of the short PLM test-action the subject needs, therefore, to make more than one repetition transporting the object from the floor to the stand. At the same time, tiredness must not impair the subject's performance. We chose three repetitions to balance these two components in this study.

The action of moving the object from the floor to the stand, had to be accomplished 3 times without pausing. After the third move was accomplished, the subject had to rest for 1-2 minutes. At each test occasion this procedure was repeated ten times (with 3 repetitions each time), i.e. a total of 30 moves forwards.

Collection and analysis of PLM data: At each test occasion the ten times three PLM test performances were captured by the optoelectronic video camera system and stored on a personal computer. For each trial of three PLM test performances the software (PLM program) calculated the mean and standard deviation for each of the five aspects of the PLM test movement. The five aspects were movement time (MT), the three movement phases, Posturo (P) -, Locomotion (L) -and Manual (M) – phases and Simultaneity Index (SI). The mean value was calculated from the three repetitions made for each measurement to obtain the maximal performance capacity.

Thus the data available for the evaluation of each subject's performance at each visit consisted of ten measures of each of the five aspects of the intentional physical task, moving a small object from the floor to a shelf.

To discover effects of spontaneous variations in performance or of test movement habituation and effects of the SML intervention, the reliability of the PLM test performance was estimated by means of repeated measurements. Three test sessions were performed; the first test session before the SML intervention, the second test session directly after the SML intervention and the third test session ten to twelve months after completion of the SML intervention. At each test session the patients came to the movement laboratory, once a week for three consecutive weeks. The age and gender matched control subjects were investigated at the same time intervals as the patients.

To capture the most reliable measure, changes over time were studied and several different approaches to the ten measures of the five aspects were compared. Three approaches were of main concern:
Approach 1) the mean of all the ten measures.
Approach 2) the mean of the last four of the ten measures.
Approach 3) the lowest mean found out of any of three consecutive measures among the ten measures (denoted as *tri-average*).

Every PLM-test performance was also recorded with a regular stationary video camera. This was done to permit later inspection of the test movements.

Questionnaire on subjective health (self made)

In study III the patients´ experiences and spine surgeons´ evaluations were assessed one year after the conclusion of the SML intervention. The patients returned for a 30 minute, one year post SML intervention, follow-up assessment by the referring spine surgeon. Before meeting with the spine surgeon, each patient answered a multiple choice questionnaire consisting of 8 questions concerning different aspects of subjective health compared with his/her perceptions prior to the intervention. The 8 aspects were: level of well being, relaxation ability, stress level, fear of movement, back pain, analgesic consumption, body function, and activity level. The patients' answers to the questionnaire and the spine surgeon's evaluation were documented in the case records, which were then analyzed.

The Karolinska Scales of personality (KSP)

Multiple studies have documented a strong association between chronic low back pain and psychopathology including personality disorders, depressive disorders and anxiety [71]. To differentiate patients with personality disorders and to compare personality traits between the patients in the SML and ET groups the self-reporting in-

ventory Karolinska Scales of Personality (KSP) was used [72, 73]. KSP was considered a valid instrument to compare personality traits and has been used in patients with chronic low back pain in earlier large studies [74]. The instrument measures stable personality traits and it comprises 135 items grouped in 15 scales; four of the scales concern anxiety proneness; three are related to vulnerability, six to aggression and hostility and two to social withdrawal [73].

The Short Form 36 Health Survey (SF 36)

To establish comparability concerning health related quality of life, between the patients in the SML and ET groups, the self-reporting inventory SF 36 was chosen. SF 36 has been shown to be a sufficient measure of health status and patient function, in studies of patients with low back problems [75]. The instrument assesses the patients' perceptions of their physical functioning, subjective well-being and general health during the preceding 4 weeks. The result is summarised in eight subscales and one physical and one mental health summary measure. Four subscales measures physical health domains and four subscales measure psychological health domains.

The test Instrument for Profile of Physical Ability (TIPPA)

To assess the patients' physical ability level the extensive test Instrument for Profile of Physical Ability (TIPPA) was chosen. The instrument was developed at a rehabilitation clinic in Gothenburg, Sweden and was published in Swedish in 2004 [76]. It is regarded as a valid, reliable and standardized instrument aimed at assessing physical ability from multiple perspectives. It comprises four variables (A-D), each variable having 5 grades. Variable B is the main variable and assesses the patient's observed physical ability while performing nine selected physical activities (Table IV). For one separate individual the TIPPA result can be illustrated graphically and two assessments can be compared easily. The median grade is used if groups of individuals are compared (Figure 5). A user manual standardizes the test procedure and the grading of the variables.

An independent physical therapist (PT), qualified in TIPPA test procedures, observed the performances and documented the results. The patients completed the TIPPA test before and after conclusion of the interventions.

TIPPA variable A-D:	I	II	III	IV	V
A: Patient's estimation of present physical ability	Very low	Low	Fairly good	Good	Very Good
B: Physical activities	Very low	Low	Moderate	High	Very high
1. Walking					
2. Speed walking					
3. Stair climbing					
4. Climbing on a stool					
5. Grip force; - left					
- right					
6. Drawing above shoulder - left					
- right					
7. Stand-up					
8. Lifting object waist to Shoulder level - left					
- right					
9. Lifting object waist to floor					
C: Patient's rating of perceived exertion	Extremely heavy	Heavy	Moderate	Light	Extremely light
D: Pain behaviour	Extremely high	High	Moderate	Low	None

Figure 5. An example of profiles from two TIPPA test assessments from the same patient

Table IV: Description of the nine selected physical activities in TIPPA - variable B with WHO ICF codes

	Selected physical activities (ICF-code d*)	**Outcome as body functions** (ICF code b*)	**Outcome unit**
1	**Walking** for 5 minutes. (d 4500)	Muscle endurance & joint range of motion (RoM)	Distance covered in meters
2	**Speed walking**, 20 m as fast as possible. (d 4508)	Muscle strength, endurance & joint RoM	Seconds
3	**Stair climbing** up and down conventional stairs, (at least 10 steps high), for 1 minute. (d 4551)	Lower extremities muscle strength, endurance & joints RoM	Number of steps covered
4	**Climbing on and off a stool**, 25 cm high, for 1 minute. (d 4551)	Whole body balance and lower extremities muscle strength & joint RoM	Number of repetitions
5	**Grip** by "Grippit Instrument"- two trials by left and by right hand. (d 4401)	Hand muscle strength & joint RoM	Newton
6	**Drawing above the shoulder level,** both arms at the same time, as long as possible. (d 4452)	Neck & shoulder muscles static endurance, stability. Shoulder joint & trunk joint RoM	Seconds (left and right)
7	**Standing-up** and sitting down from a 44 cm high chair for 1 minute. (d 4103)	Lower extremities muscle strength and endurance Lower extr. joint RoM	Number of repetitions
8	**Lifting object waist to shoulder level**, a self selected load with left and with right hand from 80 cm up to shelf at 133 cm for 2 minutes. (d 4300)	Upper extremities muscle strength and endurance. trunk & shoulder joint RoM	Load (kg) x number of repetitions
9	**Lifting object waist to floor**, a self selected load, from an 80 cm high table to the floor by turning to one side for 2 minutes. (d 4300)	Whole body muscle strength, endurance and joint RoM.	Load (kg) x number of repetitions

ICF = International Classification of Functioning, Disability and Health

Statistical methods

In study I mean, median, standard deviation (SD) and range were calculated for descriptive purposes.

In order to evaluate the reliability, the following measures were calculated and evaluated: Limits of agreement (ref), Intra Individual Standard Deviation (IISD) (ref) and the Wilcoxon Signed Rank Test. Tests between groups were performed with Mann-Whitney's U-test. Statistical tests were two-tailed and conducted at 5 % significance level. Differences between Visit 1 and Visit 2 as well as differences between Visit 1 and Visit 3 were analysed.

Mean difference and SD for difference were calculated by subtracting values obtained at a later visit from a previous visit. Limits of agreement (LOA) were calculated as $mean_{diff} \pm 1.96 * SD_{diff}$ [77]. This is a confidence interval (CI) for the difference between measurement session occasions. IISD was a defined as the SD within measures. The difference between two measurements for the same subject was expected (with 95% accuracy) to be less than $\sqrt{2}*1.96*IISD$.

In study II, in order to minimize the influence of movement habituation according to the result of the test-retest study(I) the lowest mean value found out of any of three consecutive measures among the ten computer generated measures were used to calculate each of the five aspects of the PLM task

For descriptive purposes mean, median, standard deviation (SD) and range were calculated. For comparison between groups Fisher's nonparametric permutation test was used. For comparison over time within groups Fisher's nonparametric permutation test for matched pairs was used. All tests were two-tailed and conducted at 5 % significance level.

In study IV the median is presented for categorical variables and for continuous variables the mean and standard deviations. Mann-Whitney U test was used to test differences between groups. A significance level of $p<0.05$ was considered significant.

The mean scores for the 15 KSP scales were transformed into normative *T*-scores (mean 50, S.D. 10), based on a Swedish age and gender-stratified, non-patient sample. Higher scores indicate"illness" in all scales except in the So_T scale in which a low score indicates illness [72].

In SF-36 each one of the eight health domains is scored from 0 to 100 with higher scores indicating better health and well-being. In the Swedish version the summary components, Physical component Summary and Mental component Summary, are

adjusted by the Swedish population mean and standard deviation to produce norm-based scores with a common mean of 50 and a standard deviation of 10 [78].

Qualitative assessments

In study III two interviews were performed with each patient: the first after 3-5 months of SML intervention; the second 1 month after the SML intervention was completed. In study IV focus group discussions were carried out after the completion of the two interventions; SML and ET.

Individual interviews

The interviews took the form of a dialogue between the patient and an independent interviewer. The interviewer was a male physical therapist with interview expertise and who was knowledgeable in NSCLBP, but was not a SML teacher.

Data collection procedure: Four questions were included in the interview guide:

1. Why did you choose to participate in this intervention?
2. How would you describe the intervention?
3. What effects have the intervention had so far on your symptoms?
4. How would you explain the effects this intervention have had on you?

Follow-up questions were asked in order to probe beyond immediate responses. Each interview lasted 45 – 60 minutes, and was taped and transcribed verbatim. The total transcribed material consists of 100800 words (max. 7647 words; min. 2427 words/ interview).

Content analysis of the interviews

The transcribed interviews were analysed using qualitative conventional content analysis, with an inductive approach [79]. The systematic process was performed in a 7-step iterative procedure inspired by Graneheim et al [80]. The aim of the analysis was to construct accounts comprising a selection of typical statements in the twelve patients´ descriptions of the SML intervention in the first part of the process and after its completion. The resulting text thus is a synthesis of the accounts of all twelve patients, which also renders the text comprehensible and meaningful for readers.

Step 1. Overall understanding of each patient's account: The focus was on obtaining an understanding of the content of each interview by listening to the tape and reading through the transcripts several times.
Step 2. Identifying content, extracting and synthesizing parts of the interviews into themes and sub-themes: Excerpts that elucidated experiences and perceptions related to the SML intervention, through their content and context, were systematically collated

into themes, e.g. "patients' mental and attitudinal changes" and "new action and reduced pain".
Step 3. Condensing the description of each theme: The most salient statements were selected and each theme and sub-theme was condensed to a 1 to 2 page long text
Step 4. Preliminary drafting of two condensed accounts covering the interview material: A new short text was constructed by summarizing the condensed versions of each theme and sub-theme; one describing perceptions and experiences of the intervention in the beginning of the intervention and the other after its completion.
Step 5. Assessing the content of the two constructed texts: Three independent expert readers compared the content of the new constructed texts with the original interviews. They were asked especially to determine whether any critical topics from the interviews had been omitted in the constructed text, or vice versa.
Step 6. Final revision and translation: The resulting text was translated into English by a native speaker of Swedish and English. The translator and first author of the paper then discussed the translation to ensure that translation and original text were in agreement.
Step 7. Interpretation of results: The SML teacher (CSO) interpreted and commented the content in the condensed texts from her professional perspective.

Focus group discussions

Focus group discussions were performed to assess how the patients expressed their experiences from the intervention to which they had been allocated, manifested in their own language and in accordance with their own conceptual frameworks and images of selves. It was assumed that it was possible to hear differences in the experiences from the two groups, ET and SML, through the conversations between the patients in each group [81]. As a person's perception of him- /herself is partly subconscious one cannot directly ask; 'How do you perceive yourself?' Instead one needs to introduce a topic that generates a discussion *through* which you can hear how people perceive themselves. It was considered interesting to include a method that focuses, not only on personal stories, but on the kind of stories that emerge when a group of persons with similar experiences talk to each other about a specific experience.

The patients were asked to participate in one focus group after having participated in the allocated intervention for a minimum of 6 months. This time limit was based on the assumption that this was the minimum amount of time needed to attain a well founded appraisal. Four focus groups were conducted; two aimed at patients in the SML group and two at patients in the ET group. All four focus groups were conducted by the same external moderators and the sessions lasted approximately two hours. The physical therapists who implemented the interventions and the researcher (CSO) were present at each focus group.

The four focus groups had the same structure; a moderator made a short introduction containing information on the purpose of the focus group, how the conversation was to be documented and how the material would be treated afterwards. When everyone was aware of the conditions and had agreed to take part the moderators, the therapists and the patients engaged in a 'free' conversation. This form of focus group is classified as unstructured with high-moderator-involvement [82].

The question to the focus group participants was 'What would you like to tell others about your experience from the intervention so that they (the others) can make an informed decision on whether to participate in this type of intervention?' Thus, the purpose was not to make the participants evaluate the intervention, but to invite them to contribute what meaning the intervention had to them.

Analysis of the focus group discussions

The focus group conversations were audio recorded and transcribed verbatim. The transcripts have been shortened and processed in two steps by the researcher (CSO). First, the transcripts were condensed. Secondly, the condensed material was categorized and grouped into themes. Thereafter two of the co-authors (MH, LR) went through the transcripts to ensure that the processed material was 'true' to the original transcripts; that nothing of importance had been added, neglected or distorted. One of the co-authors had the advantage of having heard the focus group first hand as a moderator (MH). The second co-author had the advantage of not having heard the focus groups first hand (LR). Finally the Swedish text was translated into English by the first author of the paper and proof-read by a native speaker of English.

RESULTS

Results Study I.

The aim of study I was to investigate if the PLM test was a valid and reliable measurement tool, able to assess dynamic movement capacity objectively, in freely moving patients with NSCLBP.

At each test occasion the PLM test-action was repeated ten times (with 3 repetitions each time) i.e. in total 30 forward moves, resulting in 10 computer based measures. Statistical calculations, comparing several different approaches to the 10 measures of the five aspects (MT, P, L, M and SI) were performed to detect effects of test movement habituation and capture the most reliable measure of the performance (I).

Effects of test movement habituation

Effects of test movement habituation existed in both the patient and the control groups. At the first visit to the movement laboratory both groups successively increased their speed during the first ten PLM test trials. The tendency was much less marked on successive visits. The systematic effects of test movement habituation are demonstrated graphically as changes over time within the same day (Figure 6).

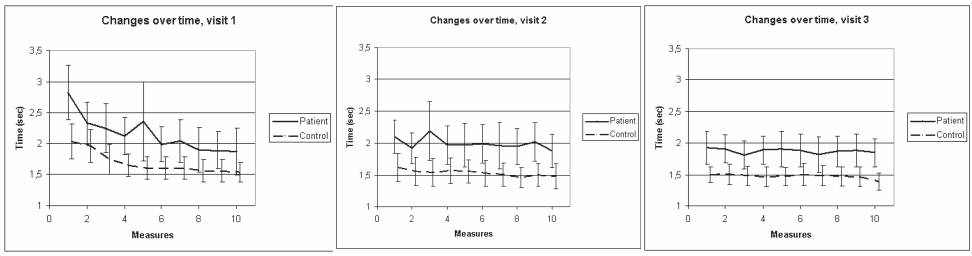


Figure 6. Comparison of mean values for movement time at visit 1, visit 2 and visit 3 for each of the 10 measures, which the software (PLM program) automatically calculated, for the patient group (n = 12) and the control group (n = 12). Error bars represent 95 % confidence intervals.

In Figure 7 box plots are used to describe changes in MT for all the 24 subjects between the 3 consecutive visits before intervention, when comparing the mean of all ten measures and the lowest mean found out of any of three consecutive measures among the ten measures (*tri-average*). The figure shows that the mean MT was more stable over time when the tri-average was used. In week 1 and 2 there were some outliers (all three were patients with NSCLBP). At visit 3 no outliers were found. The

outlier values indicate unsuccessful performance of test movement, caused perhaps by a sudden feeling of insecurity or by pain in the test situation.

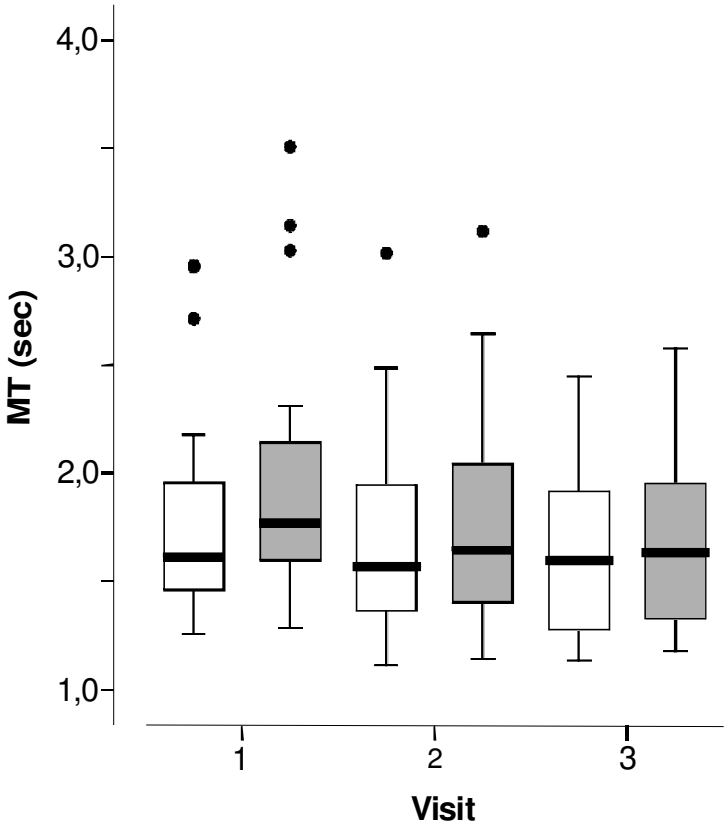


Figure 7. Comparison of movement time (MT) for all subjects at visit 1, 2 and 3 (N = 24) when using the mean of all ten measures (filled boxes) and the tri-average (open boxes). Outliers are defined as > 1.5 x IQR (Inter Quartile range).

Spontaneous variations in PLM test performance

The patients' variability in PLM test performance between the three visits at the first test session is reflected by the intra individual standard deviation (IISD). IISD for the group of patients was always greater than IISD for the control group for all the time related aspects (MT, P-, L-, M-phases) (I).

At test session one the IISD was lower for the SI than for MT, P, L and M phases. The fact that SI varied little between the 3 first visits in both groups shows that even though the speed of the PLM test performance varied, the integration of the different movement phases to a smooth whole-body movement was stable (I).

After the SML intervention the variability of the PLM test performance as reflected by changes from immediately post intervention to one-year post intervention was reduced. The IISD indicates that the stability between measurements increased after the SML intervention and became equally as high for the patient group as for the control group (I).

When comparing the PLM test results of the patient group with the control group, statistically significant differences were found. The performance of the back healthy control group was better than the performance of the patient group in all the aspects of the PLM test movement except in the L-phase. The differences are displayed in Table V.

Table V. PLM test results comparing the group of CLBP patients (N = 12) and the group of back healthy controls (N = 12) before intervention, using the tri average measure of MT, P phase, L phase, M phase and SI-index

Mean (SD) Median (Range)	Patients (n=12)	Controls (n=12)	Test between groups, p-value
MT, Mean visit 1-3, 3 fastest	1.90(0.40) 1.84(1.35,2.81)	1.49(0.28) 1.38(1.20,2.06)	0.009*
P-phase, Mean visit 1-3, 3 fastest	0.90(0.15) 0.86(0.64,1.10)	0.76(0.08) 0.73(0.67,0.91)	0.010*
L-phase, Mean visit 1-3, 3 fastest	1.29(0.23) 1.30(0.96,1.79)	1.15(0.21) 1.11(0.78,1.52)	0.18
M-phase, Mean visit 1-3, 3 fastest	1.13(0.21) 1.15(0.80,1.47)	0.90(0.19) 0.82(0.70,1.31)	0.009*
SI, Mean visit 1-3, 3 fastest	2.18(0.12) 2.15(2.02,2.37)	2.30(0.11) 2.30(2.08,2.51)	0.035*

* Statistical significant differences between groups p< 0.05.

Summary of results:

Effects of test movement habituation and/or motor learning existed both in the control group and in the patient group at visit 1 before intervention. If the tri-average measure was used and the PLM test repeated, the influence of test movement habituation was minimized and no significant systematic changes were found between visit 2-1 and 3-1. These results imply that the tri-average should be used to minimize the effects of PLM test movement habituation (I).

The reliability of the PLM test as reflected by limits of agreement (LOA) between visit 2-1 and 3-1 and by intra individual standard deviation (IISD) indicates that for the control group the variation between the three visits was substantially smaller than the variation for the patient group before the SML intervention. No significant systematic changes were found between visit 2-1 and 3-1 in the patient group if the tri-average was used. After the SML intervention the test-retest reliability of the PLM test was just as precise for the patient group as for the control group (I)

Results Study II.

The aim of study II was to evaluate how the SML intervention influenced movement capacity in patients with NSCLBP, measured with the PLM test. On average each patient chose to participate in 30 SML lessons (range 16 – 40) over 10 months (range four to twelve months). According to each patient's choice, 82 % of the SML lessons were individual and 18 % group lessons. Three of the twelve patients terminated the intervention before the maximum allowed time. None of them left because of increased pain or disability (II).

Before the SML intervention the PLM test results differed significantly between the patient group and the control group in all aspects of the PLM test except L-phase (Table V). The differences had disappeared after the SML intervention and at one year after the intervention (II).

In Figure 8 the changes over time within and between the patient group and the control group are displayed.

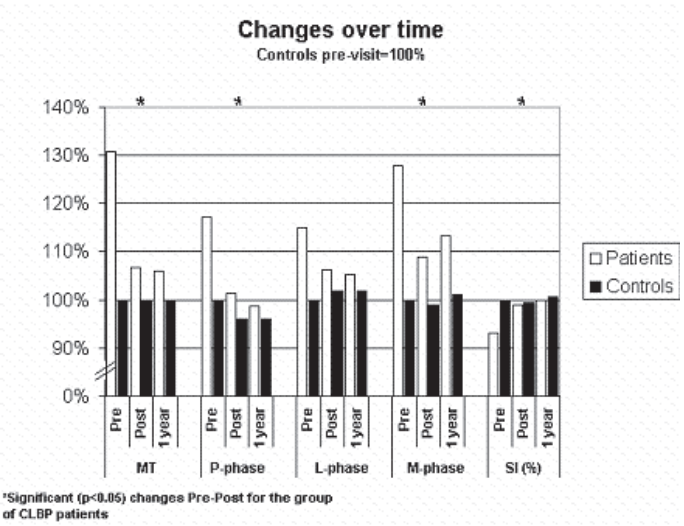


Figure 8. Comparison of changes in the five aspects of the PLM test before (pre), after (post) and one year after (1 year) intervention, within- and between the patient group and the control group.

Summary of results:

The results of the PLM tests showed that the patients improved their performance significantly over time when compared to the age and gender matched control group. After the SML intervention there were no longer any differences between the movement capacity of the patient group and the control group. The results were maintained one year after the SML intervention.

Results study III

The aim of study III was to evaluate how the SML intervention influenced a group of patients with NSCLBP regarding their subjective, cognitive perspectives. Two interviews with each patient were performed. All interviews were audio recorded and transcribed verbatim.

The contents in the interviews:

In the content analysis three main themes and four sub-themes were identified. What was said in the first interview was elaborated in the second one. This was the case for all themes:

1. Experience of the intervention:

1:1: New insights about the origin of the back pain
1:2: New action leading to reduced pain
1:3: Mental and attitudinal changes
1:4: New thoughts about reasons for the changes

2. Relation to SML teacher

3. Future perspective

The results of the content analysis of the interviews are outlined in Table VI.

Summary of results:

The patients described the SML intervention as a process during which they had learnt to reduce pain, to diminish psychological distress and to improve physical ability.

At the post SML intervention follow-up visit with the referring spine surgeons, one year after conclusion of the intervention, all but one patient reported that he/she still had some back pain, but it was no longer perceived as an impediment. All the patients said that their life had changed for the better (Figure 9).

Table VI. Summary of result from interview I and II.

No:	Themes:	Condensed texts from the patients' descriptions:	Comments:
1	**Experience of the intervention**	*I don't get told:" Do ten of these exercises three times a day", the method instead emanates from me. I should not repress my symptoms, but rather notice my reactions when I'm in pain. It is a matter of remaining calm, concentrated and observant. This has made me understand how to use my body in order to achieve maximum strength. The exercises play an important role, but it is not only a question of doing them; there is yet another dimension which is to learn how to feel and to see the connections within my own body. It may be just enough to think the movement.*	SML is characterized by the high precision in the kinaesthetically felt perceptions while moving. The work starts in a position where the patient feels at ease and where habituated patterns imposed by gravity are not prominent. The most common initial training position is supine.
1:1	New insights about the origin of the back pain	*I used to fear the pain and be somewhat angry with my back. Together, we have looked at the backbone (spine) and she (SML teacher) explained using pictures, as though to a child:" Your muscles are like a frightened doorman who holds the doors shut in order to protect the house". I do simple soft movements and breathe calmly as I try and shift body position to feel more comfortable. I have come to realise that the pain is caused by the tension in my muscles. It's like a journey of discovery and it is exciting.*	Mental imagery was used to provide the patients with experiences and thoughts that might produce beneficial change in each patient ´s self image. The patients learned to control the emotional reactions related to the pain-related fear.
1:2	New action leading to reduced pain	*When I left [after the first treatment], I felt a lightness in my body immediately. When I come home, I lie down on the floor and feel how I am relaxing. T hen I do specific small movements, trying at the same time to observe my breathing, and after a while my body tension relaxes. The pain has diminished and my body has become more supple so that I can tie my shoe laces. I can hang up the washing without feeling pain in my arms, neck and chest. I no longer wake up as often at nights and I manage without medicine for increasingly longer periods. If I feel pain, I now know how to handle it.*	Each patient was asked to choose the movement sequences they liked the most and perform them at home. It was assumed that performing these movements would not only decrease muscular effort but also result in pain alleviation and convey a sense of pleasure.

1:3	Mental and attitudinal changes	*My relationship to my back has changed; I don't know whether it is a physical or mental change, but I trust my body more and realise that it is stronger than I thought it was. My way of thinking has changed and I am more open with myself as well as with others. My mood has improved and I feel that I want so much more than I did before. I have learned to listen to the signals in my body; I have more energy and I do not get as anxious as I did before. I understand myself better and thinking in a different way even helps me to face other types of problems. I am not as sensitive to stress and I feel better.*	The patients learned to stay present in an observational position, not only in relationship to their own bodily structure but also in relation to their thoughts and feelings.
1:4	New thoughts about reasons for the changes	*I don't think one can explain with words, rather one has to learn the exercises and then, after a while, one will understand. It is sensible and not at all complicated. Maybe I had an injury in my back, which may have improved because I managed to get the nearby muscles to relax. Another alternative could be that I did not have an injury, but rather some kind of circular pain pattern that I have learned to break. I don't know which it could be and it really does not matter very much; the main thing is that I feel better.*	The theoretical framework behind the SML intervention is complex and not easy to describe. This fact was not a problem for the patients; they seemed to understand it implicitly.
2	**The relation to the SML teacher**	*I came to trust her and felt that she understood what I was conveying. She asked simple questions that made me reflect and understand. She has managed to bring out something from within me which stops me from becoming blocked and instead allows me to feel.*	The SML teacher uses *Socratic*, dialectical questioning, which implies that the patients got to answer their own questions by making them feel and reflect on their experiences, thus helping them to further their understanding.
3	**Future perspectives**	*I used to work against myself to deny the pain. I suppressed both my body and soul. Now I have become aware that I can change things on my own to improve my health. I have hope and believe that my heath could improve even more.*	Protective pain behaviour had been the main coping strategy for all the patients in this study. Hope of lasting recovery grew as the patients learned to reduce pain and diminish psychological distress.

Result of evaluation at one year after conclusion of SML intervention:

At the post SML intervention follow-up visit with the referring spine surgeons, one year after conclusion of the intervention, all but one patient reported that he/she still had some back pain, but it was no longer perceived as an impediment. All the patients said that their life had changed for the better. Nine of the twelve patients were back in fulltime employment. Three of them had been unable to work for more than two years due to back pain related disabilities. The referring spine surgeons concluded that all the patients were satisfied with the intervention.

The results from the questionnaire on subjective health are outlined in Figure 9. The median rank for the whole group was "much better" regarding subjective health at one year post intervention compared with how it had been before the intervention (Figure 9). This agreed with the oral reports given to their spine surgeons.

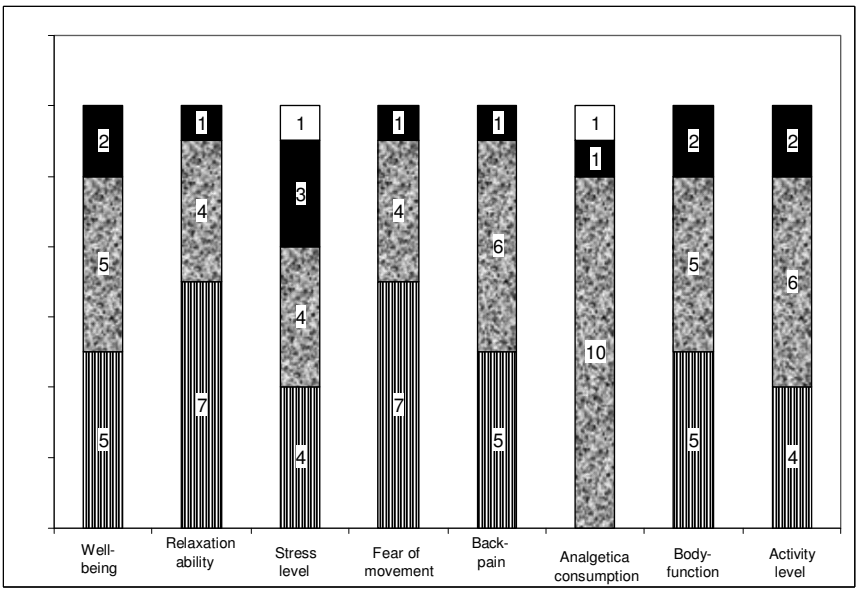


Figure 9. Every patient (N = 12) answered 8 questions concerning different aspects of subjective health at one year post intervention compared to before the intervention. The 4 ranking alternatives for all questions except "analgetics consumption" were:

much better | better | same | worse

For "analgetics consumption" there were 3 ranking alternatives:

Less | same | more

Results study IV

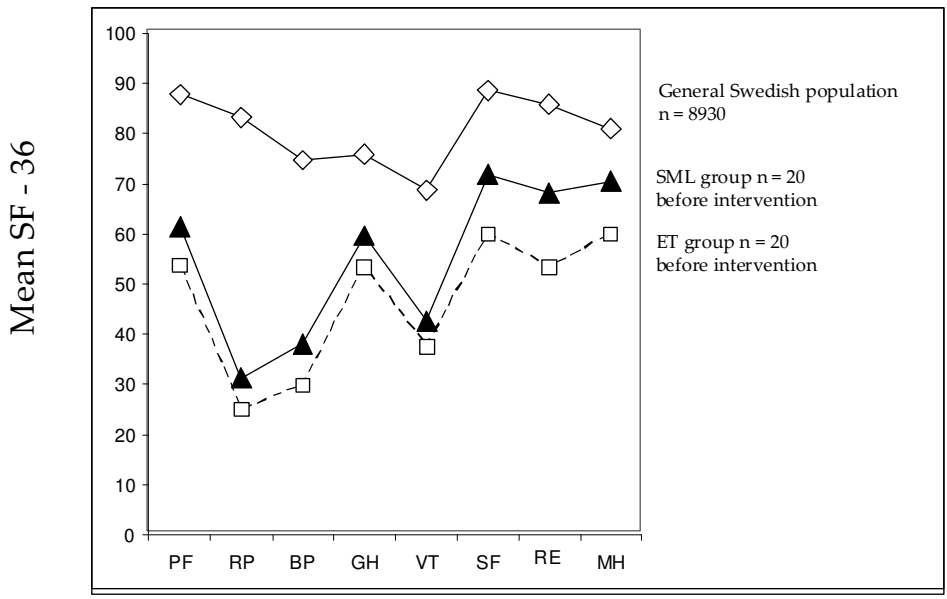
The aim of study IV was to compare how patients with NSCLBP express their experiences from two different interventions that are based on different conceptual frameworks; SML and exercise therapy (ET).

Comparability between the two randomised groups

No differences between the groups were found in age, gender or back pain duration. Of the patients allocated to ET, 12 were women and 8 men and to SML, 14 women and 6 men. The gender unevenness was congruent with earlier reported, hitherto unexplained differences in back pain prevalence [83]. The patients mean age in the ET group was 41 years (min 25, max 57) and in the SML group 42 years (min 28, max 57). Mean number of years in back pain were 7 years in both groups; (min 1, max 20).

Health related quality of life

The SF 36 instrument showed that no differences in health related quality of life were found before the interventions between the ET and the SML groups. Compared with the general Swedish population the whole group of patients (N = 40) were very limited in performing physical activities (PF scale), they had problems with daily activities due to physical health (RF scale), they were severely limited because of pain (BP scale) and they felt more tired and worn out (VT scale) [84] (Figure 10).



PF, Physical Functioning; RP, Physical role limitations; BP, Bodily Pain; GH, General health; VT, Vitality; SF, Social Functioning; RE, Emotional role limitations; MH, Mental Health

Figure 10. Health related quality of life; comparison between groups.

Personality traits

The KSP instrument showed that no differences in personality traits were found before the interventions between the ET (N = 20) and the SML (N = 20) groups. The personality traits of the whole patient group (N =40) were similar to a Swedish age and gender-stratified, non-patient sample. Only in the KSP scale "Muscular tension" the mean scores for both the ET and the SML group were higher than in the reference population (IV).

Profile of Physical Ability

The TIPPA instrument showed that no differences in profiles of physical ability were found before the interventions between the ET (N = 20) and the SML (N = 20) groups. The main TIPPA variable (B); the assessed performance of nine physical activities (Table IV) was scored as moderate in both groups. Minor differences were found in variable A and D (Table VII).

Table VII. Profile of physical ability before Interventions; comparison between groups

	Patients before intervention n = 40	
TIPPA variables A – D:	ET group n = 20	SML group n = 20
A: Patient's estimation of physical ability	Median: II Low	Median: III Fairly good
B: Physical activities assessed	Median: III Moderate	Median: III Moderate
C: Patients' rating perceived exertion	Median: III Moderate	Median: III Moderate
D: Pain behaviour observed	Median: IV Low	Median: III Moderate

Drop-outs and number of treatments in the two interventions

Only half of the 40 included patients remained in the allocated intervention during a minimum of 6 months. The number of months each patient participated in the allotted intervention is outlined in Table VIII. The number of drop-outs was similar in the two groups and the majority dropped out after only1 month. The reasons for dropping out vary and they are described in Table VIII.

Only four of the twelve patients from the ET group who stayed in the intervention for 6 months chose to continue for 12 months which was the maximum allowed time. In the SML group the corresponding number was 10 out of 11. Six of the eight patients in the ET group who chose not to continue after 6 months reported same or more pain as the reason to finish (Table VIII).

TABLE VIII: Number of months in each of the allocated interventions; Supervised Exercise Therapy (ET) and Sensory Motor Learning (SML) and reasons for dropping out, number of treatments given and participation in focus group discussion

Number of months in intervention	ET group n=20	SML group n=20	Prefer to continue self exercise as before allocated to intervention	Report same or more pain as the reason to finish the allocated intervention	Report pregnancy, illness or psychic problem as an impediment to continue allocated intervention	No reason given despite inquiry	Number of treatments/lessons given	Took part in focus group conversation
Drop outs before 1 month	n = 6	n = 8	ET; n = 1 SML; n = 3	ET; n = 3	ET; n = 1 SML; n = 4	ET; n = 1 SML; n=1	All: less than 6	Not applicable
Drop outs before 2 months		n = 1				SML; n =1	SML: n = 6	Not applicable
Drop outs after 2 but before 6 months	n = 2			ET; n =1	ET; n = 1		ET; mean: n = 17 (max 21, min 13)	Not applicable
Completed intervention after 6 but before 7 months	n = 8	n = 1	ET; n =1	ET; n = 6		ET; n = 1 SML; n = 1	ET; mean: n = 25 (max 38, min 16) SML: n = 12	ET; n = 5* SML; n =1
Completed intervention after12 months	n = 4	n = 10					ET; mean: n = 47 (max 83, min 25) SML; mean: n =29 (max 36, min 20)	ET; n = 3 SML; n = 10

* Four of the twelve patients in the ET group that completed the intervention (> 6 months in treatment), did not participate in a focus group conversation (id: 2, 3, 4 and 16)

The number of "treatments" differed between the groups (Table VIII). In this type of individualized interventions, however, it is important that the patients participate on a regular basis but that the individual schedule can differ because of individual preferences and practical circumstances. The intervention was considered completed if the responsible physical therapist judged that a patient had participated regularly for 6 months or longer regardless of the exact number of treatments. All the 23 patients (ET n =12 and SML n = 11) who participated for 6 months or longer were considered to have participated regularly in the allotted intervention (Table VIII).

Result of focus group conversations

Of the 23 patients who were invited to a focus group conversation 19 volunteered to participate. Four of the twelve patients in the ET group that completed the intervention (> 6 months in treatment) choose not to participate in a focus group conversation.

In the first ET focus group were 4 women and in the second were 2 women and 2 men. In the first SML focus group were 4 women and in the second were 5 women and 2 men (Table IX).

Four themes were identified when analysing the content of the focus group conversations.

1. Theme 1: Back pain – what can be done (Table IX A)
2. Theme 2: The aim of the intervention (Table IX B)
3. Theme 3: The relation to the therapist and to self (Table IX C)
4. Theme 4: The patients' self image (Table IX D)

Major differences in experiences of the two interventions were indentified through the focus group discussions. The results in form of condensed narratives are presented in Table IX A - D.

Theme 1: Back pain – what can be done

Major differences were found when comparing what the patients in the ET group and the SML group said about back pain. In the ET group the patients seemed convinced that the origin of the pain was a physical impairment and only the doctor had a solution. At the same time they seemed to know that the pain was evoked by their own activity choices. In the SML group the patients talked about the back pain as partly being located in their own mind and that they had become very aware of themselves and how they moved. They seemed to have accepted the fact that no one but themselves could really help them and they talked as if they had accepted this responsibility.

Table IX A; Theme I: Focus group results; condensed narratives

Themes:	The ET group:	The SML group:
Theme I: **Back pain -what can be done?**	*Back pain is so difficult because you cannot get a direct answer from a doctor:" I can operate and your back will be better". You never know for sure, even the doctor doesn't really know if it will get better. Before I am told to start exercising at least the doctor should know what is wrong; even though I understand that exercise can't be wrong. There must be something in my back which causes me so many problems and it is important for me to know why it aches and feels so uncomfortable! They only want to send me for a regular skeletal X-ray and that doesn't show everything. I have back pain every 2 -3 weeks; it hurts and then the pain disappears again after 3-7 days. I don't know what causes it. Sometimes it is nothing tangible but sometimes I know I have done something careless, such as carrying a case of bottles or a bag full of food. Then I know how to track it, but sometimes I don't think I have done anything at all to cause the pain. I would like to have a spinal fusion. If only I can get free of the pain I don't care if I don't get strong again.*	*This (intervention) is related to the idea that the problem is not located in my back, but in my mind. As long as I am aware of how I act all the time, I will protect my back and I won't put myself in situations which result in pain. If I am in pain I think:" How does it feel now? How am I sitting? How about my spine?" I am aware of myself and then I stretch and after having changed my position very little it suddenly feels good again. Then it may be OK for 5-10 minutes, but then the pain may come back somewhere else and if so I need to be aware of myself again. I think it is a big deal for me to be able to make these small changes. It is easier for me to accept my back as I am aware that it is part of me and I have taken responibility for it; it is no one else´s problem. I have experienced that the pain can disapperar so I know now that it can happen. Before I couldn't do anything; I had no alternative other than to put up with the pain. Now I know how it all works. I have to find the spot that is cramping and relax the muscles there. Then there is less pain.*

Theme 2: The aim of the intervention

In the ET focus groups the patients talked to each other about the importance of performing the prescribed physical exercises as these had been selected just for their specific disability. In the SML focus groups the patients talked about the big and difficult shift they had gone through; to stop exercising as hard as possible and start getting to know and trust in one's own body in order to protect it from stress-related overload and pain.

Table IX B; Theme II: Focus group results; condensed narratives

Themes:	The ET group:	The SML group:
Theme II: The aim of the intervention	*The training itself is good; it builds muscles and you improve your fitness at the same time. We should not exhaust ourselves, but we do need to build strong muscles. It is really hard to find the muscles deep down in my body. I thought physiotherapy would be tougher, but it is not and I think it is good. I realize now that I don't think it would have been useful if it was any tougher. We started with a soft and easy program and increased it gradually. The program was based on using the machines and mat exercises. Some exercises were easier than others; some exercises were too strenuous for my back, so these were taken out of the program and I got some others instead. You get more aware of how you handle your body. I had a number of exercises using balls and exercises in which I had to sit and balance on a giant ball. I don't think it is dangerous to push yourself a little; it is OK to have some pain and it is up to each and everyone to decide how much they can strain.*	*This is different; In the past I have been very aware of my body; but not like I am today. Earlier, I believed that the harder I did an exercise the better the result would be. But really it is exactly the opposite, the more calmly you breathe and the less often with softer, slower breaths, the more efficient it is, at least for me. I need to give myself time instead of just getting stuck and fighting on regardless. You need to train to change how you move, compared with how you have moved previously all your life; to stand and be aware of your balance from your nose to your feet and not to just rush headlong through life. A surprise for me, which was something quite different from what I was used to, was that I was not asked for my whole life history. Instead I was asked to be aware and reflect on how the experience was for me; this was a very new concept for me. "Caution" is an important word – you should have a cautious attitude regarding your own body. "Trust" is another important word; when I stand and allow the floor to support me I can experience what it means to trust in something.*

Theme 3: The relation to the physical therapist and to self

The relationship between patient and physical therapist was very different when seen from the perspectives of the patients in the ET - and SML groups. In the ET focus groups the patients talked about the physical therapist as someone they appreciated as she had expert knowledge in reducing their pain. In the SML group the patients talked more about the relationship to themselves than about the role of the therapist. It seemed as if their locus of control had made a radical shift and they had found a way to rely on themselves and their bodies.

Table IX C; Theme III: Focus group results; condensed narratives

Themes:	**The ET group:**	**The SML group:**
Theme III: **The relation to the therapist and to self**	*The physiotherapist checks your whole body and documents all of your defects so you get an individualised training program made just for you. It makes you feel safe and you dare to try different movements; things you might not have dared with someone who did not know your history. It is good to have someone supervise you in the beginning, to provide support and to prevent you from doing something silly on your own. In the very beginning the physiotherapist watches you to make sure you do everything correctly If you try too hard or put too much strain on yourself the physiotherapist will react quickly. She will notice immediately if you make up your own exercises and remind you of the correct ones. I have some exercises, which I think I can do just as well at home. Sometimes I find it a nuisance to travel twice a week when I can do the exercises at home. But I do get a little anxious in case I'll do something the wrong way. I know I have my own program, but I have no one to ask if I want to do more and incorporate other muscle groups. You really need someone to help you continue!*	*I had always been told: "You must exercise your back and your abdominal muscles in order to strenghten your back." But really it is the other way around! I first had to learn to locate which specific muscles I needed to take away any unnecessary tension, because my muscles were very tense all the time. Probably I have been too ambitious; I did not want to give up. No one else can tell me what is right or wrong. Only I can feel what is good or bad for me. It's all about understanding what is happening and I must repeat it over and over again. Now 6 months later I can work with it and I have to ask myself questions; " How am I doing right now? How am I sitting? How does it feel?" I believe this method is for the long term.; I am sure it is something I will carry with me for the rest of my life. I have become self-confident about it: "I know how to manage this, I need to move in a different way"compared with how I just rushed earlier. If I can manage this myself, I do not need ouside people who do not know my body or my personality.*

Theme 4: The patients' self image

The patients in the ET group talked to each other about their backs as something separate from themselves. They described how they negotiated with themselves to decide if the "price" they should have to pay in terms of back pain, would be acceptable for doing something they needed to do or simply for having some fun. In the SML focus groups the conversations between the patients revealed that they did not separate their backs from themselves and that back pain was perceived as a means to self discovery.

Table IX D; Theme IV: Focus group results; condensed narratives

Themes:	**The ET group:**	**The SML group:**
Theme IV: **The patients' self image**	*I think I have learned quite a bit from these exercises, I really think so. For me the stretching exercises have been best for my back. But you reach a level at which you realize they will not help you further; that is just the way it is. How long you need to exercise depends on what type of injury you have; if it is a degenerative condition, obviously you must keep doing them all the time, the pain won't disappear by itself. My goal is to feel good when I am relaxing in a resting position. I do not want to be in pain the whole time for doing nothing. If I take out the vacuum cleaner I know I am asking for trouble. I know my limits, but sometimes I let the pain to have some fun (laughter). The next day I might be in bed and in pain: Of course this is not always a good idea, but (laughter) it feels good for the soul to have some fun.*	*Even if you were healthy, I think you would get a lot out of a course or even, I'd say, a treatment like this No one had taught me how to reflect before. This means learning to know yourself and to carry that knowledge with you all the time for your entire life. Now my self-confidence is much better. I have this "roller", which I use for my back when I go to the cinema. Before I used to think "God, how embarrassing!" but not anymore. It feels like the conflict between my body and my mind is over. By being more observant about my body, I think I have learned more about myself and I know now what is not balanced in me and also in my life; how previously I have not taken responsibility for my body and how reluctant I was to ask for help. I don't know how I will feel at the end but my intuition tells me I will have gained much more than I have lost. Actually I would not have wanted to be without this.*

Summary of results

The PLM test was proved to be a reliable outcome measure, able to assess objectively how efficiently an individual can move a small object from the floor to a stand at chin level, in individuals with or without back pain. The test action constitutes a goal-directed well-known daily life activity, requiring a freely moving individual to carry out postural changes (bending down to take the handle and rising again) (the P-phase), locomotion (walking forward) (the L-phase) and a targeted arm movement (placing the object on the stand) (the M-phase).

A group of patients with NSCLBP, who had not been helped by any treatment, participated in SML lessons over several months. The PLM test was used to assess objectively how efficiently they moved. Compared with an age and gender matched control group without back pain, the patients' performance was significantly less efficient before the SML intervention. After the intervention there were no longer any differences between the movement capacity of the patient group and the control group. The results were maintained one year after the SML intervention.

From the patients' subjective cognitive perspectives, the SML intervention was described as a process during which they had learned to reduce pain, to diminish psychological distress and to improve physical ability.

When comparing how two identical patient groups with NSCLBP experienced SML and Exercise Therapy (ET) major differences were indentified. The patients in the SML group expressed that they had learned to trust in themselves and now felt able to handle their low back pain themselves. This was in contrast to the patients in the ET group who expressed insecurity and dependence on advice from back-pain experts.

A hypothesis is generated, based on these results, stating that SML – an embodied, empathic, therapeutic approach to health behaviour change - can enable patients with NSCLBP to increase control over their back pain and promote health by guiding them – back to oneself – in the sense of starting to rely on themselves and their bodily awareness. The hypothesis is based on the fact that the patients' had learned to trust in themselves and now felt able to manage their low back pain themselves. The patients' subjectively experienced positive physical and psychological changes coincided with objectively assessed improvements in movement capacity.

DISCUSSION

The overall purpose of this thesis was to generate knowledge by evaluating the Sensory Motor Learning (SML) intervention when applied in patients with nonspecific chronic low back pain (NSCLBP).

To develop and renew a practical method it is necessary to research both the practical and the scientific part of the method, which in this thesis was the SML intervention. As the SML intervention aims at influencing and promoting change in health behavior in others, the SML teacher's position requires that she/he is involved subjectively and personally moved, both as the practitioner and as the researcher.

The validity of the PLM test

Many different instruments were considered while seeking a valid outcome measure to assess the quality of the patients' movement patterns. An instrument was needed that could capture the essential distinguishing GMP of a specified action and monitor the intrinsic movements as an integrated whole, i.e. an entity comprised of interdependent parts working together. In addition, it must be possible to compile the data resulting from the instrument into meaningful constructs.

This part of the text is to illustrate how difficult is has been to find a valid outcome measure. I went to a well equipped movement laboratory to achieve our goal of measuring the patients' movement patterns with the highest precision and of combining kinematic data with ground reaction forces. We selected certain well defined movements; one was to stand on a ground reaction platform while slowly turning left and right. We placed many reflective markers at defined places on the subjects' body, from the feet to the head and we used 7 cameras. Unfortunately the amount of generated data was too large and none of the biomechanical experts who were consulted succeeded in making any sense out of it. The major problem concerned the level of the computer derived results. We did not know how the resulting kinematic and kinetic data would be interpreted in order to distinguish a movement with higher quality from one with less good quality. This implied that no meaningful outcomes could be inferred from the measurements, as it was impossible to separate the patients with inefficient quality of movements from the healthy controls.

Other, often used measurements appeared much too limited and could not assess the moving body as an entity comprised of interdependent parts working together; for example the "Timed Up and Go Test (TUG)" [85].

The PLM test matched well with the theoretically defined requirements and was considered to be the most valid outcome measure with which to assess the quality of the movement patterns in patients' with NSCLBP. To perform the PLM test the subject has to carry out postural changes (bending down to take the handle and rising again), locomotion (walking forward) and a targeted arm movement (placing the object on the stand). The performance of the PLM test thus involves the whole body and reflects crucial aspects of low back function, as it measures how quickly and how

well a subject can integrate postural changes with locomotion and a targeted arm movement, which requires rotation along the spinal axis. The fact that statistically significant differences in MT, P- and M-phases were found between the patient group and the control group shows that the PLM test has construct validity. It can detect differences in the way patients with NSCLBP and back healthy persons perform the task (Table VI).

Movement time (MT) reflects the efficiency by which a person performs the PLM test action. Efficient behaviour has to do with skill and requires the ability to perform an action with speed, accuracy, economy and resourcefulness [52, 86]. After the SML intervention the patients' MT had decreased significantly and the improvements were retained one year later (I). These results imply that the PLM test is sensitive to changes in performance as it can capture the more efficient behaviour that the patients had learned and retained.

The most efficient way to move the object quickly from the floor to the shelf is by moving the object along a straight line. The dextrous human body unconsciously follows this demand by initiating the different movement phases (P-, L- and M- phases) as simultaneously as possible. In a healthy person, this appears to give the impression of a smoothly performed, well-integrated, whole body movement. The SI index is thought to reflect how well the nervous system integrates the P-, L- and M-phases into one smooth movement. When studying the video recordings of the PLM test performances before and after intervention, there is a clear visual impression that many of the patients perform a much more natural and smooth action after the intervention. This subjective impression is thought to be the aspect that the simultaneity index (SI) is capturing.

The fact that SI varied little between visits in both groups shows that even though the speed of the PLM test performance changed, the integration of the different movement phases to a smooth whole-body movement varied little. Thus, the PLM test movement pattern of each individual was stable.

Moreover the precision of the PLM test, as reflected by changes from post intervention to one year post intervention, measured by LOA and IISD, demonstrated that the PLM test is not only sensitive to changes in performance but also to changes in variability between test occasions and/or as a result of an intervention. In this case the group of patients had significantly improved their movement capacity after the sensory motor learning (SML) intervention and the improvements were retained after one year. The higher precision of the PLM test performance after intervention strengthens the evidence that the patients with NSCLBP had learned and retained a more efficient behavior.

The reliability of the PLM test

Changes seen during repeated testing is an inherent problem with all measurements of movement capacity as repeated execution of a motor act produces changes in behaviour. The effects of practice are increased speed of performance and increased accuracy [87]. These changes are results of neural adaptive learning processes [88, 89]. Exact repetitions of motions, therefore, are not possible and the value of the variability measure is never zero. One objective in this study was to clarify to what extent changes seen with repeated PLM test performances were due to PLM test movement habituation or to spontaneous variations in PLM test performance.

The observation that only minor systematic differences existed between Visit 1 and Visit 2 at Test Session one in any of the PLM phases is interesting, since none of the 24 subjects previously had ever performed the PLM test This indicates that the PLM test task is naturally well known and patient-friendly in that it requires little training and the test can be performed by a fully dressed subject and without any restriction of movements.

At Visit 1 the patients with NSCLBP, as well as the back healthy control subjects, improved the velocity of their performance during the iterated recordings (Figure 6). The patients' change, however, was greater than that of the healthy control group, indicating that the patients needed a few more trials to reach optimal velocity than the healthy control subjects. At Visit 2 and Visit 3 the PLM test performance was stable in both groups. This indicates that most subjects already approached optimal velocity at the end of visit 1 (Figure 6).

Statistical analyses of intra-individual changes demonstrated that MT was somewhat lower at Visit 2 and 3 compared with Visit 1 (at Test Session one). This difference was most obvious for the patient group when approach "all ten" was used. This result makes sense, since the patients probably reach their maximal capacity after a few PLM trials and thereafter their ability gets impaired, whereas the healthy controls reach their maximal ability quite quickly and can continue on the same level for some time.

The fact that the changes in MT in both groups were small and seen mainly during the first visit of Test Session one, indicates that these changes in both groups were an effect of PLM test movement habituation. After the first visit at Test Session one, the PLM test performances were stable in both groups.

It is not possible to use descriptive statistics to define acceptable limits of agreement, as it depends upon the clinical circumstances [77]. This study shows that we can expect a patient's PLM test performance to vary more between two test occasions, compared with the performance of a back healthy subject.

The tri-average had the lowest IISD and can be considered the most precise and reliable measure. This approach, therefore should always be used for each of the five aspects (MT, P-, L-, M-phases and SI). For the healthy control group, IISD was negligibly small with either approach.

Practising in the narrow sense of repeated procedures will make the performance of an action less variable, but it does not influence a subject's habitual way of moving. In this study a second objective was to investigate if intervention in the form of SML could improve the efficiency of the PLM test performance, measured by MT and the integration of the different movement phases to a smoother whole-body movement (higher SI).

Outcome of SML intervention measured by the PLM test

Before intervention, the movement time (MT) of the PLM test was prolonged in the patient group compared with the control group. The prolongation was due to longer P- and M –phases, which indicates impaired movement patterns. These results are congruent with earlier reported results in which patients with chronic nonspecific back- or neck pain were compared with healthy control subjects [11-13, 90-93]. Persons with NSCLBP, similarly to persons with Parkinson Disease, are forced to perform the PLM test action in separate movement phases as they can not integrate the action into a smooth whole body movement.

The fact that the L –phase did not differ between the patient group and the control group was not a surprise since the ability to walk a short distance usually is not impaired in patients with NSCLBP.

After the SML intervention MT, P- and M- phases changed significantly in the patient group and the results were retained one year later (stable PLM "profile"). Moreover coordination, measured as the degree by which, in action, the 3 different P-, L- and M-phases were simultaneously integrated into one smooth movement (SI) was improved in the group of patients but not in the back healthy control group (Figure 8). These results indicate that the patients with NSCLBP had learned and retained a more efficient movement pattern.

The aim of the SML lessons was to guide the patients to sense, at the level of local musculoskeletal relationships, what he/she was doing and how he/she is doing it. Having identified these characteristics meant having found a way to study the own habituated movement patterns and thereby a method to change them. The PLM test seemed to have made the result of the patients' behavioural changes observable and possible to quantify.

This assumption seems to get support when studying the video recordings from the PLM test performances. Before intervention many of the patients seem to move stiffly with inefficient forward propulsion [94]. Several patients kept the spine more or less rigid while bending to grip the object or placing it on the stand. Instead they primarily bend their knees. In the video recordings after intervention many of these strategies seem to have changed. For example, after the intervention some of the patients seem to be able to turn with greater ease around the spinal axis while extending the arm from the scapulae using smooth, dynamic and highly differentiated muscular coordination.

Outcome of SML intervention assessed by patients

The fact that the movement repertoire of the previously treatment resistant patients' was normalized after the SML intervention, as assessed by the objective PLM test, was striking. From a clinical and patient oriented perspective, however, the main concern is how the process, which lead to a normalized movement capacity, influenced the patients subjectively. Thus, to combine third- and first- person methodologies in the case of the complex NSCLBP phenomenon may serve as a method for corroborating results as well as it may lead to discoveries that expand our understanding.

The main result of the qualitative interview study was that the patients, who had suffered from low back pain for many years, experienced not only reduced back pain, but also diminished psychological distress and improved physical ability.

During the first interview, the patients described improvements already in physical ability and reduction of pain. This implies that the patients had learned how to use focused attention while performing selected movements after only 3 months´ in intervention (Table VI, sub-theme 1:2).

The patients' understanding of the causes for their back pain changed when they discovered that they could influence the symptoms by thinking differently and/or by changing the way they moved (Table VI, sub-theme 1:3). Through the SML lessons the patient learned to deconstruct old habits and construct new, less painful and more efficient means for acting. Based upon this discovery the patient may start to wonder if the back pain problem may, in fact, not be irreversible; something he/she earlier took for granted that it was (Table VI, sub-theme 1:4).

SML exercises are different fundamentally from strength exercises as they are designed to enhance the patient's 'felt sense' of self [45, 95, 96]. The patients described how they had learned to use kinaesthetic awareness to discover habituated movement strategies and to work toward more comfortable and efficient movements (Ta-

ble VI, main theme 1). The patients described how images and metaphors helped them to overcome pain-related fear (Table VI, sub-theme 1:1).

The feed-forward reflections, inherent in the SML intervention, on how to relate to the 'felt sense' of self, may explain the patients' successful health promoting change process. The patients expressed that the relationship established between them and the SML therapist was an important aspect of the intervention, characterized by trust and co-operation (Table VI, theme 2). This factor may be more important for the positive outcome than one would expect. Trust conveys a sense of control and understanding and causes individuals to act as if the future was not as uncertain and ambiguous as it actually is. These insights imply that the patients may have learned to trust in themselves and their body, through the supportive and trustful relationship with the SML therapist [97].

The themes that emerged from the content analysis were coherent and described a process starting with the patients' feeling disabled and helpless, to them becoming potent and independent. The nature of qualitative research implies that all assessments are subjective and that data analyses are interpretive. It was crucial to involve the independent experts in the content analysis throughout the research process in order to respond to demands for accountable and collaborative research [98]. The SML therapist's familiarity with each patient's individual process contributed to the understanding of each patient's account.

The above discussed results are congruent with results from a pilot focus group study performed at the Institute for Stress Medicine in Gothenburg, Sweden. Patients diagnosed with Exhaustion Depression and nonspecific pain, participated in 10 individual SML lessons. Analysis of focus group discussions, audio recorded and transcribed verbatim, revealed that after the SML intervention, the patients' pain - and stress related tensions were reduced, the felt stress level diminished and a bodily felt security enhanced. The patients described how they had learned to listen to and trust in their body and they experienced a newly found sense of being present both in their relationship to self and others [99].

Comparing patients' experiences of SML and ET interventions

The most striking result of Study IV was the profound difference, between patients in the ET and the SML groups, in their perception of having control over the back pain symptoms. The patients in the ET group described that, after the intervention, they had understood the importance of performing prescribed physical exercises but they expressed their insecurity and their dependence on advice from back-pain experts. The patients in the SML group described that they had experienced major health promoting physical and mental changes and they expressed now that they no longer

needed experts and were able to handle their low back pain themselves. The results were identified through the discursive analysis of the focus group discussions.

The experiences of the patients in the SML group was congruent with the results from the analysis of individual interviews in study III, where the patients reported that they had learned to reduce pain, eliminate pain- related fear and diminish psychological distress.

There is a radical difference between focusing on defined bodily parts such as muscle groups and skeletal joints, as in the ET intervention, compared with focusing on kinaesthetic whole bodily self-awareness as in the SML intervention. When the focus of attention is on specified bodily structures the outcome is predictable and the therapist can give the patient advice based on his/her expertise. When the focus of attention is on inner 'felt sense', the outcome is unpredictable and the relationship between therapist and patient is best characterized as a researching partnership. These reflections imply that the patients in the SML group may have learned to trust in themselves and their bodies, through the empathic relationship with the SML therapist. Trust conveys a sense of control and understanding and can inspire with courage [97]. Based upon the discovery that ingrained habits were changeable, the patient may have started to wonder if the back pain problem in fact may not be irreversible; a concept that he/she earlier took for granted.

Interesting reflections emerge when acknowledging the implications of the focus of attention in the SML intervention and relating these to Bernstein's characterization of a more skilled performer. Bernstein suggests that the skilled performer has learned to: 'exploit external forces, to minimize the generation of active muscle forces and to smooth the movement's flow' [100]. In the SML intervention the patient learns to recognize a 'better' movement strategy as a kinesthetically felt sense of more freedom in breathing and moving. From the perspective of the observing SML therapist, a 'better' movement strategy is recognized when the patient's movements seem more integrated and more of the whole patient seems to be involved in the action. From a neurobiological perspective this kind of learning is though to be a result of the brain's essential capacity for change – neuroplasticity – implying that nerve cells change their characteristics by creating and strengthening some neural connections and weakening or eliminating others [101].

These reflections suggest that the patients in the SML group may have succeeded in finding a way out of the back pain problem by freeing themselves from habituated, earlier learned behavioural constraints.

Methodological aspects

Ethical as well as methodological dilemmas are often inherent in randomized, controlled clinical studies as one of the groups constitutes a control group. The patients in the control group often realize that they were not allotted to the most effective intervention. This dilemma was at least partly avoided in Study IV as the control group was offered an intervention, which according to prevailing evidence, was regarded as adequate.

The symptoms of all patients included in Study IV had resisted several conservative treatment attempts. All had tried pain reduction treatments together with individualized exercises that aimed at improving muscle strength, muscle endurance and joint flexibility. None of these had resulted in lasting relief. Some of the patients had considerable persistent low back pain despite previous surgery in the lumbar spine. This implied that a majority of the patients had experienced the ET intervention previously, whereas no one had tried the SML intervention. By offering the control group in Study IV a physical therapist who was guaranteed to be skilled and experienced and an individualized program based on each patient's specific disabilities, it was hoped that the patients would not experience the ET intervention as something they had tried already. The patients' expectations, therefore, on the outcome of the interventions, together with their motivation, was assumed to be equivalent between the two randomised groups. This assumption was supported as the number of "drop outs" during the first month was no bigger in the ET group than in the SML group (Table VIII).

'Focus groups' is a term for a group of research methods, used more and more frequently in studies in which the patients' perspectives are considered relevant. Some applications are similar to a regular group interview and generate data on the participants' different – and/or similar experiences. In this study we emphasized the discursive aspect in the analysis, meaning that we searched for the image of the intervention and its effects, which appeared in the group discussion. As the image always exist "in the eye of the observer", the reader is offered a condensed narrative that mirrors the whole discussion and its character in each group, so that he/she may be able to take his/her own opinion regarding the differences in pattern to which the authors have given attention (Table IX). The more common technique to "cut out significant citations" was considered to hide the qualitative, dynamic and extremely complex differences that seemed to exist between the two randomized groups.

As it has taken the author of this thesis many years to understand the rationale and to master the skills inherent in the SML intervention, one limitation to the thesis may be that the author is biased toward the benefits of this intervention. The author understood the scope of the SML intervention on a cognitive and rational level in parallel with her discovery of the health promoting effects it had on patients with various non-specific pain related disabilities. All other interventions, aimed at non-specific

pain related disabilities, seemed either limited as they did not address the person as a whole, or were incomprehensible.

The author's involvement in the studies on which the thesis was based, was as follows;

- She was one of the two SML teachers
- She analyzed the interviews in Study III. Three independent expert readers compared the original transcripts from the interviews and the resulting condensed texts and determined that no critical topics had been omitted or added.
- She was present at the focus group discussions. She condensed and categorized the audio recorded and transcribed material and grouped it into themes. Thereafter two of the co-authors (MH, LR) went through the transcripts to ensure that the processed material was 'true' to the original transcripts; that nothing of importance had been added, neglected or distorted. One of the co-authors had the advantage of having heard the focus group first hand as a moderator (MH). The second co-author had the advantage of not having heard the focus groups first hand (LR).

Future studies

The underlying mechanisms behind the effect of the SML intervention are not well-understood. There is no (known) peripheral pathology linked to NSCLPB and previous studies have demonstrated functional, anatomical, and neurochemical changes in the brains of patients with chronic pain [102]. It is, therefore, reasonable to assume that there is a change in patterns of central processing parallel to the change in movement patterns and subjective experience following SML intervention. Reversibility of changes in the brain, however, in patients with chronic pain with symptom improvement has not been shown, and future studies are needed to explore this further. Imaging techniques, such as functional MRI may be a useful tool to explore brain activation patterns in patients before and after successful SML intervention and might help clarify this issue.

CONCLUSIONS AND CLINICAL IMPLICATIONS

To perform the PLM test the subject has to carry out postural changes (bending down to grip the handle and rising again), locomotion (walking forward) and a targeted arm movement (placing the object on the stand). The performance of the PLM test thus involves the whole body and should be able to capture significant behavioural aspects objectively, not only in patients with NSCLBP but also in patients with other functional limitations e.g. patients with reduced hip-, knee-, neck- or shoulder function. It can be presumed that for those groups of patients, with disabilities of specific or nonspecific origin, for which the test can be proved valid and reliable, the PLM test provides a demanded possibility of recording and measuring the quality of sensory-motor functions in an objective way. As the PLM test procedure only requires a small test area and a single camera the only requirement is that the patient must be able to walk a few steps, grip the handle on the floor and reach the arm forward to place the handle on the stand.

The SML intervention is an embodied, empathic, therapeutic approach aimed at health behaviour change in individuals whose inefficient use of self gives rise to inefficient movement patterns. In this thesis it was proved that the SML intervention was able to guide patients with NSCLBP to increase control over their back pain.

It should not be presumed that the efficacy of the SML intervention is limited to patients with NSCLBP. Many other groups of patients, with restricted movement capacity due to disabilities of specific or nonspecific origin, may be able to take advantage of the SML process. The only requirement is that the patient wants to participate and will work in partnership with the SML teacher.

We shall not cease from exploration
and the end of all our exploring
will be to arrive where we started
and know the place for the first time.

LITTLE GIDDING (No. 4 of 'Four Quartets')
T.S. Eliot

SVENSK SAMMANFATTNING

SENSOMOTORISKT LÄRANDE

tillämpad på patienter med långvarig ickespecifik ländryggsmärta

Att ha ont i ryggen är mycket vanligt och var femte individ drabbas varje år. Trots att bara 10 % av samtliga fall blir långvariga är ryggsmärta ett av de största hälsoproblemen i västvärlden. Begreppet ickespecifik långvarig ländryggsmärta (ILL) används för att beteckna de fall där vare sig den ihållande smärtan eller de kroppsliga rörelsebegränsande svårigheterna kan hänföras till skador eller sjukdomar i någon kroppslig vävnad. 80 % av de långvariga fallen är ickespecifika.

Det övergripande syftet med denna avhandling var att ta fram kunskap om sensomotoriskt lärande (SML) genom att använda interventionen på patienter med ILL. För att uppnå syftet beskrevs först den teoretiska grundval som interventionen SML vilar på och därefter genomfördes fyra separata studier.

Patienter med ILL som tidigare inte blivit varaktigt hjälpta av någon slags behandling och som inte heller bedömdes kunna bli återställda genom kirurgisk åtgärd, deltog i studierna.
I studie I undersöktes om den optoelektroniska mätmetoden Posturo-Locomotion-Manipulation (PLM) var lämplig och tillförlitlig för att på ett objektivt sätt, bedöma kvaliteten på individers rörelsemönster. I studie II utvärderades hur SML interventionen påverkade rörelsemönster mätt med PLM hos en grupp patienter med ILL. I studie III intervjuades varje patient två gånger för att få kunskap om hur de påverkats av SML interventionen. I studie IV jämfördes hur två jämförbara patientgrupper med ILL beskrev sina erfarenheter av två interventioner med olikartad inriktning; anpassad fysisk träning (ET) och SML.

Resultaten visade att PLM testet var ett lämpligt och tillförlitligt instrument. Före SML hade patientgruppen ett sämre rörelsemönster än en jämförbar grupp med ryggfriska individer, mätt med PLM testet. Efter SML interventionen var kvaliteten på patientgruppens och kontrollgruppens rörelsemönster likvärdiga. Resultatet höll i sig vid undersökningen som gjordes 1 år efter avslutad intervention. I intervjuerna beskrev patienterna att de hade lärt sig att minska smärtan, de var mindre stressade och de kände sig fysiskt förbättrade. Det var stor skillnad mellan hur träningsgruppen (ET) och SML gruppen beskrev de olika interventionerna. Patienterna i SML gruppen beskrev att de hade lärt sig att lita på sig själva och de tyckte nu att de kunde klara sina ryggbesvär på egen hand. Detta var i kontrast till ET gruppens patienter som gav uttryck för ängslan och sitt beroende av hjälp ifrån ryggexperter.

Studiernas resultat har gett upphov till en hypotes som säger att SML, är en kroppsligt inriktad, empatisk och terapeutisk process som kan främja hälsoinriktad förändring. Patienterna lär sig lita på sig själva och på sin kroppsmedvetenhet. Hypotesen baseras på faktum att patienternas självförtroende hade ökat och de ansåg sig kunna ta hand om sina ryggproblem själva. De positiva fysiska och mentala förändringar som patienterna upplevde sammanföll med objektivt registrerade förbättringar i patienternas rörelsekvalitet.

ACKNOWLEDGEMENTS

This thesis would not have been possible without the direct and indirect contributions of many people, especially my supervisors and my professional teachers and mentors. In particular I want to thank:

My main supervisor, Associate Professor **Bo Johnels,** for your willingness to accept me as your doctoral student and for introducing me to the comprehensive PLM test. You have guided and supported me whenever I needed it and I have been very happy to have you as my main supervisor!

My assistant supervisor, Associate Professor **Jan Willén,** for your belief in your patients' capabilities to recover from chronic back pain and your willingness in letting them try the SML intervention. Thank you for all the energy and time you have invested in my thesis.

My assistant supervisor, **Carin Willén** PhD, for your support, encouragement and guidance in both the quantitative and qualitative research methodology. For many years you were primarily the living link between me and you husband Jan and especially during the past year you have taken the role as my main adviser and you have helped me have the time to finish this thesis. The importance of your suggestions that made me clarify essential parts of the text in the last week before print can not be overestimated. Thank you!

My assistant supervisor, Associate Professor **Monica Hane,** for your support, encouragement and belief in my capability to realize my ideas. You are the most knowledgeable and experienced praxis oriented researcher that I know. Thank you for all the energy and time you have invested in my thesis.

My co-author, Professor **Christine Räisänen,** for your generosity in giving me your valuable time and for guiding me in your area of expertise; the skills of academic writing.

My co-author, **Lisbeth Rydén** MSc, for your interest in my work and for your willingness to share your expert knowledge in focus group methodology with me and for using your time to work with the analysis of the focus group discussions.

My mentor, **Bengt-Åke Wennberg**, Director of the private Swedish Knowledge and Research Centre named Samarbetsdynamik. I do not know which words to choose to thank you for your generous guidance, support and wisdom in the area of praxis oriented research. I can say only Thank you!

My professional teacher and mentor **Larry Wm Goldfarb** PhD, Feldenkrais Trainer for all I learned from you, which allowed me to understand the scope of the Feldenkrais method, on a cognitive and rational level, as well as on the sophisticated and elusive praxis oriented level.

My professional teacher and mentor **Livia Frischer**, Psychosynthesis Teacher and Psychotherapist, for your willingness to work in partnership with me to integrate the Psychosyntesis and Feldenkrais methods into SML.

My teacher in Motivational Interviewing (MI) **Christina Näsholm**, Clinical Psychologist and Psychotherapist, for your skilful introduction to MI allowing me to see that what was so clearly and comprehensibly outlined in MI were inherent, but hidden and unspoken, principles of the Feldenkrais method.

Josefin Nilsson Associate Professor for your intelligent and clear advice after having read several of my manuscripts and the preliminary version of this thesis and for when I had questions related to clinical neurophysiology or science in general.

Daniel Nilsson MD, PhD for taking the time to read and to give me wise comments on several of my manuscripts and on the preliminary version of this thesis.

Malin Lindh Associate Professor for your generous support over many years.

Jane Carlsson Professor for taking the time to read and making important suggestions at the final stage of this work

Barbro Eriksson at the Movement Laboratory at the Sahlgrenska University Hospital for the skilful work you have invested to assess the PLM tests over several years.

Minaj Wedefalk MSc, PT for introducing me to the TIPPA test and for all the work and time you have invested in order to get the results of the TIPPA tests to be correct.

Birgitta Claeson MSc, PT for all the work you invested while performing all the TIPPA tests.

Henrik Bergman PT for performing the individual interviews.

Kerstin Knutsson, Barbro Källén and Lena Nilsson PTs for your willingness to take part in the clinical randomized study.

Johan S, Josefin C, Leif S, Linda S, Marie C, Tobias O, Thomas B, Thomas O, Kerstin H, Kerstin K, Uno P and Åsa G for your willingness to come to the Movement Laboratory to perform the PLM test 9 times over two years.

Catharina Broberg MSc, PT, **Susanne Rosberg** PhD, PT and **Carin Willen** PhD, PT for your expertise and willingness to read the individual interviews in order to determine that no critical topics had been omitted or added in the resulting condensed texts.

Elin Fälthammar, professional artist, for your willingness to work with me designing the illustrations in the thesis. Thank you for your patience with me during all the times that I was unsure and asked you to change your work once more; even the last week before print!

Carole Panton for proof reading the text and for your quick and always brilliant suggestions for improvement.

Gustaf Nelhans for your skilful editing of my texts

All friends, colleagues and students at the Department of Clinical Neuroscience and Rehabilitation, Institute of Neuroscience and Physiology; Occupational Therapy and Physiotherapy; for all help I have got from many of you and for the interest you have shown in my work.

Financial support was obtained from The Swedish Foundation for Health Care Sciences and Allergy Research (The Vårdal Foundation); The Sahlgrenska Academy, University of Gothenburg, Department of Clinical Neuroscience and Rehabilitation; Adlerbertska forskningsstiftelsen, The Foundation for Parkinson Disease Research, Greta och Einar Askers Stiftelse, Wilhelm & Martina Lundgrens Vetenskapsfond, Vera och Gunnar Sundmans Stiftelse.

REFERENCES

1. Balague F., Mannion A.F., Pellise F., Cedraschi C. Clinical update: low back pain. Lancet 2007; 369: 726-8.
2. Airaksinen O., Brox J.I., Cedraschi C., Hildebrandt J., Klaber-Moffett J., Kovacs F., Mannion A.F., Reis S., Staal J.B., Ursin H., Zanoli G. Chapter 4. European guidelines for the management of chronic nonspecific low back pain. Eur Spine J 2006; 15 Suppl 2: S192-300.
3. Nachemson A.L., Jonsson E. Neck and back pain : the scientific evidence of causes, diagnosis, and treatment. Philadelphia: Lippincott Williams & Wilkins, 2000
4. Andersson G.B. Epidemiological features of chronic low-back pain. Lancet 1999; 354: 581-5.
5. Hayden JA v.T.M., Malmivaara A, Koes BW. Exercise therapy for treatment of non-specific low back pain: Cochrane Database Syst Rev. 2008.
6. Hayden J.A., van Tulder M.W., Tomlinson G. Systematic review: strategies for using exercise therapy to improve outcomes in chronic low back pain. Ann Intern Med 2005; 142: 776-85.
7. Hayden J.A., van Tulder M.W., Malmivaara A.V., and Koes B.W. Meta-analysis: exercise therapy for nonspecific low back pain. Ann Intern Med 2005; 142: 765-75.
8. van Tulder M.W., Malmivaara A., Esmail R., Koes B.W. Exercise therapy for low back pain. Cochrane Database Syst Rev 2000; CD000335.
9. Thomas J.S. France C.R. Pain-related fear is associated with avoidance of spinal motion during recovery from low back pain. Spine 2007; 32: E460-6.
10. Popa T., Bonifazi M., Della Volpe R., Rossi A., Mazzocchio R. Adaptive changes in postural strategy selection in chronic low back pain. Exp Brain Res 2007; 177: 411-8.
11. Lund T., Nydegger T., Schlenzka D., Oxland T.R. Three-dimensional motion patterns during active bending in patients with chronic low back pain. Spine 2002; 27: 1865-74.
12. Brumagne S., Cordo P., Lysens R., Verschueren S., Swinnen S. The role of paraspinal muscle spindles in lumbosacral position sense in individuals with and without low back pain. Spine 2000; 25: 989-94.
13. Gill K.P., Callaghan M.J. The measurement of lumbar proprioception in individuals with and without low back pain. Spine 1998; 23: 371-7.
14. Sjolander P., Michaelson P., Jaric S.,Djupsjobacka M. Sensorimotor disturbances in chronic neck pain--range of motion, peak velocity, smoothness of movement, and repositioning acuity. Man Ther 2008; 13: 122-31.
15. Nijs J., Van Oosterwijck J.,De Hertogh W. Rehabilitation of chronic whiplash: treatment of cervical dysfunctions or chronic pain syndrome? Clin Rheumatol 2009; 28: 243-51.
16. Radebold A., Cholewicki J., Polzhofer G.K., Greene H.S. Impaired postural control of the lumbar spine is associated with delayed muscle response times in patients with chronic idiopathic low back pain. Spine 2001; 26: 724-30.
17. Arendt-Nielsen L., Graven-Nielsen T. Muscle pain: sensory implications and interaction with motor control. Clin J Pain 2008; 24: 291-8.
18. Ting L.H. Dimensional reduction in sensorimotor systems: a framework for understanding muscle coordination of posture. Prog Brain Res 2007; 165: 299-321.
19. Passatore M.,Roatta S. Influence of sympathetic nervous system on sensorimotor function: whiplash associated disorders (WAD) as a model. Eur J Appl Physiol 2006; 98: 423-49.
20. Kelso J.A.S. Dynamic patterns: the self-organization of brain and behavior. Cambridge, Mass.: MIT Press, 1995
21. Sullivan M.J. Toward a biopsychomotor conceptualization of pain: implications for research and intervention. Clin J Pain 2008; 24: 281-90.
22. Lund J., Donga R. The pain-adaptation model: a discussion of the relationship between chronic musculoskeletal pain and motor activity. Can. J. Physiol. Pharmacol. 1991; 69: 683 - 94.

23. Moseley G.L., Nicholas M.K., Hodges P.W. Pain differs from non-painful attention-demanding or stressful tasks in its effect on postural control patterns of trunk muscles. Exp Brain Res 2004; 156: 64-71.
24. Waddell G. The back pain revolution. Edinburgh: Churchill Livingstone, 1998
25. Leeuw M., Goossens M.E., Linton S.J., Crombez G., Boersma K., and Vlaeyen J.W. The fear-avoidance model of musculoskeletal pain: current state of scientific evidence. J Behav Med 2007; 30: 77-94.
26. Asmundson G.J., Norton P.J., Norton G.R. Beyond pain: the role of fear and avoidance in chronicity. Clin Psychol Rev 1999; 19: 97-119.
27. Verbunt J.A., Sieben J.M., Seelen H.A., Vlaeyen J.W., Bousema E.J., van der Heijden G.J., Knottnerus J.A. Decline in physical activity, disability and pain-related fear in sub-acute low back pain. Eur J Pain 2005; 9: 417-25.
28. Vlaeyen J.W., Kole-Snijders A.M., Boeren R.G., van Eek H. Fear of movement/(re)injury in chronic low back pain and its relation to behavioral performance. Pain 1995; 62: 363-72.
29. Sandlund J., Djupsjobacka M., Ryhed B., Hamberg J., Bjorklund M. Predictive and discriminative value of shoulder proprioception tests for patients with whiplash-associated disorders. J Rehabil Med 2006; 38: 44-9.
30. Johansson H., Sjolander P., Djupsjobacka M., Bergenheim M., Pedersen J. Pathophysiological mechanisms behind work-related muscle pain syndromes. Am J Ind Med 1999; Suppl 1: 104-6.
31. Feldenkrais M. Awareness through movement: health exercises for personal growth. Harmondsworth: Penguin, 1987
32. Antonovsky A. Unraveling the mystery of health: how people manage stress and stay well. San Francisco: Jossey-Bass, 1987
33. Jakobsson U. Psychometric testing of the brief screening version of Multidimensional Pain Inventory (Swedish version). Scand J Caring Sci 2009; 23: 171-9.
34. Roxendahl G. BAS-skalan Body Awareness Scale med BAS -hälsa. Lund: Studentlitteratur, 1987
35. Bunkan B. Kropp, respiration og kroppsbilde: ressursorientert kroppsundersökelse og behandling. Oslo: Universitetsforlaget, 1996
36. Olofsson C., Hur förändras "Känsla av sammanhang" av Rörelseskolans kroppsmedvetandeträning? Utvärdering av Rörelseskolan med Antonovskys Livsfrågeformulär. Examensarbete 10 poäng 1995, Vårdhögskolan i Göteborg, Institutionen för Rehabilitering: Göteborg.
37. Andersson P, Jonsson A. Förändring av det kroniska smärttillståndet hos deltagarna i Rörelseskolan - en utvärdering med mätinstrumentet MPI. Examensarbete 10 poäng 1995, Vårdhögskolan i Göteborg, Institutionen för Rehabilitering Göteborg.
38. Thapper L, Spangen B. HÄR KOMMER JAG Uppfattningar av hur rörelseskolan "Medveten genom rörelse" påverkat dess deltagare - en fenomenografisk studie. Examensarbete 10 poäng 1995, Vårdhögskolan i Göteborg, Institutionen för Rehabilitering: Göteborg.
39. Ahlborg U-B, Havstam G. Hur uppfattar människor med kronisk smärta att Rörelseskolan "Medveten genom rörelse" påverkat dem? - en fenomenografisk studie. Examensarbete 10 poäng 1995, Vårdhögskolan i Göteborg, Institutionen för Rehabilitering: Göteborg.
40. Persson K, Westerlund H. Kvalitetssäkring av hierarkiska villkorsskalor för Body Awareness Scale (BAS) och Resursorienterad kroppsundersökning (ROK) inom projektet Rörelseskolan "Medveten genom rörelse". Examensarbete 10 poäng 1995, Vårdhögskolan i Göteborg, institutionen för Rehabilitering: Göteborg.
41. Goldfarb L.W. Articulating changes: preliminary notes to a theory for Feldenkrais. Berkeley San Francisco: Feldenkrais Resources; 1990
42. Feldenkrais M. Body & mature behavior: a study of anxiety, sex, gravitation, and learning. Berkeley, Calif.: Somatic Resources; North Atlantic Books : Publishers Group West, 2005

43. Feldenkrais M. and Kemmey M. The potent self: a guide to spontaneity. San Francisco: Harper & Row, 1985
44. Feldenkrais M. The elusive obvious or basic Feldenkrais. Cupertino, Calif.: Meta Publications, 1981
45. Feldenkrais M. The case of Nora: body awareness as healing therapy. New York: Harper & Row, 1977
46. Hardy J. A psychology with a soul: psychosynthesis in evolutionary context. London; New York: Routledge & Kegan Paul, 1987
47. Ferrucci P. Psychosynthesis. New York: Crown, 1979
48. Assagioli R. The act of will. New York,: Viking Press, 1973
49. Rollnick S., Miller W.R., and Butler C. Motivational interviewing in health care: helping patients change behavior. New York: Guilford Press, 2008
50. Rollnick S., Butler C., and Mason P. Health behavior change: a guide for practitioners. Edinburgh: Churchill Livingstone, 1999
51. Goldfarb L.W. A Course of Change; Mind in Motion, Berkeley San Francisco: Feldenkrais Resources; 2002
52. Laban R., Lawrence F.C. Effort; economy of human movement. London,: Macdonald & Evans, 1974
53. Feldenkrais.com. Available from: http://www.feldenkrais.com.
54. Jacobson E. Modern treatment of tense patients, including the neurotic and depressed with case illustrations, follow-ups, and EMG measurements. Springfield, Ill.,: Thomas, 1970
55. Darwin C. The expression of the emotions in man and animals. Chicago,: University of Chicago Press, 1965
56. Ramachandran V.S. and Blakeslee S. Phantoms in the brain: human nature and the architecture of the mind. London: Fourth Estate, 1999
57. Buccino G., Baumgaertner A., Colle L., Buechel C., Rizzolatti G., Binkofski F. The neural basis for understanding non-intended actions. Neuroimage 2007; 36 Suppl 2: T119-27.
58. Buccino G., Binkofski F., Riggio L. The mirror neuron system and action recognition. Brain Lang 2004; 89: 370-6.
59. Umilta M.A., Kohler E., Gallese V., Fogassi L., Fadiga L., Keysers C., Rizzolatti G. I know what you are doing, a neurophysiological study. Neuron 2001; 31: 155-65.
60. Freeman W.J. How brains make up their minds. New York: Columbia University Press, 2000
61. Damasio A.R. The feeling of what happens: body and emotion in the making of consciousness. New York: Harcourt Brace, 1999
62. Håkansson J M.H. Empathy as an interpersonal phenomenon. Journal of Social & Personal Relationships 2003; 20: 267-84.
63. Håkansson J M.H. The role of action in empathy from the perspectives of the empathizer and the target. Current Research in Social Psychology 2002; 8: 50-62.
64. Rodgers C. Empathic: An unappreciated way of being. Counseling Psychologist 1975; 5: 2-10.
65. Gendlin E.T. Focusing. New York: Everest House, 1978
66. Kabat-Zinn J. Coming to our senses: healing ourselves and the world through mindfulness. New York: Hyperion, 2005
67. Sheets-Johnstone M. The primacy of movement. Amsterdam ; Philadelphia: John Benjamins Pub., 1999
68. Doidge N. The brain that changes itself: stories of personal triumph from the frontiers of brain science. New York: Viking, 2007
69. Morgan G. Imaginization: the art of creative management. Newbury Park, Calif.: Sage Publications, 1993
70. Johnson M. The body in the mind: the bodily basis of meaning, imagination, and reason. Chicago: Univ. of Chicago Press, 1987

71. Manchikanti L., Pampati V., Beyer C., Damron K., and Barnhill R.C. Evaluation of psychological status in chronic low back pain: comparison with general population. Pain Physician 2002; 5: 149-55.
72. Ramklint M. and Ekselius L. Personality traits and personality disorders in early onset versus late onset major depression. J Affect Disord 2003; 75: 35-42.
73. Gustavsson J.P. Stability and validity of self-reported personality traits. Contributions to the evaluation of the Karolinska Scales of Personality. Thesis. Department of Clinical Neuroscience and the Institute for Environmental Medicine, Stockholm 1997; 85 pp.
74. Hagg O., Fritzell P., Ekselius L., Nordwall A. Predictors of outcome in fusion surgery for chronic low back pain. A report from the Swedish Lumbar Spine Study. Eur Spine J 2003; 12: 22-33.
75. Walsh T.L., Hanscom B., Lurie J.D., Weinstein J.N. Is a condition-specific instrument for patients with low back pain/leg symptoms really necessary? The responsiveness of the Oswestry Disability Index, MODEMS, and the SF-36. Spine 2003; 28: 607-15.
76. Missaghi-Wedefalk M., Lindh M, Nordholm L., Schön-Ohlsson C. Test Instrument for Profile of Physical Ability = TIPPA. Nordisk Fysioterapi 2004; 8: 74 - 83.
77. Altman D.G. Practical statistics for medical research. Boca Raton, Fla.: Chapman & Hall/CRC, 1999
78. Sullivan M K.J. SF-36 Hälsoenkät (Swedish manual and interpretation guide). Gothenburgh: Health Care Research Unit, 1994
79. Elo S. and Kyngas H. The qualitative content analysis process. J Adv Nurs 2008; 62: 107-15.
80. Graneheim U.H. and Lundman B. Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. Nurse Educ Today 2004; 24: 105-12.
81. Krueger R.A. and Casey M.A. Focus groups: a practical guide for applied research. Thousand Oaks, Calif.: Sage Publications, 2000
82. Morgan D.L. Focus groups as qualitative research / David L. Morgan. Thousand Oaks, Calif.: Sage Publications, 1997
83. Schneider S., Randoll D, Buchner M. Why do women have back pain more than men? A representative prevalence study in the federal republic of Germany. Clin J Pain 2006; 22: 738-47.
84. Sullivan M K.J. SF 36 Hälsoenkät (Swedeish manual and interpretation guide). Gothenburg: Health Care Research Unit 1994
85. Shumway-Cook A. and Woollacott M.H. Motor control: translating research into clinical practice. Philadelphia: Lippincott Williams & Wilkins, 2007
86. Luoto S., Taimela S., Alaranta H., Hurri H. Psychomotor speed in chronic low-back pain patients and healthy controls: construct validity and clinical significance of the measure. Percept Mot Skills 1998; 87: 1283-96.
87. Sage G.H. Introduction to motor behavior: a neuropsychological approach. Reading, Mass.: Addison-Wesley Pub. Co., 1977
88. Grillner S. and Wallen P. Innate versus learned movements--a false dichotomy? Prog Brain Res 2004; 143: 3-12.
89. Hatze H. Motion variability--its definition, quantification, and origin. J Mot Behav 1986; 18: 5-16.
90. Sihvonen T., Lindgren K.A., Airaksinen O., Manninen H. Movement disturbances of the lumbar spine and abnormal back muscle electromyographic findings in recurrent low back pain. Spine 1997; 22: 289-95.
91. Sihvonen T., Partanen J., Hanninen O., Soimakallio S. Electric behavior of low back muscles during lumbar pelvic rhythm in low back pain patients and healthy controls. Arch Phys Med Rehabil 1991; 72: 1080-7.
92. Ahern D.K., Follick M.J., Council J.R., Laser-Wolston N., Litchman H. Comparison of lumbar paravertebral EMG patterns in chronic low back pain patients and non-patient controls. Pain 1988; 34: 153-60.

93. Esola M.A., Mc Clure P.W, Fitzgerald G.K Siegler S. Analysis of Lumbar Spine and Hip Motion During Forward Bending in Subjects With and Without a History of Low Back Pain. Spine 1996; 21: 71-78.
94. Winters J.M. and Woo S.L.Y. Multiple muscle systems: biomechanics and movement organization. New York: Springer-Verlag, 1990
95. Gallagher S. How the body shapes the mind. Oxford; New York: Clarendon Press, 2005
96. Buchanan P.A. and Ulrich B.D. The Feldenkrais Method: a dynamic approach to changing motor behavior. Res Q Exerc Sport 2001; 72: 315-23.
97. Lewis J.D W.A. Trust as a social reality. Social Forces 1985; 63: 967 -985.
98. Krippendorff K. Content analysis: an introduction to its methodology. Thousand Oaks, Calif.: Sage, 2004
99. Lindegård Andersson A, Schön-Ohlsson C, Johansson A. Upplevelser av behandling med sensomotorisk träning hos patienter med utmattningssyndrom - En kvalitativ pilotstudie. ISM-häfte nr 2 - Institutet för stressmedicin Göteborg 2008 Available from: www.stressmedicin.com
100. Bernstein N.A. The co-ordination and regulation of movements. Oxford, New York,: Pergamon Press, 1967
101. Flor H D.M. Sensorimotor training and cortical reorganisation. Neurorehabilitation 2009; 25: 19-27.
102. Tracey I. and Bushnell M.C. How neuroimaging studies have challenged us to rethink: is chronic pain a disease? J Pain 2009; 10: 1113-20.