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Sensory Motor Learning in Patients With Chronic Low Back Pain

A Prospective Pilot Study Using Optoelectronic Movement Analysis

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Study Design. The effect of sensory motor learning (SML) on chronic low back pain (CLBP) patients' movement capacity was evaluated with the optoelectronic Posturo-Locomotion-Manual (PLM) test.

Objective. To study SML changes of an intentional dynamic behavior of daily life in a group of CLBP patients and compare the performance with an age- and sex-matched group of back-healthy individuals.

Summary of Background Data. In a previous study, the PLM test was found reliable when used in CLBP patients. SML addresses dynamic movement capacity. There is little scientific evidence of the effectiveness of educational interventions in improving motor behavior.

Methods. Twelve patients with treatment-resistant CLBP were selected by two orthopedic spine surgeons. Twelve back-healthy age- and sex-matched individuals were included as controls. The patients participated in weekly SML lessons during a maximum of 12 months. All study participants were investigated with the PLM test, before intervention, directly after intervention, and 10 to 12 months after completion of the intervention, and patients were compared with controls.

Results. Before intervention significant differences in performance were found between the group of patients and the healthy control group. After the intervention, the CLBP patients had improved their performance so there were no longer any significant differences between the groups. The results were retained 12 months after intervention.

Conclusions. The study shows that the CLBP patients had learned and retained a more efficient behavior. The results suggest that SML is an effective intervention for nonspecific CLBP patients.

Key words: sensory motor learning, Feldenkrais method, nonspecific chronic low back pain, optoelectronic measurement, quantitative movement analysis, Posturo-Locomotion-Manual test. **Spine 2005;30:E509–E516**

Low back pain is an endemic problem.[1–3] Individuals who do not recover from an incident of back pain within 3 months will need rehabilitation. Estimates indicate that the total cost of back pain corresponds to 1% to 2% of the GNP.[4,5] Nonspecific chronic back pain involves sensory, affective, and cognitive components[6–8] since human behavior is a function of a complex adapting nervous system.[9–13]

Reliable measurement tools are needed to assess chronic low back pain (CLBP) patients' capacity to perform dynamic activities of daily life.[4,14] Several questionnaires have been developed.[15–19] However, only moderate correlation has been found between CLBP patients' self-reported activity limitations and corresponding clinician-measured performance tests.[20,21]

Clinical examinations are observer-dependent.[22,23] A study on agreement between physiotherapists, who rated stroke patients' movement performance *via* videotape, demonstrated a high interrater variance. The conclusion of the study was that more complex and reliable clinical measurements need to be developed.[24]

To objectively capture the whole pattern of movements by which a person performs an intentional physical task, all movements ought to be monitored as an integrated whole, *i.e.*, a system comprised of interdependent parts working together.[11]

The optoelectronic Posturo-Locomotion-Manual (PLM) test, in which a subject repeatedly moves a small object from the floor to a shelf, has been in clinical use for a decade to objectively assess intentional behavior in patients with various diagnoses.[25–27] The PLM test was developed for capturing movement capacity in freely moving patients with Parkinson's disease.[28–30] It is simple and patient-friendly and gives quantitative and qualitative data on the performance of an intentional task of daily life (Figure 1).

A test-retest study on a group of CLBP patients and an age- and sex-matched back-healthy group was performed. To identify the most precise measure, changes over time were studied and different approaches to the computer generated raw PLM data were compared. For the group of CLBP patients, the lowest mean value out of

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Figure 1. The Posturo-Locomotion-Manual test. The freely moving subject is instructed to transport an object as quickly as possible from floor to stand.

three consecutive measures had the lowest intra-individual standard deviation and the lowest coefficient of variation and was considered the most precise measure.[31] Therefore, this approach to the raw data should always be used for each of the five aspects of the PLM task, which the PLM program generates.

Moreover, the test-retest showed that CLBP patients' PLM test performance will differ more, between two test occasions, than the performance of back-healthy subjects.[31] To control for systematic changes, the PLM test therefore has to be performed several times over a few weeks. The results match the hypothesis on which the test-retest was accomplished and support the theory that the PLM test is reliable and has construct validity when used in CLBP patients.[31]

Sensory motor learning (SML) addresses nonspecific pain syndromes and the accompanying dysfunctional motor behavior as tied to embodied habits, including cognitive, perceptual, and kinesthetic aspects.[32,33] SML practices are based on systemic understanding of the human body's design for movement and a perception-oriented pedagogy in order to expand a person's movement capacity.[34–37] SML practices are based on the hypothesis that people can learn to improve their daily motor performance by discovering better ways to use their physical and mental resources in relation to self-image, environment, and task requirements.[33,38–40] Major attention is directed to the quality of each patient's whole-person dynamic performance. The pain symptoms give important information. However, symptomatic pain relieving treatments are not used in SML practices.

The aim of this pilot study was to evaluate the effect of SML on CLBP patients' movement capacity measured with the optoelectronic PLM test.[28]

Patients and Methods

Patients 25 to 65 years of age with severe CLBP, referred from primary care physicians and other clinicians to a spine surgeon at the Department of Orthopaedics in Gothenburg, Sweden, were eligible to participate in the pilot trial.

Inclusion criteria were in line with the multicenter randomized controlled trial from the Swedish Lumbar Spine Study Group on Lumbar Fusion *versus* nonsurgical treatment for CLBP[41]:

- Swedish-speaking patients of both sexes 25 to 65 years of age with severe CLBP.
- Severe low back pain duration for more than 2 years.
- Degenerative changes in the lower lumbar spine with at least a decrease of the disc height of 50% or more in 1 or 2 levels noted on plain radiographs. Other pathologies, *e.g.*, disc herniations or spinal stenosis, were excluded by computed tomography (CT) and/or magnetic resonance imaging (MRI).
- The patient should have been on sick leave (or have had "equivalent" major disability) for at least 1 year.
- Physical therapy treatments of any kind should have been unsuccessful.

Moreover, we decided to allow patients with previous low back pain surgery, with fusion but with persisting considerable low back pain, to be included.

Exclusion criteria were as follows:

- Specific radiologic findings such as spondylolisthesis, signs of spinal stenosis, disabling arthritic joints, fractures, infection, inflammatory processes, or neoplasm.
- Psychiatric illness.

Twelve patients with treatment-resistant CLBP were selected by two orthopedic spine surgeons. Four of these patients were previously operated with fusion of the lower lumbar spine (Table 1). Twelve age- and gender-matched volunteers with no back pain history were recruited as controls. Their occupations and fitness level varied. None of them was extremely well trained or had physical defects.

Measurements. To perform the PLM test, the subject was asked to repeatedly move a small (500 g) object with a convenient handle, from a clearly marked starting place on the floor, to a stand located at chin level, 1.5 m in front of the starting place. Thus, the body had to carry out postural changes (bending down to take the handle and rising again), locomotion (walking forward), and a goal-directed arm movement (placing the object on the stand) (Figure 1A).

Table 1. Chronic Low Back Pain Patients and Healthy Controls Prior to Inclusion

	Age at Inclusion (yr)		Sex		Years of Severe CLBP Prior to Inclusion		Low Back Surgery Prior to Inclusion	
Patient No.	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	Mean: 43	F (N = 7)	F (N = 6)	Mean: 9	Mean: 0	No (N = 8)	No (N = 12)
	Median: 42	Median: 44	M (N = 5)	M (N = 6)	Median: 8	Median: 0	Yes (N = 4)	Yes (N = 0)

To eliminate the risk for bias or inaccuracy, the 12 CLBP patients were tested in the PLM test movement laboratory once a week during 3 consecutive weeks, before intervention, directly after intervention, and 10 to 12 months after completion of he intervention. The 12 persons in the group of back-healthy controls were tested once a week during 3 consecutive weeks, at three periods with 10 months between each period.

A trained laboratory assistant performed the test in a clinical movement laboratory. The subject to be tested was instructed to stand at the marked starting place with the object on the floor beside him or 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. This action, moving the object from the floor to the stand, was to be accomplished three times without pausing. After the third move was accomplished, the subject was to rest for 1 to 2 minutes. At each test occasion, this procedure was repeated 10 times (with three repetitions each time), *i.e.*, a total of 30 transfers from floor to stand.

Measurement technique. The PLM test used an optoelectronic measurement system to record the dynamic performance during the 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 the object. The markers were viewed every 20 milliseconds by a video camera system that had an infrared flashlight. The computer software inspected the velocity profiles of the markers placed on the subject and on the handle and calculated the movements of the body in two-dimensional space while the subject moved forward (Figure 2A). The movement backward to the starting place was not recorded.

Three movement phases were identified: posturo (P), locomotion (L), and manual (M) phases (Figure 1B). The P-phase was derived from the velocity profile of the marker on the head and measures the time spent to raise 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, 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 2B).

Movement time (MT) was identified from the velocity profiles of the marker placed on the handle by calculating the mean time spent for the forward transport of the object from the starting position on the floor to the stand (Figure 2B).

The most efficient way to quickly move the object from the floor to the shelf is by transporting the object along a straight line. The dexterous human body unconsciously subordinates itself to this demand by initiating the different movement phases (P-, L-, and M- phases) with a high degree of simulta-

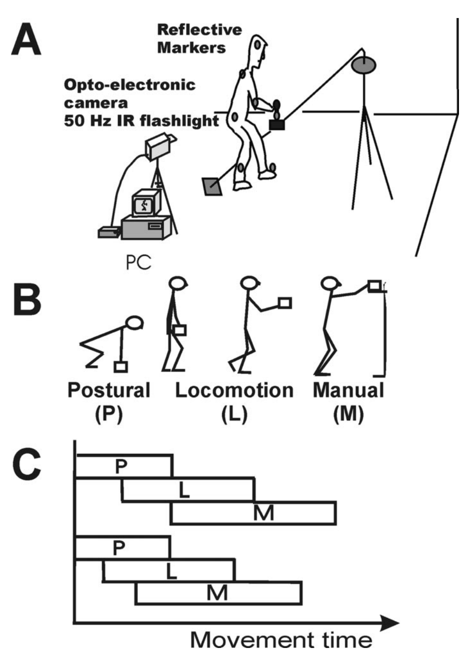

Figure 2. Setup of the Posturo-Locomotion-Manual test. **A**, The body movements are recorded using an optoelectronic camera and infra-red reflective markers. **B**, The time for raising the body (P), locomotion (L), and arm movement (M) is calculated. **C**, Decreased movement time (MT) can be accomplished by an increase in simultaneity of the postural (P), locomotor (L), and manual (M) phases. The simultaneity index (SI) reflects this association.

neity. To the eye, this gives the impression of a smoothly performed well-integrated whole body movement.

To assess the degree by which, in action, the three 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.[28] This index will increase if gait (L-phase) and/or arm movement (M-phase) is initiated earlier during the PLM test action (Figure 2C). Increasing the simultaneity will speed up the movement task.

At each test occasion, the 10 PLM test performances, each consisting of three repetitions, were captured by the optoelectronic video camera system and stored in a personal computer. For each trial of three PLM repeated test movements, the software (PLM program) automatically calculated mean and standard deviation for each of the five PLM aspects. The five aspects were MT, the three movement phases (P-, L-, and M-), and SI. Thus, the raw data available for evaluation of each subject's performance at each visit consisted of 10 measures of each of the five aspects of the intentional physical task, moving a small object from the floor to a shelf.

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

Intervention. The 12 LBP patients were asked to participate in one SML lesson every week during a maximum of 12 months.

Each SML lesson focused on one movement sequence of relevance for the actual CLBP patient's disability and level of skill. The SML teacher (one of the authors, C.U.M.S.-O.) guided the patient with CLBP through movement sequences organized around a particular functional theme. Sometimes the same movement sequence was addressed in several lessons. At other times, a new movement sequence was addressed in each lesson.[35] This choice was influenced by the SML teacher, based on which movement pattern underlying the movement task that was found difficult to perform for the actual patient. However, at each occasion, it was the patient that made the final choice of the lesson's focus.

The patients had the same SML teacher in all lessons, and they could choose to participate in one SML lesson every week during a maximum of 12 months. Each lesson took 1 hour, and a patient could choose to participate in one of the weekly scheduled group lessons as an alternative to an individual lesson. The teachings took place in a spacious room at a private SML practice.

The patients were asked to dress in clothes that allowed free movement. Depending on the movement pattern to be explored, the patient was either lying down on a treatment table, sitting or standing. The SML teacher either guided the patient verbally through the chosen movement sequence or communicated a specific part of the movement sequence through directed touch. Thus, the patient was invited to discover and to explore some details of his/her habitual way of moving and to compare those to alternative strategies. For example, each patient was guided to explore the impact his/her way of using of the floor/ground had on the felt sense of ease of movement. Once the patient was able to perceptually discern how his/her habitual ways of moving differed from other possibilities, it was hoped that the ability to consciously regulate and coordinate his/her movements guided by a kinesthetically preferred movement direction would be enhanced. A "better" movement strategy is subjectively recognized by a kinesthetic sense of more freedom in breathing and moving.[35,42]

Statistical Methods. To minimize the influence of movement habituation according to the result of the test-retest study,[31] the lowest mean value found out of any of three consecutive measures among the 10 computer generated measures were used to calculate each of the five aspects of the PLM task.

For descriptive purposes mean, median, standard deviation, and range were calculated. For comparison between groups, Fisher's nonparametric permutation test was used.[43] For comparison over time within groups, Fisher's nonparametric permutation test for matched pairs was used.[43] All tests were two-tailed and conducted at the 5% significance level.

Ethics. After oral and written information, the selected 24 subjects consented to take part in the study. The research ethical committee at the faculty of medicine at Gothenburg University approved the study.

Results

On average, every patient with CLBP chose to participate in 30 SML lessons (range, 16–40) during 10 months (range, 4–12 months). According to the choice of each patient, 82% of the SML lessons were individual lessons and 18% group lessons. Three of the 12 patients with CLBP decided, for various reasons, to conclude the SML lessons before the maximal allowed 12 months of SML lessons (Table 2).

MT of the object differed significantly before intervention when comparing the group of patients with CLBP with the healthy control group ($P = 0.005$). The significant difference in MT between the patients with CLBP and the healthy controls had disappeared at the measurements made directly after intervention. Also, 10 to 12 months after the completion of the intervention, there was no difference in MT, as the patients with CLBP now moved significantly faster than before intervention (Table 3; Figure 3).

The duration of the P-phase differed significantly at the measurement made before intervention, when comparing the group of patients with CLBP with the healthy control group ($P = 0.014$). This significant difference

Table 2. Number of Sensory Motor Learning Lessons in Which the Patients With Chronic Low Back Pain (N = 12) Participated

Patient Age (yr)	Intervention (mo)	Lessons (total)	Group Lessons	Individual Lessons
39	12	40	10	30
40	12	21	2	19
52	12	38	5	33
45	12	32	8	24
42	12	34	4	30
26	12	40	10	30
42	5	18	3	15
44	7	19	2	17
32	4	16	1	15
34	12	38	9	29
44	12	36	5	31
61	12	40	8	32
Mean: 42	Mean: 10	Mean: 31	Mean: 6	Mean: 25
Median: 42	Median: 12	Median: 35	Median: 5	Median: 30

Table 3. Comparison of Posturo-Locomotor-Manual (PLM) Test Results Including Movement Time (MT), Three Movement Phases (Postural [P], Locomotion [L], Manual [M] Phases), and Simultaneity Index (SI) Between the Group of Chronic Low Back Pain Patients (N = 12) and the Group of Healthy Controls (N = 12) Before Intervention (pre), Directly After Intervention (post), and 1 Year After Intervention (1 yr)

	Group		
Variable	Treatment (N = 12) [mean (SD); median (range)]	Control (N = 12) [mean (SD); median (range)]	*P*
MT pre	1.95 (0.44); 1.87 (1.35, 2.81)	1.49 (0.28); 1.38 (1.23, 2.06)	0.005
MT post	1.59 (0.28); 1.59 (1.08, 2.04)	1.49 (0.30); 1.42 (1.19, 2.10)	0.41 (NS)
MT 1 yr	1.58 (0.24); 1.62 (1.03, 1.83)	1.49 (0.31); 1.45 (1.07, 2.20)	0.44 (NS)
P-phase pre	0.89 (0.15); 0.85 (0.64, 1.10)	0.76 (0.08); 0.73 (0.67, 0.91)	0.014
P-phase post	0.77 (0.13); 0.77 (0.54, 1.02)	0.73 (0.05); 0.73 (0.65, 0.81)	0.32 (NS)
P-phase 1 yr	0.75 (0.14); 0.75 (0.48, 0.95)	0.73 (0.05); 0.73 (0.64, 0.82)	0.67 (NS)
L-phase pre	1.31 (0.24); 1.28 (0.96, 1.79)	1.14 (0.21); 1.11 (0.78, 1.52)	0.082 (NS)
L-phase post	1.21 (0.23); 1.16 (0.85, 1.60)	1.16 (0.21); 1.13 (0.89, 1.58)	0.62 (NS)
L-phase 1 yr	1.20 (0.18); 1.22 (0.84, 1.43)	1.16 (0.22); 1.09 (0.89, 1.63)	0.65 (NS)
M-phase pre	1.15 (0.22); 1.17 (0.80, 1.47)	0.90 (0.19); 0.82 (0.73, 1.31)	0.007
M-phase post	0.98 (0.19); 1.01 (0.69, 1.27)	0.89 (0.22); 0.84 (0.66, 1.38)	0.31 (NS)
M-phase 1 yr	1.02 (0.18); 1.08 (0.70, 1.23)	0.91 (0.23); 0.85 (0.62, 1.50)	0.18 (NS)
SI pre	1.76 (0.17); 1.76 (1.42, 1.95)	1.89 (0.11); 1.90 (1.68, 2.10)	0.027
SI post	1.87 (0.13); 1.84 (1.69, 2.09)	1.88 (0.12); 1.90 (1.72, 2.11)	0.87 (NS)
SI 1 yr	1.89 (0.13); 1.88 (1.69, 2.10)	1.90 (0.11); 1.90 (1.75, 2.04)	0.97 (NS)

NS = not significant.

had disappeared at the measurement made directly after intervention and also 10 to 12 months after the completion of the intervention as the time spent raising the body from the moment the object was gripped until the body was fully straightened had decreased significantly (Table 3; Figure 3).

The time spent for locomotion (L-phase) did not differ at the measurement made before intervention, directly after intervention, or 12 months later when comparing the group of patients and the healthy control group (Table 3; Figure 3).

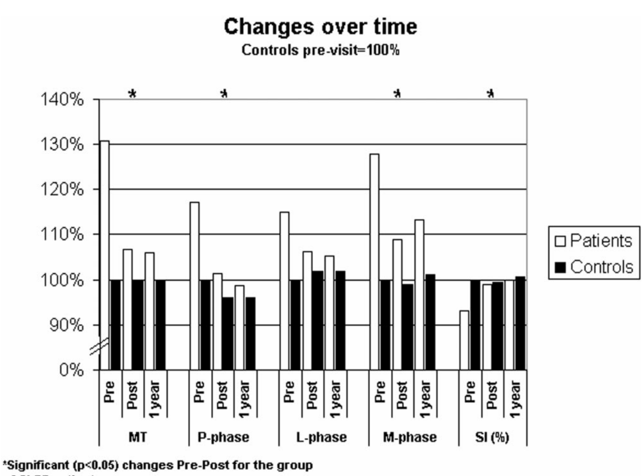

Figure 3. Comparison of changes in the five aspects of the Posturo-Locomotor-Manual (PLM) test profile (movement time [MT], movement phases [P-, L-, and M-phases], and Simultaneity Index [SI]) before intervention (pre), after intervention (post), and 1 year after intervention (1 year), within and between groups of patients with chronic low back pain (CLBP) (N = 12) and healthy controls (N = 12). Statistical significance pre *versus* post treatment for patients: $*P < 0.05$.

The duration of the M-phase differed significantly at the measurement made before intervention, when comparing the group of patients with CLBP and the healthy control group ($P = 0.007$). The difference in M-phase had disappeared at measurements made directly after intervention and 10 to 12 months after the completion of the intervention as the time spent for the forward goal-aiming arm movement, placing the handle on the stand had decreased significantly (Table 3; Figure 3).

The SI was significantly lower at the measurement made before intervention, when comparing the group of patients and the healthy control group ($P = 0.027$). At the measurements made after intervention, this difference had disappeared and there were no longer any significant group differences between the group of patients with CLBP and the group of back-healthy controls (Table 3; Figure 3).

In summary, the group of CLBP patients improved their performance significantly over time when compared with the back-healthy controls. Comparing the change from measurements made before intervention to the first measurements made after intervention, MT, P-phase, M-phase, and SI differed significantly between groups ($P = 0.002$, $P = 0.014$, $P = 0.019$, and $P = 0.013$, respectively). These significant differences in MT, P-phase, and SI were retained when comparing the measurements made before intervention to the measurements made 1 year after the completion of the intervention ($P = 0.008$, $P = 0.027$, and $P = 0.008$, respectively). There was no significant difference between groups regarding the change over time in L-phase (Table 4; Figure 3).

Discussion

Chronic low back pain might be seen as a form of learned pain behavior.[44] This implies that how we move after

Table 4. Comparison of Changes in the Performance of the Five Aspects of the Posturo-Locomotion-Manual (PLM) Test Profile (Movement Time (MT), Postural (P), Locomotion (L), Manual (M) Phases and Simultaneity Index (SI)) Over Time (Pre–post, pre–1 yr) Within and Between the Group of Patients with Chronic Low Back Pain (N = 12) and the Group of Healthy Controls (N = 12).

	Treatment Group (n = 12)		Control Group (n = 12)		
Variable	[mean (SD); median (range)]	*P* (within group)	[mean (SD); median (range)]	*P* (within group)	*P* (between groups)
Change in MT (pre *vs.* post)	−0.36 (0.39); 0.21 (−1.06, −0.01)	<0.001	0.00 (0.11); −0.01 (−0.22, 0.18)	0.98 (NS)	0.002
Change in MT (pre *vs.* 1 yr)	−0.37 (0.40); −0.31 (−1.02, 0.15)	0.006	0.00 (0.19); 0.01 (−0.26, 0.25)	0.96 (NS)	0.008
Change in P-phase (pre *vs.* post)	−0.13 (0.11); −0.11 (−0.37, 0.01)	0.001	−0.04 (0.06); −0.03 (−0.16, 0.08)	0.044	0.014
Change in P-phase (pre *vs.* 1 yr)	−0.14 (0.14); −0.16 (−0.40, 0.07)	0.007	−0.03 (0.08); −0.01 (−0.01, 0.08)	0.16 (NS)	0.027
Change in L-phase (pre *vs.* post)	−0.10 (0.23); −0.09 (−0.55, 0.24)	0.16 (NS)	0.02 (0.05); 0.02 (−0.06, 0.11)	0.24 (NS)	0.10 (NS)
Change in L-phase (pre *vs.* 1 yr)	−0.11 (0.26); −0.06 (−0.54, 0.19)	0.18 (NS)	0.02 (0.11); −0.01 (−0.18, 0.22)	0.56 (NS)	0.13 (NS)
Change in M-phase pre *vs.* post	−0.17 (0.21); −0.11 (−0.54, 0.10)	0.020	0.00 (0.08); 0.03 (−0.13, 0.09)	0.89 (NS)	0.019
Change in M-phase (pre *vs.* 1 yr)	−0.12 (0.24); −0.07 (−0.53, 0.22)	0.102 (NS)	0.01 (0.12); 0.03 (−0.18, 0.19)	0.77 (NS)	0.094 (NS)
Change in S-index (pre *vs.* post)	0.11 (0.14); 0.09 (−0.08, 0.39)	0.020	−0.02 (0.08); −0.02 (−0.13, 0.18)	0.54 (NS)	0.013
Change in S-index (pre *vs.* 1 yr)	0.14 (0.11); 0.15 (−0.12, 0.27)	0.003	0.00 (0.11); −0.02 (−0.19, 0.17)	0.96 (NS)	0.008

NS = not significant.

minor or major accidents or stress-related overload could be a result of how we unconsciously restrict our movements. The restricted movements may start a vicious circle, where increased muscle tone gradually can give rise to movement patterns that lack flow and efficiency and lead to habituation and nonaccurate movements.

The evaluation of CLBP patients' capacity to perform dynamic activities is difficult because of the lack of suitable outcome measures available.[45] In a complex behavior as the PLM test, which involves postural change and transport of an object through the environment, the number of degrees of freedom to be controlled is considerable. To capture the movement pattern by which the subject performs the action, it is necessary to monitor the movements of the body as an integrated whole, *i.e.*, an entity comprised of interdependent parts working together.[11,46] The optoelectronic PLM test corresponds to these requirements. It is easy to perform, and it captures an intentional behavior with relevance for daily life in a reliable way.

When the PLM test results of the group of patients with CLBP before intervention was compared with the PLM test results of the healthy control group, MT, P-, and M-phase were prolonged, which indicates impaired movement patterns (Table 3). These results are congruent with earlier reported results where patients with chronic nonspecific back or neck pain were compared with healthy controls.[47–53]

After intervention, MT, P-, and M-phases changed significantly in the patient group and the results were retained after 1 year (stable PLM "profile"). Moreover, coordination, measured as the degree by which, in action, the three different P-, L-, and M-phases were simultaneously integrated into one smooth movement (SI) was improved in the group of patients with CLBP but not in the healthy control group (Table 3; Figure 3). These results indicate that the patients with CLBP had learned a more efficient movement pattern.

When studying the video recordings of the PLM test performances before and after intervention, there is a clear impression that many of the CLBP patients perform a much more natural and smooth action after intervention. This subjective impression is thought to be the aspect that the SI is capturing.

Possible reasons behind the differences in movement pattern before and after intervention that the PLM test measured appear when studying the video recordings more closely.

Before intervention, many of the patients with CLBP seem to move stiffly with inefficient forward propulsion.[54] Several patients keep 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 with CLBP seem to be able to turn with greater ease around the spinal axis while extending the arm from the scapulas with smooth dynamic muscle work.

The fact that there were no significant differences in the L-phase when comparing the group of CLBP patients and the group of back-healthy controls was not a surprise since the PLM test does not reflect segmental spinal motion, even though style of gait may be related to CLBP.[55–57]

The SML systems, as for example, the Feldenkrais method,[35,58] assume that humans act in accordance with all aspects of their self-image. This implies that the ability to perceive or imagine the detailed structure of our own moving body is crucial to dexterity.[13,40,59]

Some authors suggest that the emphasis of physical therapy for nonspecific back pain might change from symptomatic methods to restoration of function.[3,14] Some clinical studies indicate that SML might be an effective intervention for patients with nonspecific musculoskeletal disorders.[60,61] However, so far there is no evidence on the effectiveness of any SML system.

The SML teacher guides the patient to observe himself from the first-person viewpoint of his own proprioceptive and kinesthetic senses. This implies to move from a problem perspective to a pattern perspective and to focus on resources for movement reeducation, that is, to discover nonpurposeful, habitual movements that are interfering with desired movements. Freeing restricted movement patterns are supposed to produce significant relief of pain.[33,62–64]

Nine of the 12 patients with CLBP chose to participate in the SML lessons for the maximal allowed 12 months. One of the 3 patients with CLBP that decided to conclude the SML lessons before the maximal allowed time did so because he felt able to return to full-time work. The other 2 patients with CLBP chose to stop for other reasons (Table 2). However, nobody stopped the intervention because the SML lessons increased pain or disability.

■ Conclusion

This study shows that the movement capacity of the group of patients with CLBP changed significantly after the SML intervention and the improvements were retained after 1 year. This implies that the patients with CLBP had learned and retained a more efficient behavior. The result suggests that SML is a worthwhile intervention for improving dynamic movement capacity patients with CLBP. It can be concluded that the video observations elucidate both the results of the objective PLM tests and the result of the SML intervention.

■ Key Points

- Sensory motor learning addresses nonpurposeful habitual movements to improve dynamic movement capacity in patients with nonspecific chronic pain.
- After the intervention, the group of chronic low back pain patients had improved their performance so there were no longer any significant differences compared with a matched group of back-healthy individuals.
- The study shows that the group of chronic low back pain patients had learned and retained a more efficient behavior.
- The results suggest that sensory motor learning is an effective intervention for improving dynamic movement capacity in chronic low back pain patients.

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