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Individualized Low-Load Motor Control Exercises and Education Versus a High-Load Lifting Exercise and Education to Improve Activity, Pain Intensity, and Physical Performance in Patients With Low Back Pain: A Randomized Controlled Trial

STUDY DESIGN: Randomized controlled trial.

BACKGROUND: Low back pain is a common disorder. Patients with low back pain frequently have aberrant and pain-provocative movement patterns that often are addressed with motor control exercises.

OBJECTIVE: To compare the effects of low-load motor control (LMC) exercise and those of a high-load lifting (HLL) exercise.

METHODS: Seventy participants with recurrent low back pain, who were diagnosed with nociceptive mechanical pain as their dominating pain pattern, were randomized to either LMC or HLL exercise treatments. Participants were offered 12 treatment sessions over an 8-week period. All participants were also provided with education regarding pain mechanisms.

METHODS: Participants were assessed prior to and following treatment. The primary outcome measures were activity (the Patient-Specific Functional Scale) and average pain intensity over the last 7 days (visual analog scale). The secondary outcome measure was a physical performance test battery that included 1 strength, 3 endurance, and 7 movement control tests for the lumbopelvic region.

RESULTS: Both interventions resulted in significant within-group improvements in pain intensity, strength, and endurance. The LMC group showed significantly greater improvement on the Patient-Specific Functional Scale (4.2 points) compared with the HLL group (2.5 points) ($P<.001$). There were no significant between-group differences in pain intensity ($P = .505$), strength, and 1 of the 3 endurance tests. However, the LMC group showed an increase (from 2.9 to 5.9) on the movement control test subscale, whereas the HLL group showed no change (from 3.9 to 3.1) ($P<.001$).

CONCLUSION: An LMC intervention may result in superior outcomes in activity, movement control, and muscle endurance compared to an HLL intervention, but not in pain intensity, strength, or endurance. Registered at ClinicalTrials.gov (NCT01061632).

LEVEL OF EVIDENCE: Therapy, level 2b–.

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KEY WORDS: *deadlift, functional rehabilitation, motor learning, stabilization exercises, subgrouping*

There is growing evidence that altered posture and movement patterns are common in patients with low back pain (LBP).[10,11,27,33,41] It is proposed that the repetition of altered alignments and movements may result in localized regions of tissue stress,[1] which may provide a basis for ongoing nociceptive pain of mechanical character.[38]

A variety of interventions have been proposed to retrain postures and movement patterns. Common features are the use of relearning strategies and exercises to change spinal alignment,[27,32,33,43] movement patterns,[6,7,27,32,33,41,43] and muscle recruitment patterns in global[7] and/or local muscles.[9,15,22,40] Though there is no consensus on the umbrella term for these exercises, the present study refers to them as motor control exercises. According to Shumway-Cook and Woollacott,[34] mo-

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tor control involves the way in which the central nervous system organizes muscles into coordinated movements, sensory information is used to select and control movement, and movement patterns are influenced by perceptions. There is also no consensus regarding what exercises are most effective. In a recently published review[4] of the efficiency of motor control exercises, including segmental and specific stabilizing exercises, it was concluded that these exercises may be superior to many other treatments. In a prospective study[20] including patients with LBP who received individualized exercises targeting movement patterns,[7,11,28,33,41] the exercises showed promising results regarding movement control and activity.

Most motor control exercises, whether focused on muscle recruitment pattern or retraining of optimal movement pattern, are usually performed with lower loads. A recent review[4] has shown that none of the included studies compared the effects of low-load motor control (LMC) exercises with an exercise focusing on the ability to maintain optimal movement patterns, spinal alignment, and effective activation of stabilizing muscles during a high load. The deadlift (DL), a resistance training exercise performed with a barbell, covers all these aspects and aims at increasing strength.[9,13,15,17,25] Studies on people without back pain have shown that both local and global stabilizing muscles are activated in this exercise,[13,17,25] and that the DL activates the stabilizing muscles to a greater extent than exercises performed on a gym ball.[25] In a pilot study,[18] this exercise was also shown to be effective in decreasing pain and disability in patients with LBP.

It has been shown that in the rehabilitation of patients with LBP, it is important to include cognitive aspects.[23,24,43] For example, a recent randomized controlled trial[43] showed that including cognitive aspects in rehabilitation was superior to manual therapy and exercises only. Further, in a study[23] in which the participants received education regarding pain physiology, it was shown that a change in measures of pain attitudes and pain catastrophizing was associated with improvement in the straight leg raise test and forward-bending ability. Thus, the aim of the present study was to compare the effects of LMC exercises and a high-load lifting (HLL) exercise in a study where education regarding pain mechanisms was also included in rehabilitation. Notably, only patients with nociceptive mechanical LBP[38] as their dominating pain pattern were included.

TABLE 1 BACKGROUND CHARACTERISTICS OF THE PARTICIPANTS IN THE LMC AND THE HLL EXERCISE GROUPS*

Characteristic	LMC (n = 35)	HLL (n = 35)
Age, y	42 ± 11	42 ± 10
Female, n (%)	19 (54)	20 (57)
Low back pain duration, wk	340 ± 290	312 ± 310
Height, cm	172 ± 10	174 ± 8
Weight, kg	78 ± 15	74 ± 13
Smoker, n (%)	3 (9)	3 (9)
Taking analgesics, n (%)	18 (51)	18 (51)
Physical activity moderate intensity, min/wk	165 ± 160	179 ± 148
Physical activity high intensity, min/wk	34 ± 66	45 ± 71
Kinesiophobia (17-68)	34 ± 7	32 ± 7
Roland-Morris questionnaire (0-24)	7 ± 5	7 ± 4
7-d VAS (0-100)	47 ± 28	43 ± 24
PSFS (0-10)	3.8 ± 1.4	4.8 ± 1.4
Lift strength, N	892 ± 422	932 ± 412
Prone bridge, s	56 ± 31	72 ± 45
Sidebridge on right arm, s	36 ± 26	45 ± 28
Biering-Sørensen, s	75 ± 35	87 ± 43
Movement control test battery, n	2.9 ± 1.6	3.9 ± 1.6

Abbreviations: HLL, high-load lifting; LMC, low-load motor control; PSFS, Patient-Specific Functional Scale; VAS, visual analog scale.
**Values are mean ± SD unless otherwise indicated.*

METHODS

Design

THIS RANDOMIZED CONTROLLED TRIAL was conducted in an outpatient physical therapy clinic in Sweden, registered in the Clinical Trial Registry of the US National Institutes of Health (NCT01061632), and approved by the Regional Ethical Review Board in Umeå, Sweden (09-200M).

Participants

Consecutive patients aged 25 to 60 years, seeking care at 2 occupational health care services for pain and/or discomfort in their lower back for 3 or more months in duration, with or without referred leg pain, and who were subclassified by their physical therapist as having nociceptive mechanical pain as their dominating pain characteristic were asked if they wanted to participate in a study about training for LBP problems. For a patient to be diagnosed as having nociceptive mechanical LBP, the pain had to be localized to the area of injury/dysfunction; have a clear, proportionate mechanical nature to aggravating and easing factors; and be intermittent with movement/mechanical provocation.[35,38] Further, the physical therapists ensured that the patients had no ongoing claims for compensation, no fractures or acute disc herniation in the spinal region, no earlier or present psychiatric and mental deficits, and no contraindication to exercise. Once they agreed to participate in the study, prospective participants were contacted by a study administrator to confirm that they did not suffer from any systemic illness; rheumatic diseases; fibromyalgia; or inflammatory, endocrine, neurologic, connective tissue, psychiatric, or cancer diseases; and were not pregnant. Thereafter, information about the study, an informed-consent form, and questionnaires were sent to their home addresses, and they were scheduled for an appointment with a physical therapist for a final verification of their eligibility. The physical therapist made a full assessment to determine that the pain was predominantly of a nociceptive mechanical nature[38] and that signs and symptoms of other pain mechanisms, such as central sensitization[36] or nerve root signs/peripheral neuropathic pain,[37] were not evident. Yellow-flag inquiries were also made. Negative pain beliefs and nonoptimal pain-coping strategies were allowed, but it was ensured that mechanical factors, and not beliefs, provoked the experience of pain. This was done in such a way that a movement the participant mentioned to be pain provoking or avoided was specifically examined. First, the participant was encouraged to perform the movement using his or her preferred strategy and asked to report symptoms. Thereafter, the physical therapist tried to modify how the participant moved or aligned the lumbar region during the activity. The symptoms during the corrected movement were compared to those during the primary movement. During the second movement, the participant's pain experience was expected to decrease.

All participants gave their written consent and were informed about their right to withdraw participation at any time without further explanation. Risk of harm or injury was minimized by encouraging participants to report any discomfort or pain during or between sessions. The descriptive statistics are presented in **TABLE 1**.

Randomization and Interventions

After the participants gave their consent, the randomization procedure was performed. The randomization was performed by a person who had not been in contact with any of the participants. First, the participants were assigned a number in sequence of their enrollment in the study. It was noticed that 2 participants were younger than 25 years; however, as they met all other inclusion and exclusion criteria, they were considered eligible for the study and were included. The randomization was stratified for sex and age (young, age 42 years and below; old, age 43 years and above) into 4 groups. Within each group, separate randomization was performed by applying a computer-generated procedure of "n out of N." This procedure randomly draws n cases, with each n being assigned to the sequence running number, forming the HLL group, whereas the participants not being drawn form the LMC group.

The LMC intervention took place at a physical therapy clinic and the HLL intervention at a sports center. The LMC intervention was performed individually and the HLL was performed in groups of 5 participants. All participants were offered 12 treatment sessions over an 8-week period (weeks 1-4, 2 sessions per week; weeks 5-8, 1 session per week). The duration of each session was 20 to 30 minutes for the LMC and 60 minutes for the HLL. The LMC and HLL exercises are described below and in detail in **APPENDIX A**, available online at www.jospt.org.

Both physical therapists, one assigned to the HLL group and one to the LMC group, had many years of experience of teaching patients and were asked to educate the participants about pain mechanisms, with an emphasis on nociceptive pain and how non-ideal movement and alignment strategies could contribute to lumbar-region tissue stress and symptoms. The time spent on education was need based and varied within both groups and participants. Questions and discussions were encouraged. The physical therapists were fully convinced that each intervention was the optimal one, and they used a variety of feedback to teach and facilitate correct performance during the exercises.

LMC Exercises

The physical therapist took a detailed anamnesis and performed a physical examination[33] and, accordingly, selected individual exercises.[6,7,27,28,30,33] The exercises aimed to normalize the dominating movement impairment for each participant. The strategy was to start from a basic level and continue to a gradually increased level of difficulty. Home exercises were a significant part of the training, especially for the exercises in stage 1, in which the participants were encouraged to make at least 10 repetitions 2 to 3 times a day. Because it was considered important to always perform the movements ideally with an optimal muscle recruitment pattern, the exercises were always followed up, and if considered ideally performed, they were progressed.

First (stage 1), based on the participants' movement impairments that were associated with increased LBP symptoms, the participants' ability to control the joint neutral positions was retrained in supine, four-point kneeling, sitting, and/or standing positions. The participants learned how to find their neutral position in the lumbopelvic region and how to control movements in their lumbar spine with minimal effort while moving their arms/legs (eg, to dissociate hip movements from lumbopelvic movements). In stage 2, the participants learned how to control the movements in the lumbopelvic region with minimal effort when performing activities that produced their nociceptive mechanical pain. In particular, the painful positions and movements that the participants mentioned in the anamnesis were targeted. The participants were encouraged to observe how their muscles were activated[7,27,30,33,40] and how their muscles coordinated during the no-longer-painful alignments/movements. The ability of the global stabilizing muscles[7] to control movements through-

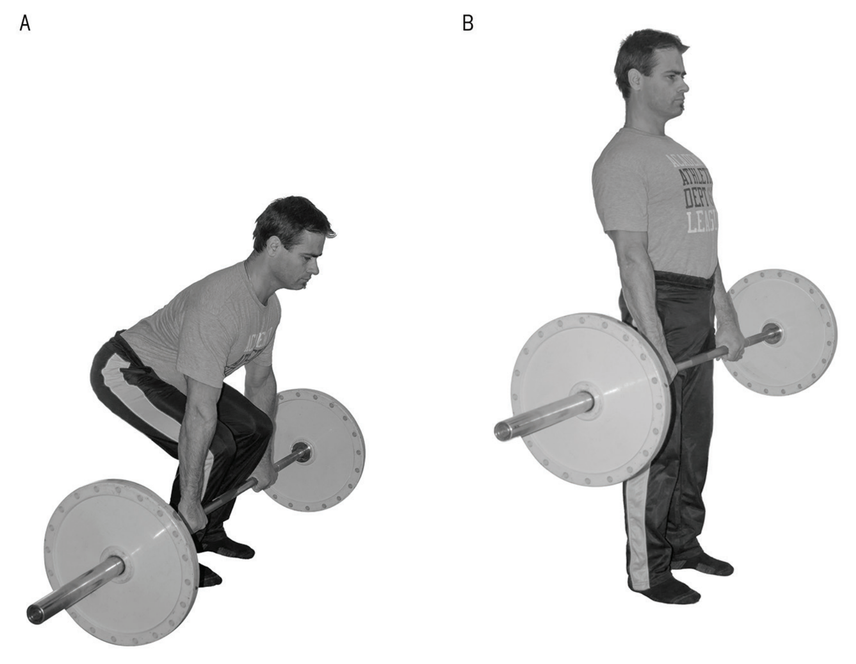

FIGURE 1. High-load lifting exercise.

out joint range was also trained. Gradually (stage 3), the participants learned to control dynamic movements of the spine necessary for various tasks and activities that the participants earlier found difficult/painful to perform.

HLL Exercise

To represent an HLL exercise, we chose the DL exercise, which activates the stabilizing muscles and focuses on maintenance of an optimal alignment of the spine during the lift.[13,17,25] The physical therapist selected appropriate initial weight on the bar, based on the anamnesis and findings in the physical examination. The physical therapist taught the participants an optimal lifting technique and ensured that the participants maintained a neutral alignment of the spine when performing the exercise. To perform the exercise, the participant stood in front of a barbell with the bar 22.5 cm above the ground. The participant squatted down, performing hip and knee flexion, and grasped the barbell (**FIGURE 1A**). Simultaneous extension of the knee and hip joints was performed to lift the barbell until the participant was in erect position (**FIGURE 1B**). The eccentric phase was initiated by lowering the barbell through hip flexion and keeping the bar close to the thighs until it passed the kneecap, where knee flexion concluded the descent. Between repetitions, participants let go of the barbell and paused before initiating the next repetition. The load was slowly progressed during the intervention period by gradually increasing the number of lifts and/or the weight on the bar. The participants were encouraged to use the same lifting technique during daily activities.

Data Collection

Outcome measurements were obtained at baseline and at follow-up at 2 and 12 months. The primary outcomes were the Patient-Specific Functional Scale (PSFS)[14,39] and pain assessed as average pain in the last 7 days on a visual analog scale (VAS).[12] As secondary outcomes, a physical performance test battery was included. At baseline and 2 months, the participants answered the questionnaires and performed the physical performance test battery at the physical therapy clinic. At 12 months, the questionnaires were sent to the participants' home addresses with a response envelope, and the physical performance test battery appointment was booked separately.

The baseline data also included the participants' characteristics: age, sex, weight, height, smoking, physical activity, fear of movement and injury (the Tampa Scale of Kinesiophobia),[19] and disability (the 24-item Roland-Morris Disability Questionnaire).[31] All data were collected by 2 experienced physical therapists blinded to the treatment allocation.

Primary Outcomes

Using the PSFS, participants identified the 3 most important activities that they had difficulty performing or were unable to perform due to LBP, and rated on an 11-point scale (ranging from 0, "unable to perform activity" to 10, "able to perform activity at preinjury level") the current level of ability associated with each activity. The PSFS is considered reliable, valid, and responsive.[8]

The participants also rated their average pain intensity over the last 7 days on a VAS ranging from 0 to 100 mm, with 0 mm representing "no pain at all" and 100 mm the "worst imaginable pain." The VAS is considered a valid and reliable measure of pain intensity.[12]

Secondary Outcomes

The physical performance test battery included a lift strength test,[2] the prone bridge, the sidebridge (on right arm), and the Biering-Sørensen test,[2,3] and a movement control test battery. All tests were carried out in standardized positions. For the lift strength test, the maximal isometric lift capacity was noted in Newtons. In the prone bridge, sidebridge, and Biering-Sørensen test, emphasis was on maintaining a neutral lumbar spine for as long as possible (seconds). Seven movement control tests based on descriptions by Sahrmann[33] and Van Dillen et al[41] and further described by Luomajoki et al[21] were included in the movement control test battery. The tests challenge patients' ability to control the lumbar spine in neutral position while moving in adjacent joints. The tests used are the waiter's bow (evaluates flexion control), sitting knee extension (bilateral evaluates flexion control, unilateral evaluates flexion/rotation left/right control), and prone-lying active knee flexion (bilateral evaluates extension control, unilateral evaluates extension/rotation left/right control). Participants performed the complete set of tests. Each positive test scored 1 point, that is, 3/7 means the participant performed 3 of the 7 tests correctly.

Data Processing and Statistical Analysis

Between- and within-group significant differences of the intervention were assessed with linear mixed-model analyses. Fixed factors in the model were group (HLL, LMC), time (baseline, 2 months, 12 months), and group by time. The baseline values were always included in the analyses. Linear mixed-model analysis was chosen because it uses all the available information in data in a repeated-measures design and is robust in handling missing data.[5] Further, the baseline values were compared between the participants who attended the follow-ups and those who dropped out using the 2-sided Student *t* test or the chi-square test (**APPENDIX B**, available online at www.jospt.org). Also, the percentages of the participants who changed their scores by 30% or greater (minimal important change[26]) for each outcome measure were calculated.

The present 12-month follow-up study is part of a larger data set that included a 24-month follow-up using only questionnaire data. The sample size was calculated for the VAS (average pain in the last 7 days) with 80% power to detect an intervention effect that would differ between groups by 15 ± 21 mm on the VAS, with an alpha level set at .05. This calculation gave an estimated sample size of 31; therefore, 35 participants were enrolled in each intervention to ensure power even with dropouts.

A *P* value of less than .05 was considered significant, and all statistical tests were 2 sided.

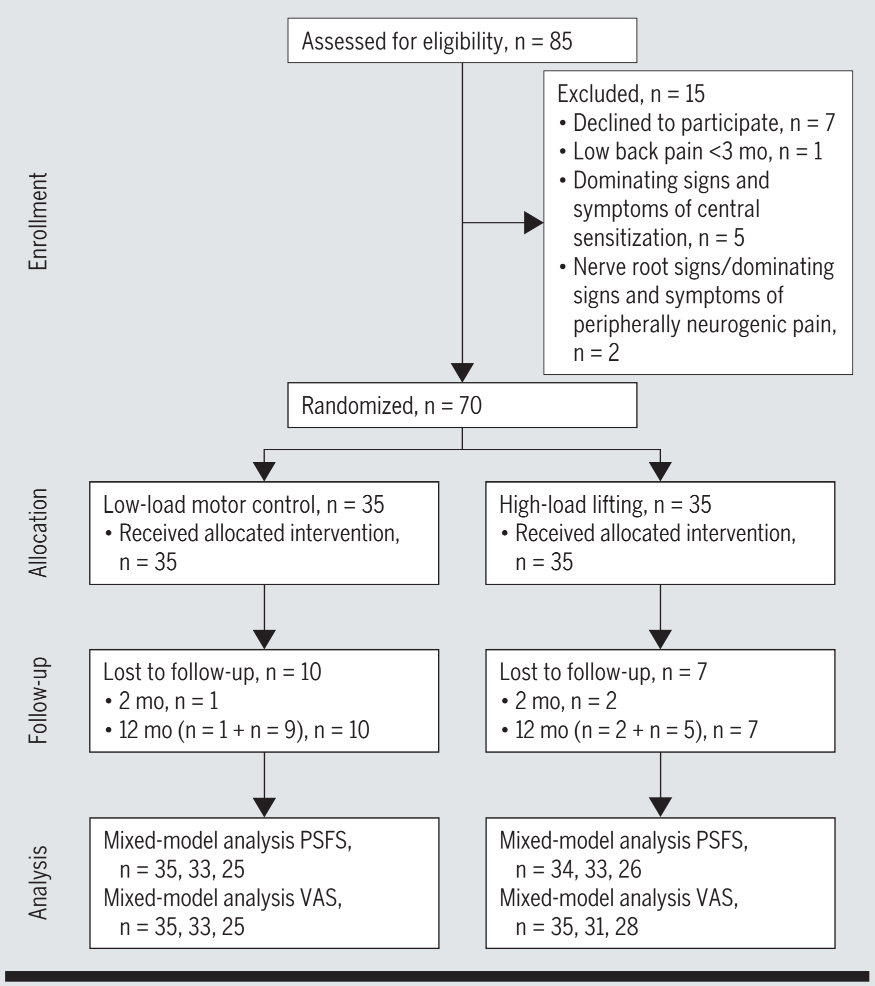

FIGURE 2. Flow of participants: low-load motor control exercises versus a high-load lifting exercise. Abbreviations: PSFS, Patient-Specific Functional Scale; VAS, visual analog scale.

RESULTS

FIGURE 2 shows the flow of participants through the trial. Of the 85 individuals referred to the study administrator, 15 were considered ineligible at the verification examination (**FIGURE 2**), 7 due to dominating signs and symptoms of central sensitization[36] and nerve root signs/peripheral neurogenic pain.[37] Another 7 participants declined to participate after inclusion but before randomization (unknown reasons), and 1 was ineligible due to pain of less than 3 months in duration.

Descriptive statistics of baseline characteristics of the participants are presented in **TABLE 1**. Participants worked mainly industrial types of jobs, though others had more administrative duties. None were currently on full-time sick leave. The groups were similar for all baseline characteristics except PSFS scores, which in the LMC group were significantly lower. No significant differences on the PSFS or VAS at baseline were detected between the participants who answered the questionnaires (PSFS, n = 51; VAS, n = 53) and those who did not at the 12-month follow-up. The performance on the prone bridge (74 seconds versus 50 seconds) and the Biering-Sørensen test (90 seconds versus 69 seconds) was higher at baseline among those who attended the 12-month follow-up testing (n = 41) compared to those who did not (n

TABLE 2 UNADJUSTED TEST RESULTS OF PAIN INTENSITY, THE PSFS, AND TESTS INCLUDED IN THE PHYSICAL PERFORMANCE TEST BATTERY AT BASELINE AND AT 2-MONTH AND 12-MONTH FOLLOW-UPS*

	Unadjusted Outcome Values				Adjusted Treatment Effects	
Test	LMC Mean[†]	LMC MIC	HLL Mean[†]	HLL MIC	Between-Group Mean Change[†]	*P* Value
7-d VAS (0-100)						
Baseline (n = 70)	47 (38, 57)		43 (35, 51)			
2-mo follow-up (n = 62)	30 (21, 40)	53%	22 (14, 31)	70%	−2 (−14, 9)	.687
12-mo follow-up (n = 53)	25 (16, 34)	61%	24 (13, 34)	67%	4 (−8, 17)	.505
PSFS (0-10)						
Baseline (n = 70)	3.8 (3.3, 4.3)		4.8 (4.3, 5.2)			
2-mo follow-up (n = 65)	7.8 (7.2, 8.4)	88%	6.8 (6.1, 7.6)	58%	−1.9 (−2.9, −0.9)	≤.001
12-mo follow-up (n = 50)	8.0 (7.3, 8.8)	89%	7.3 (6.6, 8.0)	69%	−1.8 (−2.8, −0.7)	≤.001
Lift strength, N						
Baseline (n = 70)	892 (745, 1040)		932 (794, 1079)			
2-mo follow-up (n = 68)	961 (824, 1108)	15%	1059 (922, 1206)	18%	39 (−39, 127)	.320
12-mo follow-up (n = 41)	902 (735, 1069)	18%	1177 (1030, 1334)	17%	59 (−49, 157)	.275
Prone bridge, s						
Baseline (n = 70)	56 (45, 66)		72 (56, 88)			
2-mo follow-up (n = 68)	83 (65, 101)	65%	85 (66, 103)	32%	−29 (−31, −1)	.034
12-mo follow-up (n = 41)	82 (50, 114)	53%	86 (66, 105)	21%	−24 (−39, −5)	.007
Sidebridge, s						
Baseline (n = 70)	36 (27, 46)		45 (35, 55)			
2-mo follow-up (n = 68)	48 (37, 59)	38%	54 (43, 64)	39%	−4 (−13, 6)	.426
12-mo follow-up (n = 40)	40 (24, 56)	44%	51 (41, 61)	14%	−5 (−17, 6)	.377
Biering-Sørensen, s						
Baseline (n = 70)	75 (63, 87)		87 (72, 102)			
2-mo follow-up (n = 68)	87 (74, 99)	35%	101 (83, 119)	27%	1 (−10, 13)	.832
12-mo follow-up (n = 42)	99 (77, 122)	41%	109 (94, 125)	24%	−14 (−28, −1)	.035
MC test battery, n						
Baseline (n = 70)	2.9 (2.4, 3.5)		3.9 (3.3, 4.4)			
2-mo follow-up (n = 66)	5.1 (4.6, 5.7)	70%	4.3 (3.8, 4.8)	44%	−1.8 (−2.7, −1.0)	≤.001
12-mo follow-up (n = 43)	5.9 (5.2, 6.5)	75%	3.1 (2.5, 3.8)	15%	−3.7 (−4.6, −2.7)	≤.001

Abbreviations: HLL, high-load lifting group; LMC, low-load motor control group; MC, movement control; MIC, minimal important change; PSFS, Patient-Specific Functional Scale; VAS, visual analog scale.

**Also presented are the percentage of participants who improved at least 30% on a specific score/test (MIC) and between-group mean changes from baseline to 2 and 12 months, respectively, received from the linear mixed-model analyses, with time (baseline and 2-month and 12-month follow-up) and group (LMC, HLL) as fixed factors and baseline values as covariates.*

[†] *Values in parentheses are 95% confidence interval.*

= 29), whereas the performance on the other tests did not significantly differ.

The participants in the HLL group attended 11.0 treatment sessions, in comparison with 6.1 in the LMC group. Two of the participants from the HLL group reported adverse effects. One of these withdrew from the study during the intervention period, and another participant dropped out without giving any explanation after 1 session. None from the LMC group reported adverse effects, but 1 withdrew from the study due to abdominal surgery unrelated to the intervention.

The baseline and follow-up values, percentages of participants who changed their scores by 30% or greater (minimal important change[26]) for each outcome measure, and between-group mean changes from baseline to 2 months and 12 months, with their corresponding 95% confidence intervals, are presented in **TABLE 2**. Both exercise interventions significantly increased PSFS scores (time, $P \leq .001$ [$P \leq .001$ from baseline to 2 months and from baseline to 12 months]) and decreased VAS scores (time, $P \leq .001$ [$P \leq .001$ from baseline to 2 months and from baseline to 12 months]). The linear mixed-model analyses showed that, for PSFS, there was a significant between-group mean change (group by time) in favor of the participants in the LMC group, who increased their scores from 3.8 to 8.0 (unadjusted mean scores). The corresponding figures for the participants in the HLL group were 4.8 to 7.3. There were no significant differences in between-group mean changes for VAS scores ($P = .505$). Both exercise interventions also significantly increased the participants' performance on the lift strength test (time, $P \leq .001$ [$P = .023$ from baseline to 2 months and $P = .037$ from baseline to 12 months]), prone bridge (time, $P \leq .001$ [$P \leq .001$ from baseline to 2 months and from baseline to 12 months]), sidebridge (time, $P \leq .001$ [$P \leq .001$ from baseline to 2 months and $P = .275$ from baseline to 12 months]), and Biering-Sørensen test (time, $P \leq .001$ [$P = .004$ from baseline to 2 months and $P \leq .001$ from baseline to 12 months]). There were no significant differences in between-group mean changes (group by time) for most of the tests, except for the prone bridge test in favor of the LMC group. For the movement control test battery, the analyses showed a significant difference in between-group mean changes in favor of the LMC group. The LMC group increased the number of correctly performed tests from 2.9 to 5.9, whereas the HLL group did not significantly change performance (3.9 to 3.1).

DISCUSSION

WHEN COMPARING THE EFFECTS OF LMC with HLL, a significantly beneficial effect of LMC was found for PSFS scores. This finding may partly be explained by the fact that the participants in the LMC group reported lower PSFS scores at baseline and partly by the fact that, during the intervention period, they focused on controlling posture and muscle activation during movements and activities that provoked their pain. At their first visit to the physical therapist, they were asked to show how they performed activities that they reported to be painful. In all stages (1-3), the patient-preferred movement strategy was modified to correct the spinal alignment or nonoptimal movement pattern, and the participants were encouraged to observe how their muscles were activated and coordinated during the no-longer-painful movements. This feedback might have inspired the participants to practice more optimal patterns during many of their daily tasks (stages 2-3). Further, the mean effect of the LMC on PSFS scores was higher than that in earlier published studies investigating the effect of voluntary activation of deep stabilizing muscle exercises.[9,15,22] We believe that this might primarily be due to the fact that the present study included a more homogeneous group of participants than previous studies. This is confirmed in a systematic review[16] where it was found that in the very few studies that tried to subclassify patients and match pain profiles with interventions, pain and disability reductions were significantly larger.

Both groups significantly increased their performance on the strength and endurance tests. For the participants in the HLL group, this was probably due to the fact that they progressively lifted heavier loads during the exercise period. However, we cannot exclude the potentially positive effect of pain education. The participants might have learned that pain during training is not an indication to be inactive, as long as the pain subsides after training, and therefore continued to be active. Interestingly, the participants in the LMC group also increased their performance. This might partly be due to pain education,[23] but also to more ideal movement patterns,[6] which decrease stress and strain on the lumbar tissues and thereby desensitize them, enabling increased performance.[32,33] Moreover, there was a beneficial effect of LMC on the movement control test battery. A focus on keeping the spine in neutral position during the DL did not lead to ability to correctly perform movement control tests. In conclusion, there seems to be a transferability from LMC training in combination with pain education to strength and endurance tests, but not from HLL training to movement control tests.

About 65% of the participants perceived a meaningful change in pain intensity level (minimal important change, 30% or greater[26]) from baseline to 12-month follow-up. The finding that there was no significant difference between the 2 exercise therapies in pain reduction is in accordance with the findings of earlier studies.[42] We believe that the reason for this may be that the physical therapists in both intervention groups addressed the patients' misplaced beliefs about their pain and supported self-management.[24] The exact benefits of the physical exercises and the cognitive aspects regarding the effect on pain level in the present study cannot, however, be calculated.

All participants were offered 12 treatment sessions. The reason for this was the late treatment response observed in an earlier pilot study about the effects of DL training.[18] The participants in the LMC group, however, could not be motivated to attend all sessions, as they considered themselves adequately rehabilitated after about 6 sessions. It is notable that similar, and by some measures superior, outcomes were achieved in significantly fewer treatment sessions for the LMC group. If these results can be confirmed in future studies, they may have significant implications for cost and efficiency.

We are aware that the term *motor control exercises* means different things to physical therapists around the world. According to the definition by Shumway-Cook and Woollacott,[34] the LMC exercises as well as the DL exercise could be considered motor control exercises. Regarding the expression *low-load motor control*, the fact that the DL was performed without load on the bar at the first training session could also indicate that the DL exercise is a kind of LMC exercise in its initial phase. It has, however, been suggested that if the local muscle system is not able to specifically activate during low-load activities, the retraining needs to include attempts to specifically recruit the mechanical action independently of the global system.[30] Specific voluntary activation of the local muscles was not included in the HLL intervention.

Methodological Considerations

First, this study included a more homogeneous group of patients compared to most studies, and the results might not be generalizable to patients with other pain characteristics. Second, we did not test the intertester or intratester reliability of the test leaders or of the physical therapists to classify the participants as having nociceptive mechanical LBP. There is, however, support for the ability of physical therapists to identify movement dysfunctions with good intratester and intertester reliability,[10,21,44] and the physical therapists at the occupational health care services followed the criteria regarding nociceptive pain characteristics.[29,38] Third, no placebo control group was included, so the effect of the intervention over time should be interpreted cautiously. Fourth, the fact that different therapists provided the 2 interventions might have influenced the outcomes. However, due to their conviction that their intervention was optimal, they probably influenced the participants in a similar positive way. Last, the fact that the exercises in the LMC intervention were chosen on a patient-specific basis may have advantaged the LMC group. The reason for the LMC treatment strategy to include an individual motor relearning program is that this represents good clinical practice in applying motor control training.

A possible reason why many participants were lost to follow-up at 12 months is that they were given no or only 1 reminder. Because the baseline values did not differ between those who were retained in the study and those who were not (except for the prone bridge and Biering-Sørensen tests), the responses at 12 months, although limited, may be considered representative of the participants regarding the primary outcome measures.

CONCLUSION

The LMC intervention may result in superior outcomes in activity, movement control, and muscle endurance tests compared to HLL, but not in pain intensity and maximal isometric lift strength, in patients with nociceptive mechanical LBP. ◉

KEY POINTS

FINDINGS: The LMC intervention showed significantly greater improvement in activity, movement control, and trunk muscle endurance test performance compared with the HLL. Both interventions showed similar significant effects over time regarding pain intensity and maximal lift strength. Most patients in both intervention groups reached a clinically meaningful improvement in pain intensity and activity over time.

IMPLICATIONS: Education regarding pain physiology, optimal posture, and movement patterns in combination with training can be recommended for use among patients with a nociceptive mechanical LBP pattern.

CAUTION: The present study included patients with nociceptive mechanical LBP as their predominant pain pattern and the results may therefore not be generalizable to patients with other pain characteristics.

ONLINE APPENDICES

The LMC and HLL exercises, and a table showing the results of the analyses comparing the baseline data of participants who participated in the 12-month follow-up and those who did not participate, are available online at www.jospt.org.

REFERENCES

1. Adams MA. Biomechanics of back pain. *Acupunct Med*. 2004;22:178-188.
2. Barnekow-Bergkvist M, Hedberg G, Janlert U, Jansson E. Development of muscular endurance and strength from adolescence to adulthood and level of physical capacity in men and women at the age of 34 years. *Scand J Med Sci Sports*. 1996;6:145-155. http://dx.doi.org/10.1111/j.1600-0838.1996.tb00082.x
3. Biering-Sørensen F. Physical measurements as risk indicators for low-back trouble over a one-year period. *Spine (Phila Pa 1976)*. 1984;9:106-119.
4. Byström MG, Rasmussen-Barr E, Grooten WJ. Motor control exercises reduces pain and disability in chronic and recurrent low back pain: a meta-analysis. *Spine (Phila Pa 1976)*. 2013;38:E350-E358. http://dx.doi.org/10.1097/BRS.0b013e31828435fb
5. Chakraborty H, Gu H. A Mixed Model Approach for Intent-to-Treat Analysis in Longitudinal Clinical Trials With Missing Values. Research Triangle Park, NC: RTI International; March 2009.
6. Comerford M, Mottram S. *Kinetic Control: The Management of Uncontrolled Movement*. Edinburgh, UK: Elsevier/Churchill Livingstone; 2012.
7. Comerford MJ, Mottram SL. Functional stability re-training: principles and strategies for managing mechanical dysfunction. *Man Ther*. 2001;6:3-14. http://dx.doi.org/10.1054/math.2000.0389
8. Costa LO, Maher CG, Latimer J, et al. Clinimetric testing of three self-report outcome measures for low back pain patients in Brazil: which one is the best? *Spine (Phila Pa 1976)*. 2008;33:2459-2463. http://dx.doi.org/10.1097/BRS.0b013e3181849dbe
9. Costa LO, Maher CG, Latimer J, et al. Motor control exercise for chronic low back pain: a randomized placebo-controlled trial. *Phys Ther*. 2009;89:1275-1286. http://dx.doi.org/10.2522/ptj.20090218
10. Dankaerts W, O'Sullivan P, Burnett A, Straker L. Altered patterns of superficial trunk muscle activation during sitting in nonspecific chronic low back pain patients: importance of subclassification. *Spine (Phila Pa 1976)*. 2006;31:2017-2023. http://dx.doi.org/10.1097/01.brs.0000228728.11076.82
11. Dankaerts W, O'Sullivan P, Burnett A, Straker L. Differences in sitting postures are associated with nonspecific chronic low back pain disorders when patients are subclassified. *Spine (Phila Pa 1976)*. 2006;31:698-704. http://dx.doi.org/10.1097/01.brs.0000202532.76925.d2
12. Dworkin RH, Turk DC, Farrar JT, et al. Core outcome measures for chronic pain clinical trials: IMMPACT recommendations. *Pain*. 2005;113:9-19. http://dx.doi.org/10.1016/j.pain.2004.09.012
13. Escamilla RF, Francisco AC, Kayes AV, Speer KP, Moorman CT, 3rd. An electromyographic analysis of sumo and conventional style deadlifts. *Med Sci Sports Exerc*. 2002;34:682-688.
14. Fairbairn K, May K, Yang Y, Balasundar S, Hefford C, Abbott JH. Mapping Patient-Specific Functional Scale (PSFS) items to the International Classification of Functioning, Disability and Health (ICF). *Phys Ther*. 2012;92:310-317. http://dx.doi.org/10.2522/ptj.20090382
15. Ferreira ML, Ferreira PH, Latimer J, et al. Comparison of general exercise, motor control

exercise and spinal manipulative therapy for chronic low back pain: a randomized trial. *Pain*. 2007;131:31-37. http://dx.doi.org/10.1016/j.pain.2006.12.008

16. Fersum KV, Dankaerts W, O'Sullivan PB, et al. Integration of subclassification strategies in randomised controlled clinical trials evaluating manual therapy treatment and exercise therapy for non-specific chronic low back pain: a systematic review. *Br J Sports Med*. 2010;44:1054-1062. http://dx.doi.org/10.1136/bjsm.2009.063289

17. Hamlyn N, Behm DG, Young WB. Trunk muscle activation during dynamic weight-training exercises and isometric instability activities. *J Strength Cond Res*. 2007;21:1108-1112. http://dx.doi.org/10.1519/R-20366.1

18. Holmberg D, Crantz H, Michaelson P. Treating persistent low back pain with deadlift training – a single subject experimental design with a 15-month follow-up. *Adv Physiother*. 2012;14:61-70. http://dx.doi.org/10.3109/14038196.2012.674973

19. Lundberg MKE, Styf J, Carlsson SG. A psychometric evaluation of the Tampa Scale for Kinesiophobia – from a physiotherapeutic perspective. *Physiother Theory Pract*. 2004;20:121-133. http://dx.doi.org/10.1080/09593980490453002

20. Luomajoki H, Kool J, de Bruin ED, Airaksinen O. Improvement in low back movement control, decreased pain and disability, resulting from specific exercise intervention. *Sports Med Arthrosc Rehabil Ther Technol*. 2010;2:11. http://dx.doi.org/10.1186/1758-2555-2-11

21. Luomajoki H, Kool J, de Bruin ED, Airaksinen O. Reliability of movement control tests in the lumbar spine. *BMC Musculoskelet Disord*. 2007;8:90. http://dx.doi.org/10.1186/1471-2474-8-90

22. Macedo LG, Latimer J, Maher CG, et al. Effect of motor control exercises versus graded activity in patients with chronic nonspecific low back pain: a randomized controlled trial. *Phys Ther*. 2012;92:363-377. http://dx.doi.org/10.2522/ptj.20110290

23. Moseley GL. Evidence for a direct relationship between cognitive and physical change during an education intervention in people with chronic low back pain. *Eur J Pain*. 2004;8:39-45. http://dx.doi.org/10.1016/S1090-3801(03)00063-6

24. Moseley L. Combined physiotherapy and education is efficacious for chronic low back pain. *Aust J Physiother*. 2002;48:297-302.

25. Nuzzo JL, McCaulley GO, Cormie P, Cavill MJ, McBride JM. Trunk muscle activity during stability ball and free weight exercises. *J Strength Cond Res*. 2008;22:95-102. http://dx.doi.org/10.1519/JSC.0b013e31815ef8cd

26. Ostelo RW, Deyo RA, Stratford P, et al. Interpreting change scores for pain and functional status in low back pain: towards international consensus regarding minimal important change. *Spine (Phila Pa 1976)*. 2008;33:90-94. http://dx.doi.org/10.1097/BRS.0b013e31815e3a10

27. O'Sullivan P. Diagnosis and classification of chronic low back pain disorders: maladaptive movement and motor control impairments as underlying mechanism. *Man Ther*. 2005;10:242-255. http://dx.doi.org/10.1016/j.math.2005.07.001

28. O'Sullivan PB. Lumbar segmental 'instability': clinical presentation and specific stabilizing exercise management. *Man Ther*. 2000;5:2-12. http://dx.doi.org/10.1054/math.1999.0213

29. Petty NJ. *Neuromusculoskeletal Examination and Assessment. A Handbook for Therapists*. 4th ed. Edinburgh, UK: Elsevier/Churchill Livingstone; 2011.

30. Richardson C, Hodges P, Hides J. *Therapeutic Exercise for Lumbopelvic Stabilization: A Motor Control Approach for the Treatment and Prevention of Low Back Pain*. 2nd ed. Edinburgh, UK: Churchill Livingstone; 2004.

31. Roland M, Morris R. A study of the natural history of back pain. Part I: development of a reliable and sensitive measure of disability in low-back pain. *Spine (Phila Pa 1976)*. 1983;8:141-144.

32. Sahrmann S. *Movement System Impairment Syndromes of the Extremities, Cervical and Thoracic Spines*. St Louis, MO: Elsevier/Mosby; 2011.

33. Sahrmann SA. *Diagnosis and Treatment of Movement Impairment Syndromes*. St Louis, MO: Mosby; 2001.

34. Shumway-Cook A, Woollacott MH. *Motor Control: Translating Research Into Clinical Practice*. 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2007.

35. Smart KM, Blake C, Staines A, Doody C. The discriminative validity of "nociceptive," "peripheral neuropathic," and "central sensitization" as mechanisms-based classifications of musculoskeletal pain. *Clin J Pain*. 2011;27:655-663. http://dx.doi.org/10.1097/AJP.0b013e318215f16a

36. Smart KM, Blake C, Staines A, Thacker M, Doody C. Mechanisms-based classifications of musculoskeletal pain: part 1 of 3: symptoms and signs of central sensitisation in patients with low back (±leg) pain. *Man Ther*. 2012;17:336-344. http://dx.doi.org/10.1016/j.math.2012.03.013

37. Smart KM, Blake C, Staines A, Thacker M, Doody C. Mechanisms-based classifications of musculoskeletal pain: part 2 of 3: symptoms and signs of peripheral neuropathic pain in patients with low back (±leg) pain. *Man Ther*. 2012;17:345-351. http://dx.doi.org/10.1016/j.math.2012.03.003

38. Smart KM, Blake C, Staines A, Thacker M, Doody C. Mechanisms-based classifications of musculoskeletal pain: part 3 of 3: symptoms and signs of nociceptive pain in patients with low back (±leg) pain. *Man Ther*. 2012;17:352-357. http://dx.doi.org/10.1016/j.math.2012.03.002

39. Stratford P, Gill C, Westaway M, Binkley J. Assessing disability and change on individual patients: a report of a patient specific measure. *Physiother Can*. 1995;47:258-263. http://dx.doi.org/10.3138/ptc.47.4.258

40. Tsao H, Hodges PW. Persistence of improvements in postural strategies following motor control training in people with recurrent low back pain. *J Electromyogr Kinesiol*. 2008;18:559-567. http://dx.doi.org/10.1016/j.jelekin.2006.10.012

41. Van Dillen LR, Maluf KS, Sahrmann SA. Further examination of modifying patient-preferred movement and alignment strategies in patients with low back pain during symptomatic tests. *Man Ther*. 2009;14:52-60. http://dx.doi.org/10.1016/j.math.2007.09.012

42. van Middelkoop M, Rubinstein SM, Verhagen AP, Ostelo RW, Koes BW, van Tulder MW. Exercise therapy for chronic nonspecific low-back pain. *Best Pract Res Clin Rheumatol*. 2010;24:193-204. http://dx.doi.org/10.1016/j.berh.2010.01.002

43. Vibe Fersum K, O'Sullivan P, Skouen JS, Smith A, Kvåle A. Efficacy of classification-based cognitive functional therapy in patients with non-specific chronic low back pain: a randomized controlled trial. *Eur J Pain*. 2013;17:916-928. http://dx.doi.org/10.1002/j.1532-2149.2012.00252.x

44. Vibe Fersum K, O'Sullivan PB, Kvåle A, Skouen JS. Inter-examiner reliability of a classification system for patients with non-specific low back pain. *Man Ther*. 2009;14:555-561. http://dx.doi.org/10.1016/j.math.2008.08.003

APPENDIX A

INTERVENTIONS

The interventions took place at a physical therapy clinic (LMC group) and at a sports center that supplied the exercise equipment (HLL group). The LMC intervention was performed individually and the HLL included groups of 5 participants. Participants were offered 12 treatment sessions over an 8-week period (weeks 1-4, 2 sessions per week; weeks 5-8, 1 session per week). The duration of each session was 20 to 30 minutes for the LMC group and 60 minutes for the HLL group. Both interventions were provided by senior physical therapists who had more than 10 years of experience with motor control exercises (LMC group) or the deadlift exercise (HLL group).

The physical therapists used a variety of feedback to teach and facilitate correct performance during the exercises. For example, the participants were encouraged to watch the movement (shown by the physical therapist), to watch the movement in a mirror, and to palpate their spine and spinal muscles during the movements. Further, the participants in the LMC group received instant feedback by experiencing the difference between a painful movement and the same movement performed more ideally and without pain. Participants in the HLL group were instructed that a pain intensity under 50 mm on a visual analog scale was acceptable while performing the deadlift, on the condition that the pain subsided after each completed set and the movement pattern/spinal neutral position did not change.

LMC Exercise

The exercises were individually selected and aimed to normalize the dominating movement impairment for each participant. The strategy was to start from a basic level and continue to a gradually increased level of difficulty. It was considered important to always perform the movements ideally with an optimal muscle recruitment pattern. This had to be ensured when practicing at the physical therapy clinic.

Cognitive and lifestyle behaviors that influenced pain were also targeted by teaching the participants about how non-ideal movement and alignment strategies could contribute to lumbar-region tissue stress. First, the participant learned about how his or her movement pattern and daily activities affected his or her current pain. The participant was taught how the pain system works normally and the cause of his or her current condition through description of tissue and pain mechanisms. Further, it was outlined how movement faults, abnormal resting postures, and altered motor control are associated with musculoskeletal tissue changes and why the self-reported activities were painful—and how and why the more optimal movement patterns the participants learned from the physical therapist decreased their pain sensation. For example, a participant who moved in the lumbar spine before bending the hips when bending forward was informed about this and was also informed about how this repetitive use of flexion movements and alignments across the day potentially contributes to increased lumbar-region tissue stress and symptoms.

Regarding the home exercises, and especially for the exercises in stage 1, the participants were encouraged to make at least 10 repetitions 2 to 3 times a day, with the goal to incorporate the new movement strategy into daily living. In stages 2 and 3, the participants were encouraged to focus on muscle recruitment and movement pattern during the activities and to perform them as often as possible.

Stage 1

The participants learned how to find their neutral position in the lumbopelvic region in supine, four-point kneeling, sitting, and/or standing and how to control the movements in their lumbar spine with minimal effort while moving their arms/legs. This part also included specific training to dissociate movements between the upper and lower back and between the low back, shoulder, and hip joint, respectively. The exercises aimed at improving timing and magnitude of movements in the hips and thoracic spine relative to the low back area, that is, to maintain the lumbar spine in its neutral position during movements in adjacent joints (hips, thoracic spine, and shoulders). Examples are shown in **FIGURE 1**. In this stage, the exercises were performed under highly controlled conditions, with focus on the participants' awareness of alignment and postural position, muscle tension, and effort in order to experience the sensation of "easy" low-load holding.

FIGURE 1. Examples of exercises in stage 1.

APPENDIX A

Stage 2

The participants learned how to control the movements in the lumbopelvic region with minimal effort when performing activities that produced their nociceptive mechanical pain. In particular, the most painful positions and movements were targeted; for example, if a participant had pain during flexion movements and tended to compensate for a lack of hip flexion with lumbar flexion during an activity, he or she received a lot of guided practice to prevent the flexion pattern during these movements. Examples of exercises are shown in **FIGURE 2**.

To enable a corrected movement pattern, exercises that aimed at reducing overactivity and stiffness of superficial mobilizing muscles were performed. Also, exercises that aimed at improving the ability of global stabilizing muscles to control movements throughout joint range were performed if required.

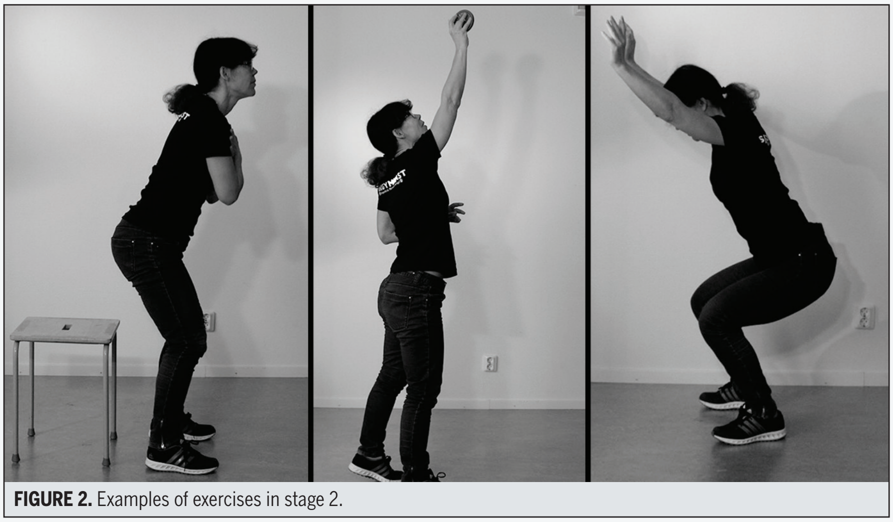

FIGURE 2. Examples of exercises in stage 2.

Stage 3

The participants learned to incorporate the control of a dynamic movement of the spine from the neutral position to the typical end-range position necessary for specific tasks/activities. For example, the participant learned to control a flexion movement starting from neutral lumbar spine, initiating hip flexion with activity of stabilizing trunk muscles, allowing the spine to move into a controlled flexion movement. In this stage, spinal movements in various dynamic tasks and functional positions during daily life activities, for example, working overhead or taking part in physical activities, were targeted. Examples of tasks and positions are shown in **FIGURE 3**.

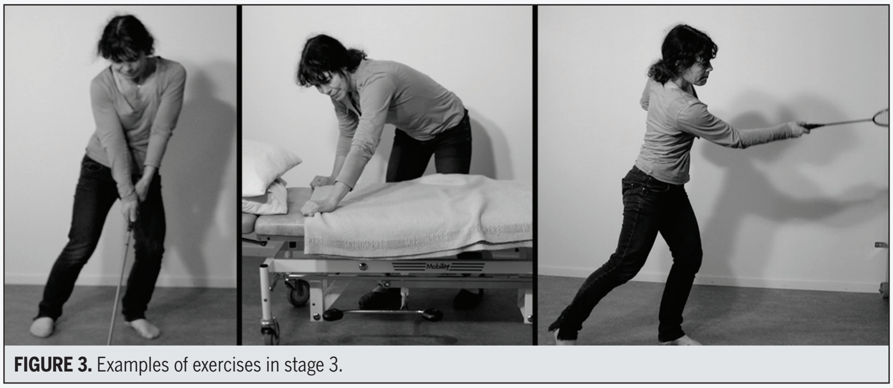

FIGURE 3. Examples of exercises in stage 3.

HLL Exercise

The deadlift exercise focuses on maintenance of an optimal alignment of the spine and on activation of the stabilizing muscles during the lift. It could therefore be considered to be an optimal high-load motor control exercise. The physical therapist chose an appropriate initial weight on the bar, based on the participant's pain history and pain response to the deadlift exercise. Participants reported their pain intensity before, during, and after the deadlift session. Before each session, the participants were asked if their pain intensity increased after the previous session, and if it did, the load was not increased. In consideration of the assumption that patients with low back pain generally have deconditioned tissues in their low back, a slow progression of

APPENDIX A

the training intensity was employed as the load was increased by 2.5-kg increments. The participants learned an optimal lifting technique and the physical therapist ensured that the participants maintained a neutral alignment of the spine when performing the exercise and before increasing the load.

The exercise was executed accordingly (**FIGURE 4**). The participant stood in front of a barbell with Olympic weights, 22.5 cm above the ground, and was instructed to position the lumbar spine in a neutral position and to activate the stabilizing muscles of the spine and trunk (**FIGURE 4A**). This was controlled by the physical therapist before the lift commenced. Then, the participant squatted down, performing hip and knee flexion, maintaining the lumbar spine in neutral, and grasping the barbell (**FIGURE 4B**). A simultaneous extension of the knee and hip joints was performed to lift the barbell (**FIGURE 4C**) until the participant was in erect position (**FIGURE 4D**). The eccentric phase was initiated by lowering the barbell through hip flexion and keeping the bar close to the thighs until it passed the knee-cap (**FIGURE 4E**), where knee flexion concluded the descent (**FIGURE 4F**). Each phase was carried out with equal importance regarding activation of the stabilizing muscles to ascertain that the spine was held in neutral position. Between repetitions, participants let go of the barbell and paused before initiating the next repetition. The total load was slowly progressed during the intervention period by gradually increasing the number of lifts and/or the weight on the bar. The warm-up consisted of several sets at a low load, with more repetitions before increasing the load on the bar. Thereafter, the participants initially rested about 5 minutes between sets and, as the training progressed, the rest period between sets was extended to the time the participants felt comfortable to initiate the next set.

As the participants began treatment, the first sessions focused on teaching proper technique and activation of stabilizing muscles by using a low load on the barbell, 5 to 10 repetitions per set, and moderate volume (total lifted weight per session). After the period of accommodation and neural adaptation to the exercise, the training progressed by gradually increasing the volume by number of lifts per session and/or weight on the bar to higher loads, and by shifting focus to stimulate hypertrophy and maximal strength. In this phase, depending on participant symptoms, the repetitions ranged from 1 to 10, where a lower number of repetitions equaled higher loads. To keep track of each participant's training and progression, the instructor noted change in symptoms between sets, repetitions, and sessions as well as intensity of the previous session.

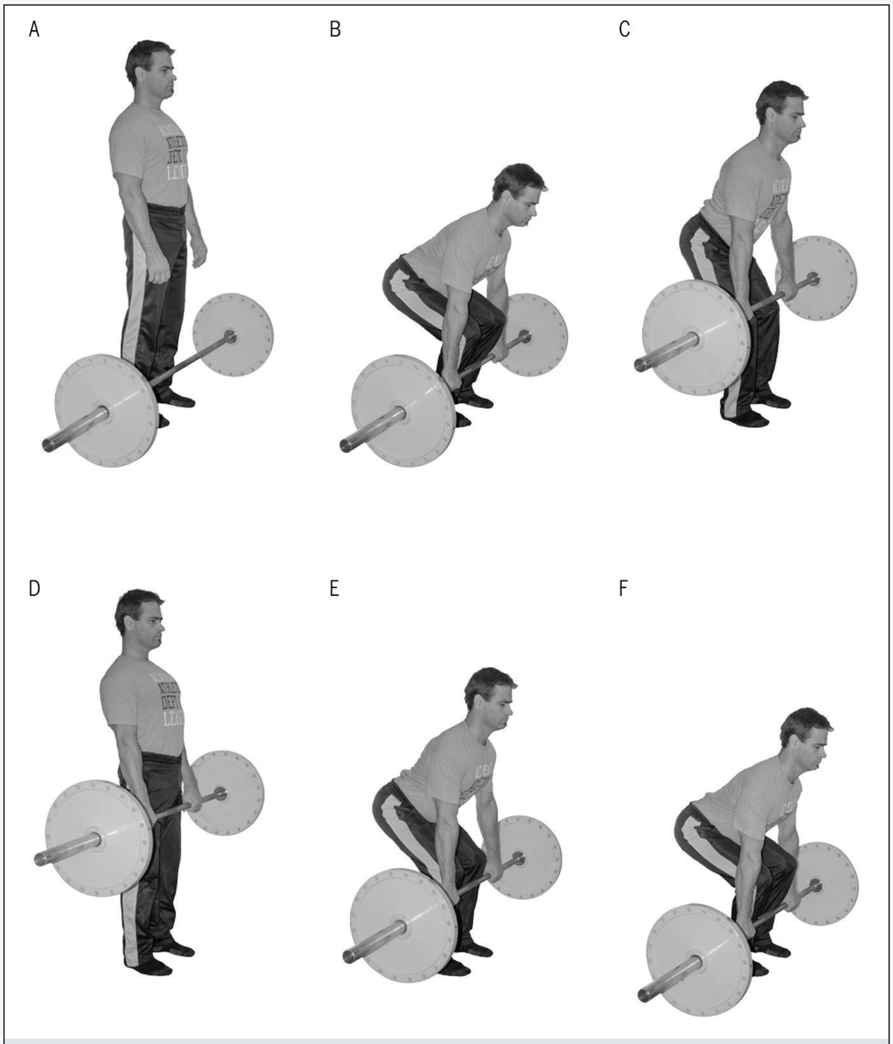

FIGURE 4. The deadlift exercise used as a high-load lifting exercise.

APPENDIX A

Cognitive behaviors that influenced pain were also targeted. Participants who experienced kinesiophobia and who were apprehensive about stressing their low back through lifting weights were reassured by the physical therapist that the risk of aggravating their symptoms was insignificant because of the mild progression with 2.5-kg increments. Further, participants were taught about tissue and pain mechanisms and how weak muscles decrease stability of the low back and increase stress on pain-generating structures. The physical therapist emphasized the importance of maintaining the neutral spine during daily activities to generate force through the limbs and decrease stress on the low back. The participants were also instructed to practice the same lifting technique at home during their daily activities.

Abbreviations: HLL, high-load lifting group; LMC, low-load motor control group.

APPENDIX B

RESULTS OF THE ANALYSES COMPARING THE BASELINE DATA OF PARTICIPANTS WHO PARTICIPATED IN THE 12-MONTH FOLLOW-UP AND THOSE WHO DID NOT PARTICIPATE*

Characteristic	Answered Questionnaire at 12 mo	Did Not Answer Questionnaire at 12 mo	*P* Value
Age, y	43 ± 10	41 ± 10	.440†
Female, %‡	49 (35, 63)	74 (52, 95)	.065§
Taking analgesics, %‡	45 (30, 59)	68 (45, 91)	.083§
Physical activity moderate intensity, min/wk	180 ± 162	142 ± 120	.222†
Physical activity high intensity, min/wk	41 ± 73	33 ± 50	.327†
Kinesiophobia (17-68)	32 ± 7	33 ± 6	.541†
Roland-Morris questionnaire (0-24)	7.3 ± 4.8	7.3 ± 3.2	.942†
7-d VAS (0-100)	41.8 ± 26.1	53.4 ± 24.2	.092†
PSFS (0-10)	4.3 ± 1.5	4.2 ± 1.5	.777†
Characteristic	**Participated in Testing at 12 mo (n = 41)**	**Did Not Participate in Testing at 12 mo (n = 29)**	***P* Value**
Lift strength, N	941 ± 382	883 ± 461	.592†
Prone bridge, s	74 ± 42	50 ± 31	.013†
Sidebridge on right arm, s	43 ± 28	37 ± 27	.362†
Biering-Sørensen, s	90 ± 41	70 ± 35	.031†
MC test battery, n	3.5 ± 1.7	3.3 ± 1.5	.601†

Abbreviations: MC, movement control; PSFS, Patient-Specific Functional Scale; VAS, visual analog scale.
**Values are mean ± SD unless otherwise indicated.*
†Independent-sample t test between those who remained in the study and those who did not.
‡Values are mean (95% confidence interval).
§Chi-square test between those who remained in the study and those who did not.