Research Report

Trunk Muscle Stabilization Training Plus General Exercise Versus General Exercise Only: Randomized Controlled Trial of Patients With Recurrent Low Back Pain

Background and Purpose. The purpose of this randomized controlled trial was to examine the usefulness of the addition of specific stabilization exercises to a general back and abdominal muscle exercise approach for patients with subacute or chronic nonspecific back pain by comparing a specific muscle stabilization–enhanced general exercise approach with a general exercise–only approach. Subjects. Fifty-five patients with recurrent, nonspecific back pain (stabilization–enhanced exercise group: n=29, general exercise–only group: n=26) and no clinical signs suggesting spinal instability were recruited. Methods. Both groups received an 8-week exercise intervention and written advice (*The Back Book*). Outcome was based on self-reported pain (Short-Form McGill Pain Questionnaire), disability (Roland-Morris Disability Questionnaire), and cognitive status (Pain Self-Efficacy Questionnaire, Tampa Scale of Kinesiophobia, Pain Locus of Control Scale) measured immediately before and after intervention and 3 months after the end of the intervention period. Results. Outcome measures for both groups improved. Furthermore, self-reported disability improved more in the general exercise–only group immediately after intervention but not at the 3-month follow-up. There were generally no differences between the 2 exercise approaches for any of the other outcomes. Discussion and Conclusion. A general exercise program reduced disability in the short term to a greater extent than a stabilization–enhanced exercise approach in patients with recurrent nonspecific low back pain. Stabilization exercises do not appear to provide additional benefit to patients with subacute or chronic low back pain who have no clinical signs suggesting the presence of spinal instability. [Koumantakis GA, Watson PJ, Oldham JA. Trunk muscle stabilization training plus general exercise versus general exercise only: randomized controlled trial of patients with recurrent low back pain. *Phys Ther.* 2005;85:209–225.]

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There is ample evidence that active approaches to the rehabilitation of patients with subacute and chronic low back pain (LBP) are beneficial.[1,2] Exercise therapy, as an approach that engages patients in activity, can be useful after the acute stage of LBP; however, positive results have been documented with different types of exercise utilized by physical therapists, suggesting there is little evidence that a particular "type" of exercise is any better than another.[3] As new training methods are emerging, a better understanding of the effects of such techniques on patient status is currently considered an important area of research.[4,5]

Classic trunk exercises performed in physical therapy activate the abdominal and paraspinal muscles as a whole and at a relatively high contraction level.[6,7] Although there are several randomized controlled trials (RCTs) on the usefulness of classic trunk exercises,[8–10] increasing attention recently has been paid to the preferential retraining of the local stabilizing muscles of the spine.[11,12] All muscles with intervertebral attachments that are better suited for providing intersegmental stability are categorized under this group (multifidus, transversus abdominis, internal oblique), as opposed to the longer trunk muscles (erector spinae, rectus abdominis), which are dedicated to generating movement.[13] Preferential retraining of the stabilizing muscles, with their initial low-level isometric activation and their progressive integration into functional tasks, is proposed as an essential component of back muscle rehabilitation.[14] Some authors maintain that, when there is a deficit of the stabilizing muscles, incorrect compensation of their activity takes place from the movement muscles if classic exercise techniques are used, leading to alterations of the appropriate muscle coordination patterns[14] and increasing the risk of reinjury of the spine.[15]

What remains currently unknown is whether stabilization exercises are better suited to certain types of patients or whether they can be generally applied to any patient with LBP. Unsubstantiated suggestions that stabilization training may be useful in reducing pain and disability for all patients with nonspecific LBP have appeared in the literature,[16–19] but these assertions have not been definitively demonstrated.

No RCT has tested the assertion that stabilization training is beneficial in a sample of patients with subacute or nonspecific chronic LBP using pain and disability as outcomes. In a study of patients with acute nonspecific LBP,[20] stabilization training for the multifidus muscle was found to be less effective on its own than when combined with a course of manipulative therapy. Therefore, the particular RCT has shown an additional benefit of manipulative therapy over stabilization exercise prescription for acute LBP, in line with current reviews supporting the use of manipulation at an acute stage of symptoms.[3]

Some evidence supports the role of stabilization exercises in LBP with respect to symptom recurrence, but the 2 relevant RCTs have been conducted in specific subgroups of patients with LBP.[11,12] The first study[11] compared stabilization exercise against standardized medical care (analgesics, advice). Participants were required to have acute first-episode unilateral LBP and between-sides asymmetry in multifidus muscle cross-sectional area (CSA) of more than 11%.[11] A 3-year follow-up showed a link between improvement in multifidus muscle CSA

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and reduced LBP recurrence in the group that received stabilization exercise.[21] The second study—comparing stabilization exercise against general exercise that was different for each patient and physical therapy modalities in patients with radiologically identified lumbar spondylolysis or spondylolisthesis associated with the level of symptoms—indicated large short-term and long-term improvement in favor of the stabilization exercise group on pain ($\overline{X}$=35, SD=23, $P<.0001$; between-group difference in 0–100 pain scale scores after intervention) and disability report ($\overline{X}$=13, SD=16, $P<.0001$; between-group difference in 0–100 disability scale scores after intervention).[12] However, in these 2 trials, the specific effect of the trunk-stabilizing muscle exercise regimen was not compared to general back and abdominal exercises.

A more recent study[22] that compared stabilization exercises against 2 other general back extensor exercise regimens in patients with nonspecific chronic LBP demonstrated positive results for multifidus muscle CSA increase in favor of one of the general exercise approaches. This finding contradicts the theory that general exercise would not be as effective for restoration of multifidus muscle size.[14] However, no pain or disability data were reported for that trial. Therefore, the effectiveness of stabilization exercises in patients with nonspecific LBP is not yet fully established.

In keeping with the biopsychosocial model of LBP management, change in patient disability cannot be viewed simply as a product of physical changes, but instead as a combination of changes in physical activity, pain, and patient beliefs. Therefore, we cannot disregard the nonphysiological benefits of exercise interventions, especially in view of current thinking, which considers change in psychosocial factors in patients with chronic pain to be a desirable outcome that needs to be monitored.[23] The performance of therapeutic exercises by patients involves certain common underlying implementation principles in cognitive-behavioral management, namely promoting a self-management perspective, pacing of activity, and habit reversal,[24] which lead to a behavioral adjustment toward reduced disability.[25] The decrease in disability brought about by exercise and activity engagement through physical therapy interventions has been shown in several studies to be associated with concurrent positive changes in psychosocial factors, such as activity-related fear,[26–28] self-confidence for activity performance,[29,30] and perceptions of control over pain.[28] We therefore considered it important to assess, as secondary outcomes, psychological variables in our study to determine if there were improvements.

The aim of this study was to investigate whether stabilization exercises are a useful supplement to general trunk exercises in patients with recurrent nonspecific LBP. Our experimental hypothesis was that a training program consisting of general exercise only would be less effective than a general exercise program combined with specific trunk muscle stabilization exercise techniques in reducing patient self-reported pain, disability, and psychological determinants of prolonged disability (fear-avoidance beliefs, self-efficacy beliefs, and appraisals of control).

Method

Design

An RCT was performed with patients randomly assigned to 1 of 2 treatment groups: (1) a group that received general exercise combined with specific trunk muscle stabilization exercise techniques or (2) a group that received general exercise only. The research physical therapist (GAK) who was in charge of the study and who performed the outcome assessments of subjects and data analyses was unaware of group allocation throughout the study. However, the clinical physical therapist (FR) who administered the exercise programs could not be masked to group allocation. Patients were not aware of the theoretical bases of each of the exercise regimens because the study's objective was described to them in the following way: "to identify any differential effect between 2 exercise regimens for the trunk muscles, which have a role in protecting the spine from further injury."

Subjects

Patients were recruited from the orthopedic clinic of a local hospital and several general practitioners' practices. Patients took part in the study after informed consent had been obtained. The rights of human subjects were protected at all times.

Patients were eligible for the study if they had a history of recurrent LBP (repeated episodes of pain in past year collectively lasting for less than 6 months)[31] of a nonspecific nature, defined as back pain complaints occurring without identifiable specific anatomical or neurophysiological causative factors.[2] To establish this, all patients included in the trial had a prior clinical examination by their physician, including a radiograph or a magnetic resonance imaging scan. Patients with previous spinal surgery, "red flags" (ie, serious spinal pathology or nerve root pain signs) as outlined in the Clinical Standards Advisory Group (CSAG) report for back pain,[1] or signs and symptoms of instability (radiological diagnosis of spondylolysis or spondylolisthesis corresponding to a symptomatic spinal level; "catching," "locking," "giving way," or "a feeling of instability" in one direction or multiple directions of spinal movements)[32] were excluded. Patients were recruited for the trial at the

Table 1.
Between-Group Baseline Comparisons of Subjects' Characteristics[a]

	Stabilization–Enhanced General Exercise Group (n=29)		General Exercise–Only Group (n=26)		
	$\bar{X}$	SD	$\bar{X}$	SD	*P*
Anthropometry					
Age (y)[b]	39.2	11.4	35.2	9.7	.16
Height (cm)[b]	170.1	7.5	174.4	9.1	.06
Body mass (kg)[b]	75.9	12.8	80.5	12.0	.18
BMI (kg/m^2)[b]	26.2	4.2	26.4	3.2	.87
History of LBP					
Time since first onset (mo)[b]	57.1	48.1	44.2	51.6	.34
Current duration (wk)[c]	12.0	7.3–22.0	12.0	8.0–12.0	.78

[a] BMI=body mass index, LBP=low back pain.
[b] Means and standard deviation data, analyzed with independent samples *t* test.
[c] Median and interquartile ratio data, analyzed with Mann-Whitney *U* test.

subacute or chronic stage (onset of their current episode of pain 6 weeks)[33] if their symptoms persisted. The anthropometric and LBP history data of patients who took part in the RCT are presented in Table 1. Patients had to be medically fit (no heart problems, pregnancy, or inflammatory arthritis) and willing to participate in the exercise program and be able to travel independently to the hospital. All subjects were employed at the time of study and were not involved in any current workers' compensation or litigation procedures. The subjects' progress throughout the trial is outlined in the Figure.

Procedure

Enrollment/data collection. All subjects were interviewed and examined by a research physical therapist who was unaware of their group allocation, to ensure that the inclusion and exclusion criteria were fulfilled. Suitable patients were asked to complete a number of questionnaires (described later) that were repeated immediately after intervention (8 weeks) and 3 months later. Additional comprehensive functional testing (paraspinal muscle force-generating capacity and endurance and physical performance speed tests) also was done before and after intervention by the research physical therapist, and this testing is described elsewhere.[34] During the 3-month follow-up period, patients were advised to continue with their exercise regimen, without keeping a patient diary for exercise adherence after the intervention period. All testing done before and immediately after intervention was conducted in a local research center by the research physical therapist, and the 3-month follow-up was conducted through postal questionnaires. The exercise programs were conducted in the gym of a local NHS Trust outpatient physical therapy department, with a clinical physical therapist in charge of both programs.

Randomization. This procedure was undertaken by an independent trial manager. Following completion of all preintervention assessments, subjects were randomly assigned to 1 of the 2 intervention groups via a computer-generated random number sequence. Randomization codes were kept in sealed envelopes with consecutive numbering.

Intervention. Common components of the 2 programs included a warm-up period (stretching exercises and stationary bicycling for 10–15 minutes). For the specific stabilization exercise administration and the progressive integration with general exercises, a staged approach was followed, according to previous recommendations[14] (Appendix). The first session was performed on an individual basis for subjects assigned to this group and lasted 30 to 45 minutes. In this session, subjects were given individual leaflets to take home illustrating the anatomy of the local stabilizing muscles, with written, clear instructions on how to preferentially activate these muscles.

Briefly, low-load activation of the local stabilizing muscles was initially administered, with no movement (isometrically) and in minimally loading positions (4-point kneeling, supine lying, sitting, standing). Progressively, the holding time and then the number of contractions were increased in those positions up to 10 contraction repetitions × 10-second duration each (weeks 1 and 2).[14] The clinical measure used to ensure correct activation of the transversus abdominis muscle was to observe a slight drawing-in maneuver of the lower part of the anterior abdominal wall below the umbilical level, consistent with the action of this muscle.[14] In addition, a bulging action of the multifidus muscle should have been felt under the clinical physical therapist's fingers when they were placed on either side of the spinous processes of the L4 and L5 vertebral levels, directly over the belly of this muscle.[14]

Various facilitation techniques were used throughout the program to draw subjects' attention to the specific nature of the desired muscle contractions (tactile and pressure cues over areas of the specific muscles, auditory cues to enhance their contraction, use of contraction of the pelvic-floor muscles).[14] Furthermore, subjects were made aware of and were told to avoid several incorrect muscle activation ("substitution") strategies, where a

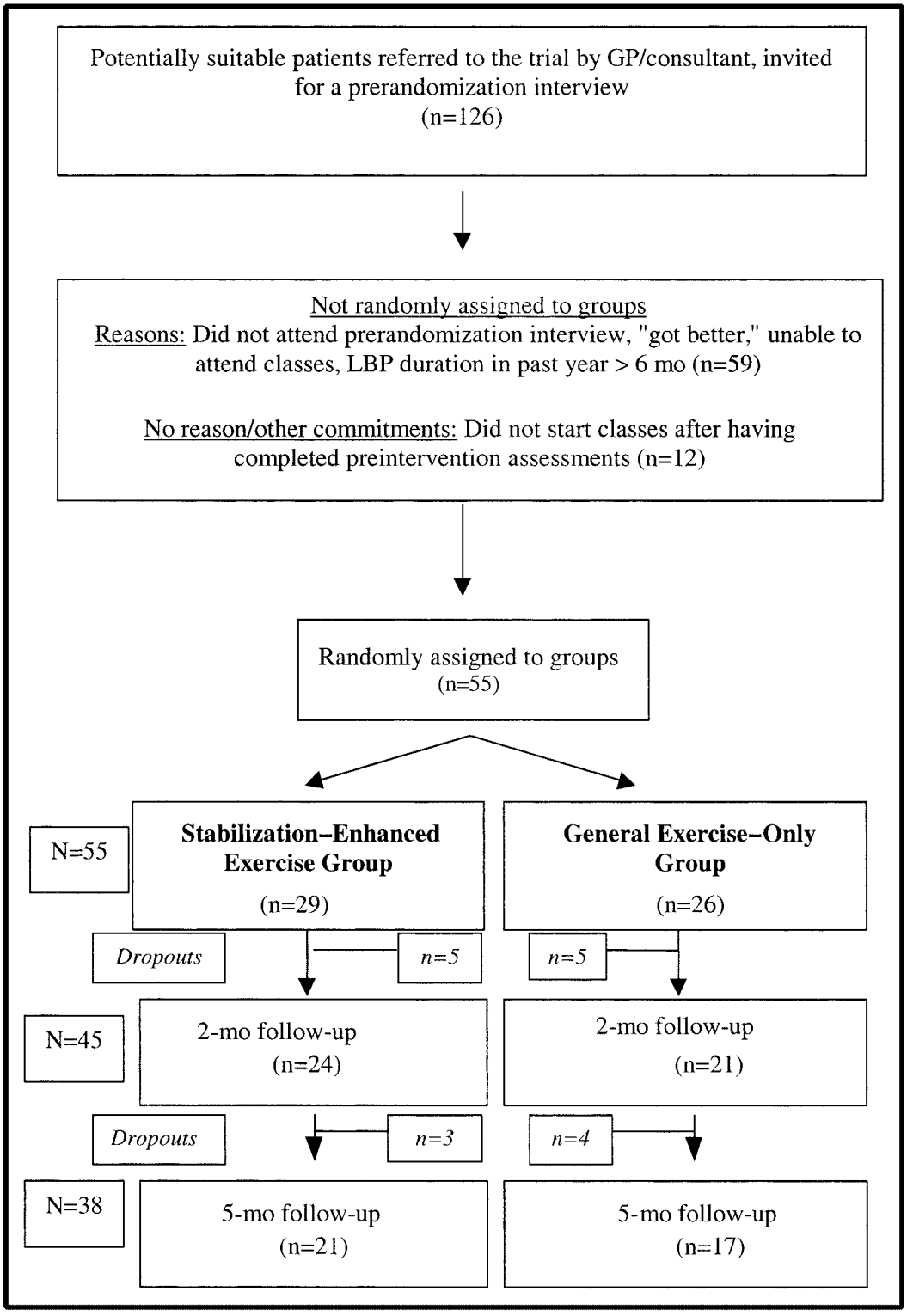

Figure.
Flow chart outlining patients' progress throughout the trial. GP=general practitioner, LBP=low back pain.

movement muscle takes over the control of movement from the stabilizing muscles (too much effort causing unwanted spasms in the movement muscles or spinal movement at the initial stages were discouraged). Integration with dynamic function (activities that required spinal or limb movements) through incorporation of the stabilizing muscles' co-contraction into light functional tasks (Appendix) was advised as soon as (1) the specific pattern of coactivation was achieved in the minimally loading positions and (2) the subjects could comfortably perform 10 contraction repetitions × 10-second duration each (weeks 3–5). Heavier-load functional tasks, with exercises similar to those performed by the subjects who performed general exercise only, were progressively introduced in the 3 last weeks of the program.[14]

For the subjects who performed general exercise only, exercises activating the extensor (paraspinals) and flexor (abdominals) muscle groups were administered (Appendix). Because muscle contraction occurring with exercise imposes extra loading on the spinal tissues, the general exercises were selected on the basis of maximizing the contraction benefit/spinal loading ratio, according to recommendations provided from recent experimental studies.[6]

The same frequency (twice per week), program duration (8 weeks), and class duration (45–60 minutes per session) were provided for both groups. A previous study[35] has shown that patients with subacute and chronic LBP activate their paraspinal muscles at about 30% of their maximum activation level during the performance of stabilization exercises and at about 60% to 70% during the performance of muscle force exercises (trunk and leg extensions in a prone position). Based on this literature, we set the pure total exercise time for the general exercise–only group (99 minutes, 10 seconds) to about half of that in the stabilization–enhanced exercise group (180 minutes, 40 seconds). This approach was followed to attempt to balance the groups with respect to the amount of estimated total force output of the trunk muscles targeted by the exercises.

A senior clinical physical therapist with 8 years of experience in musculoskeletal rehabilitation, who had attended specialized stabilization exercise seminars and had subsequently become very familiar with those exercise interventions through application of stabilization exercises for about a year before the initiation of the trial, was responsible for holding the exercise sessions with both intervention groups. The physical therapist monitored and made decisions about the progression of the exercises on every session for each subject based on correct performance of the previous exercise stage. Eight exercise levels of progressively increasing difficulty were provided for both groups, if subjects were able to progress each week to a new level, based on graded exposure exercise principles.[27] If this was not feasible for some subjects, they remained at the same exercise level. Subjects were seen in exercise groups, with the specific muscle stabilization–enhanced general exercise group consisting of 5 to 7 participants, because the clinical physical therapist considered this the optimum size for most efficient time management. The number of subjects in the general exercise–only group was kept similar or slightly increased (up to 10 subjects). Subjects also were asked to repeat the exercises at home, for a maximum of half an hour 3 times per week, from the beginning of the program.

Patient education. All subjects received an information booklet (*The Back Book*[36]) providing the latest scientific facts on LBP management at the beginning of the program. The main aim of this booklet is to change patient beliefs and behaviors regarding back pain.[37]

Exercise adherence. The clinical physical therapist who administered the exercise sessions monitored class adherence, and subjects were required to keep an exercise diary monitoring home adherence. The number of sessions in class environment and at home was recorded.

Outcome Measures

Pain report. Pain perception was measured using the Short-Form McGill Pain Questionnaire (SF-MPQ), a responsive pain scale that yields reliable and valid data,[38] derived from the original McGill Pain Questionnaire.[39] The SF-MPQ consists of 15 descriptors of pain quality (11 sensory, 4 affective), each rated on an intensity scale from 0 to 3 and on a visual analog scale (VAS) for pain intensity from 0 to 100 mm, with higher scores representing higher levels of pain on both scales. Scores could range from 0 to 33 for the sensory scale and from 0 to 12 for the affective scale. We used 3 separate VASs to measure pain intensity over different time frames: VAS A measured current pain intensity, VAS B measured pain intensity over the past week on average, and VAS C measured pain intensity over past month on average. The reliability of data for those scales was tested over a small time interval (3–7 days) in 11 randomly selected subjects before the start of intervention by estimation of intraclass correlation coefficients (ICC [3,1]) and their 95% confidence intervals (95% CI) and standard error of measurement values (SEM). Visual analog scale A yielded the least reliable data (ICC=.46, 95% CI=0.13–0.81, SEM=15.87) and was not used further. The reliability for VAS B was: ICC=.88, 95% CI=0.63–0.96, SEM=6.59. The reliability for VAS C was: ICC=.77, 95% CI=0.37–0.93, SEM=5.69.

Disability report. Disability was measured using the Roland-Morris Disability Questionnaire (RMDQ), a 24-item scale (0="no disability," 24="highest disability") with clinically acceptable reliability, validity,[40,41] and responsiveness.[42]

Assessment of Pain Beliefs

Fear of movement/injury or reinjury. Fear of movement/injury or reinjury was measured using the 17-item Tampa Scale of Kinesiophobia (TSK), a scale determining the level of a person's fear to perform physical movement and activities resulting from a feeling of vulnerability to painful injury or reinjury. The scale yields data having construct validity because the data have been shown to correlate with measurements of disability obtained with the RMDQ ($r=.49$, $P<.01$).[43] Reliability for the TSK also has been ascertained in a sample of people with LBP ($r=.78$).[44] Scores range between 17 ("no fear") and 68 ("highest fear").

Pain self-efficacy beliefs. Self-efficacy refers to a person's beliefs in his or her capabilities for performing specific actions or meeting specific situational demands.[45] The Pain Self-Efficacy Questionnaire (PSEQ), is a 10-item scale used to assess the level of self-confidence in performing functional and social activities despite the presence of pain.[46] The scale's reliability ($r=.79$) and concurrent and construct validity have been determined for data obtained with the PSEQ.[46] The scale is responsive both for behavioral[47] and fitness-based[48] rehabilitation programs for people with LBP. Scores range between 0 ("no self-efficacy") and 60 ("highest self-efficacy").

Pain locus of control. The Pain Locus of Control (PLC) Scale measures whether patients perceive that their LBP can be effectively controlled by themselves or whether control lies externally (health care professionals, medication). The scale's structure and the reliability of its data compare favorably with those of similar scales.[49] It consists of 2 subscales: a pain control subscale ($r=.95$) that examines patients' beliefs about being able to affect their pain levels and a pain responsibility subscale ($r=.67$) that examines the extent to which patients believe that managing pain should be the physician's responsibility or something for which they have to take a degree of responsibility.[49] Both subscales are responsive in a pain-management program setting[50] but not for assessing the effectiveness of fitness programs for patients with chronic LBP.[48] Pain control subscale scores range between 0 and 30, and pain responsibility subscale scores range between 0 and 15, with higher scores indicating better pain control or pain responsibility.

Sample-Size Estimation

The trial was designed to have at least 80% power to detect a 2.5-point between-group difference in the scores of the RMDQ, the primary outcome measure in the study. This difference is considered as the minimally detectable important change.[51] Sample size estimation was performed with nQuery Advisor version 3.0 software.* For a common standard deviation of 3.7 points,[20] and using a 2-group 1-tailed t test ($P=.05$), 38 subjects per group were required to detect a between-group difference for the RMDQ at the 90% level and 28 subjects per group at the 80% level.

When the minimum number of subjects to be recruited was reached, an interim power calculation analysis was conducted to assess whether the power of our study had been achieved. Power analysis revealed that power of 80% had been achieved for the RMDQ, therefore recruitment of further subjects stopped.

Data Analysis

Normality of distribution for all data collected was analyzed with the Kolmogorov-Smirnov test. Summary statistics for anthropometric and outcome variables were compared at baseline for the 2 exercise groups (independent-samples t test or Mann-Whitney U test) to establish whether the applied randomization procedure was successful.

A 2×3 (exercise group $\times$ time) analysis of variance for repeated measures on the second factor was used to analyze each outcome measure separately. The sphericity assumption was checked with the Mauchly test. In addition to examining statistical significance, calculation of mean differences and 95% CIs between each follow-up point and pretreatment data were performed (independent-samples t tests).[52] The level of significance was set at $P=.05$ for all comparisons.

All analyses were performed primarily according to the "intention-to-treat" (ITT) principle, with all subjects randomly assigned for intervention analyzed in their assigned groups.[53,54] Friedman et al,[54] however, also suggest that, when withdrawals are inevitable, both a per-protocol analysis and an ITT analysis should be performed; if both types of analysis concur, the result can be accepted with more confidence. A per-protocol analysis was performed alongside the ITT, using only data from subjects who provided follow-ups on both occasions (n=38). Missing data for ITT analyses were handled with a relatively conservative approach by inserting group means in the place of missing values.[55] Statis-

* Statistical Solutions, Stonehill Corporate Center, Suite 104, 999 Broadway, Saugus, MA 01906.

tical analyses were performed using SPSS software, version 9.0.[†]

Results

Out of 126 referrals to the trial, 67 subjects fulfilled the set criteria for inclusion. Twelve of those subjects, although initially examined, were not randomly assigned to exercise groups because they later decided they could not participate. From the 55 randomly assigned subjects, 10 dropped out of the program (n=5 per group), most of them due to time constraints, and 2 subjects in the stabilization–enhanced exercise group dropped out due to increased pain during the exercise program. Another 7 subjects who completed the postintervention follow-up (4 in the general exercise–only group, 3 in the stabilization–enhanced exercise group) did not return their questionnaires at the 20-week assessment for unknown reasons, although a second reminder was sent out 2 weeks after the first mailing (Figure).

Data collected for most of the variables (Tabs. 1 and 2) followed a normal distribution (Kolmogorov-Smirnov test, P=.06–.99), apart from current episode duration (P<.0005). Parametric statistical tests were used for most data comparisons. Current episode duration data are presented as medians and interquartile ranges (IQRs) and analyzed nonparametrically (Tab. 1). Only the VAS B baseline data were different between groups (Tab. 2); all other variables were considered sufficiently similar from the outset to assume the groups were the same.

Changes With Exercise

For all self-report measures used (pain, disability, and all pain belief scales), the interaction of time with exercise class participation were not significant (P>.05), thus indicating that both groups had achieved similar change over time (Tab. 2). The RMDQ data just failed to reach statistical significance when all 3 time points were analyzed together with an analysis of covariance (ANCOVA) (P=.05, Tab. 2). When the 2 follow-up time points were analyzed separately and for the RMDQ only, there was a statistically significant between-group difference immediately following exercise (mean difference=2.55, P=.027) in favor of the general exercise–only group, but this difference was no longer present at the 3-month follow-up. Both groups improved immediately following intervention (P<.001), and these improvements were maintained 3 months later for all outcome measures apart from the PLC pain control subscale, which remained unchanged (Tab. 3). For all outcome measures, results were the same with both types of analyses (ITT and per protocol). Only the results of the ITT analyses, therefore, are presented (Tabs. 2 and 3). The VAS B data were adjusted for the differences in baseline using an ANCOVA.

Adherence to Exercise

Adherence data for clinic-based exercise were normally distributed. These data were available for all participants who attended the program on a regular basis (n=45). The number of sessions attended was similar for both groups (stabilization–enhanced exercise group: $\overline{X}$=12.21, SD=2.69; general exercise–only group: $\overline{X}$=11.33, SD=2.67; P=.28). Home adherence data were negatively skewed (P=.02) and thus were analyzed with nonparametric statistics (Mann-Whitney U test). Subjects in both groups who completed the program also completed a high number of exercise sessions at home. This could only be verified in 35 out of 45 subjects who completed the program (10 subjects had not completed a home diary). No between-group differences were present (stabilization–enhanced exercise group: median=23.50, IQR=20.00–24.00; general exercise–only group: median=22.00, IQR=15.00–24.00; P=.57).

Discussion

According to some authors, all patients with LBP may benefit from spinal stabilization exercise retraining on the premise that deconditioning of trunk muscles leads to instability symptoms,[16–19] without any definitive proof from a relevant RCT yet. To test for this, we recruited subjects with nonspecific LBP. However, our findings tend to suggest that general trunk muscle exercises alone, without the addition of stabilization exercises, reduce patient self-reported disability more effectively immediately after the end of a 2-month exercise period. A statistically significant difference was observed between the 2 groups for the reduction in RMDQ scores (mean difference=2.55, P=.027) in favor of the general exercise–only group for the RMDQ data acquired immediately posttreatment. Both groups made a clinically significant improvement based on a 4-point within-group change[56]; however, the improvement in the stabilization–enhanced exercise group was suboptimal compared with the general exercise–only group for the immediate postexercise comparison. According to previous research, a 2.5-point between-group difference in RMDQ scores can be considered as minimally important[51]; therefore, the null hypothesis for our study can be rejected based on this result. However, for all of the remaining outcome measures, no between-group differences could be detected either immediately postexercise or 3 months later. The difference in the RMDQ scores also was no longer present at the 3-month follow-up.

The greater improvement in the general exercise–only group may signify that perhaps specific muscle stabilization retraining is more relevant to patients with either gross spinal instability symptoms[12] or pronounced side-

[†] SPSS Inc, 444 N Michigan Ave, Chicago, IL 60611.

Table 2.
Scores by Group Over Time and *P* Values for the Interaction Effect[a]

	Pretreatment[b]				8 Weeks				20 Weeks				
	Stabilization–Enhanced General Exercise Group (n=29)		General Exercise–Only Group (n=26)		Stabilization–Enhanced General Exercise Group (n=29)		General Exercise–Only Group (n=26)		Stabilization–Enhanced General Exercise Group (n=29)		General Exercise–Only Group (n=26)		
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	*P*
Pain scale													
SF-MPQ, sensory descriptors	12.2	4.0	12.9	5.2	7.9	4.1	7.7	5.2	6.4	4.8	8.3	5.2	.29[c]
SF-MPQ, affective descriptors	3.5	2.9	3.5	2.8	1.7	1.6	1.1	1.3	1.3	1.9	1.9	2.0	.18[c]
SF-MPQ, total score	15.7	5.4	16.3	6.4	9.6	5.2	8.8	5.9	7.7	6.4	10.2	6.3	.15[c]
VAS B (pain in past week)	26.9	20.6	40.2	24.6	12.3	13.7	21.3	17.3	15.8	15.3	17.8	14.2	.30[d]
VAS C (pain in past month)	49.9	26.4	55.9	25.5	22.3	18.3	27.8	15.6	23.1	18.8	28.8	16.9	.98[c]
Disability													
RMDQ	9.2	4.6	11.3	5.2	5.1	4.0	4.7	3.5	4.5	3.8	5.2	3.5	.05[c]
Pain beliefs													
Fear of movement (TSK)	37.6	6.3	40.5	8.9	33.7	6.5	35.1	7.1	31.5	6.1	32.9	5.3	.57[c]
PSEQ	42.0	12.3	37.3	11.1	49.2	8.6	48.1	7.7	51.2	8.3	48.9	9.4	.38[c]
PLC, pain control	12.4	4.5	11.2	6.0	12.4	4.3	11.3	5.0	10.9	3.6	9.9	4.1	.99[c]
PLC, pain responsibility	8.4	1.9	8.0	2.4	9.4	1.9	9.3	2.2	9.7	1.9	10.2	1.9	.23[c]

[a] SF-MPQ=Short-Form McGill Pain Questionnaire, VAS=visual analog scale, RMDQ=Roland-Morris Disability Questionnaire, TSK=Tampa Scale of Kinesiophobia, PSEQ=Pain Self-Efficacy Questionnaire, PLC=Pain Locus of Control Scale.
[b] Independent-samples *t* test showed no differences at baseline between the 2 groups for all outcome measures ($P>.05$) apart from VAS B ($P=.034$).
[c] 2 × 3 (exercise group × time) analysis of variance.
[d] Adjusted for baseline, 2 × 3 analysis of covariance.

Table 3.
Within- and Between-Group Differences and Between-Group 95% Confidence Intervals (95% CI) for Outcome Measures on Each of the Measurement Occasions[a]

	Stabilization–Enhanced General Exercise Group (n=29)		General Exercise–Only Group (n=26)		Between-Group Mean Difference	95% CI
	$\bar{X}$	SD	$\bar{X}$	SD		
Pain scale						
MPQ, sensory descriptors[b]						
8 wk–pretreatment	−4.25	4.63	−5.21	5.48	0.95[c]	−1.78 to 3.68
20 wk–pretreatment	−5.79	5.05	−4.63	6.00	−1.16[c]	−4.15 to 1.82
MPQ, affective descriptors[b]						
8 wk–pretreatment	−1.81	2.87	−2.32	2.34	0.51[c]	−0.91 to 1.94
20 wk–pretreatment	−2.23	3.30	−1.52	2.65	−0.71[c]	−2.34 to 0.92
MPQ, total score[b]						
8 wk–pretreatment	−6.06	6.44	−7.49	6.43	1.42[c]	−2.06 to 4.91
20 wk–pretreatment	−8.02	7.39	−6.11	7.30	−1.91[c]	−5.89 to 2.07
VAS B (pain in past week)[b,d]						
8 wk–pretreatment	−18.18	18.80	−14.92	16.52	−3.26[c]	−10.15 to 3.63
20 wk–pretreatment	−15.16	19.10	−17.78	19.70	2.62[c]	−4.58 to 9.82
VAS C (pain in past month)[b]						
8 wk–pretreatment	−27.57	29.96	−28.16	26.64	0.58[c]	−14.82 to 15.99
20 wk–pretreatment	−26.82	27.23	−27.10	27.14	0.28[c]	−14.45 to 15.00
Disability						
RMDQ[b]						
8 wk–pretreatment	−4.05	3.26	−6.60	4.97	2.55[e]	0.30 to 4.81
20 wk–pretreatment	−4.65	3.26	−6.03	4.98	1.38[c]	−0.87 to 3.64
Pain beliefs						
Fear of movement (TSK)[b]						
8 wk–pretreatment	−3.95	5.11	−5.40	6.51	1.46[c]	−1.69 to 4.61
20 wk–pretreatment	−6.13	6.57	−7.62	7.09	1.49[c]	−2.21 to 5.18
PSEQ[b]						
8 wk–pretreatment	7.17	11.41	10.75	11.22	−3.58[c]	−9.71 to 2.55
20 wk–pretreatment	9.19	11.06	11.53	10.97	−2.34[c]	−8.31 to 3.62
PLC, pain control[f]						
8 wk–pretreatment	0.04	5.05	0.09	5.96	−0.05[c]	−3.05 to 2.96
20 wk–pretreatment	−1.43	5.24	−1.26	5.76	−0.17[c]	−3.17 to 2.84
PLC, pain responsibility[b]						
8 wk–pretreatment	0.97	2.06	1.33	2.09	−0.36[c]	−1.50 to 0.77
20 wk–pretreatment	1.26	2.26	2.24	2.13	−0.97[c]	−2.18 to 0.23

[a] SF-MPQ=Short-Form McGill Pain Questionnaire, VAS=visual analog scale, RMDQ=Roland-Morris Disability Questionnaire, TSK=Tampa Scale of Kinesiophobia, PSEQ=Pain Self-Efficacy Questionnaire, PLC=Pain Locus of Control Scale.
[b] Significant within-group differences (for both groups) detected with within-group *t* test.
[c] Nonsignificant between-group differences detected with between-group *t* test.
[d] Adjusted for baseline.
[e] Significant between-group differences detected with between-group *t* test.
[f] Nonsignificant within-group differences (for both groups) detected with within-group *t* test.

to-side differences in the size of the multifidus muscle[11] than to our subjects, who did not present any signs and symptoms of clinical instability as described in the literature.[32,57] The patients in the study by O'Sullivan et al[12] had radiological confirmation of an unstable segment related to the pain distribution, and also the patients in the study by Hides et al[11] showed a good correlation between the level of side-to-side multifidus muscle CSA imbalance and the level of their pain.

The mode of action of stabilization retraining still remains unclear, because it has not been shown to be capable of mechanically containing an unstable segment, even upon improvement of muscle activation.[58] No direct long-term effect of stabilization exercises on the status of the local stabilizing muscles has been demonstrated. Hides et al[21] demonstrated less LBP symptom recurrence 3 years after treatment but did not verify the role of CSA, which was measured only in the initial study[11] and not the follow-up.[21] Similarly, no

long-term improvement in the activation of the local stabilizing muscles has been presented.[12] Thus, these studies suggest only a possible role for "stabilization" and illustrate the need for more comprehensive long-term assessments.

From a methodological point of view, the frequency and duration of the studied interventions (2–5 times per week for 8 weeks) were deemed appropriate to produce demonstrable benefits, based on previous studies of similar or less exercise duration.[9,48,59,60] Because increasing doses of low back active exercises have been associated with an increase in reported benefits,[61] we attempted to avoid confounding our results due to this factor by balancing the exercise dosage between the groups, based on prior literature on the loading imposed on the trunk muscles with each type of exercise. Exercises were administered in a progressive manner for both groups, and classes were supplemented with exercise leaflets to maintain motivation. The relatively high level of adherence both during classes and at home confirms patient motivation to complete the exercise program. The treating physical therapist had extensive expertise in stabilization exercise intervention delivery through attendance of specialized seminars on the topic and its subsequent application. However, correct contraction of the stabilizing muscles could not be achieved in all subjects in the stabilization–enhanced exercise group until 2 to 3 sessions had passed, and subjects had to be constantly corrected by the treating physical therapist each time new exercises were introduced, similar to the study by O'Sullivan et al.[12] However, the subjects in the general exercise–only group could perform the exercises correctly by following the leaflets provided, with minimal instruction required from the physical therapist.

A limitation to our study was that, apart from the clinical physical therapist palpating the transversus abdominis and multifidus muscle contraction in the subjects in the stabilization–enhanced exercise group, there was no other means of verifying whether these muscles were recruited appropriately. However, due to our intention to monitor the effect of stabilization exercises delivered under pragmatic, clinical conditions used in everyday practice, the use of sophisticated devices such as electromyographic biofeedback units or real-time ultrasound scanners, as advised by some authors,[11,62] was avoided. Positive effects of stabilization exercises also have been reported by O'Sullivan et al,[12] who used less sophisticated feedback techniques such as the facilitation techniques used in our study.

Two subjects dropped out from the stabilization–enhanced exercise group due to complaints of pain. Their increase in pain, however, could not be attributed with certainty to the exercises, because pain did not begin during exercise performance time. The percentage of subjects from this group who developed pain (6.9%) was not alarmingly high enough to suspect that the increase in pain was due to the exercises administered, nor has such an incident been reported in any similar previous study.

An important finding of our study was that, although exercise was prescribed under a biomechanical framework (to train the muscles surrounding the spine in order to protect it) and we did not adopt strict psychological principles of exercise delivery, within-group improvement in 3 of the 4 psychological outcome measures was documented for both groups. Namely, participants' ideas about fear of movement/injury or reinjury, self-confidence in the performance of activities despite the pain, and the PLC pain responsibility subscale (patients' degree of responsibility in controlling their pain levels) registered improvements on both posttreatment follow-ups. However, no appreciable change was noted in one other outcome measure (PLC pain control subscale). Similar multidimensional changes have been reported by several researchers who adopted primarily a "physiological type" of approach to intervention[63] as well as those who used psychological approaches in conjunction with exercise.[28,47,48,64]

The information provided in *The Back Book* may have resulted in a positive shift in patient beliefs regarding LBP, as previously demonstrated.[37] In our opinion, however, the shift in beliefs also was reinforced by patient problem-solving interactions with the treating physical therapist on how to perform the exercises and by the fact that some pain during exercise was to be considered normal may have led to increased patient adherence,[65] allowing the subjects to participate in a number of exercise routines. Patients' exposure to potentially back-straining movements, such as spinal flexion, has been shown to decrease the avoidance of such activities[27,66] and perhaps patient levels of disability in general. Exercises were delivered in a progressive method, from easier to more difficult for both programs, to progressively introduce patients to more demanding exercises, according to graded exposure principles.[27] Due to the design of our study, it was not clear whether all of these factors resulted in the improvement of patient beliefs regarding LBP.

Several studies have shown that patients who are less fearful and more optimistic about their abilities to function despite LBP report less pain behavior and disability and demonstrate fewer functional limitations[27,43,67–71] compared with patients who have increased fear and decreased pain self-efficacy beliefs. The reduction noted in some of the psychological

factors measured also may have been related to decreased pain and disability report. However, due to the nature of our trial and the very few time points when the data were collected, a clear order of the change in the variables measured (pain, disability, and patient beliefs) could not be established. This can be a future avenue for exploration.

The characteristics of our subjects were similar to those of subjects in other studies, thus reinforcing the generalizability of our findings. Our initial pain and disability scores were similar to those reported previously.[11,12,20] We considered within-group changes in subjects' reports of pain and disability documented in this study to be clinically important.[56,72] Initial levels of beliefs about LBP and its controllability (PSEQ, PLC) were similar to those in a rehabilitation study of patients with chronic LBP who were moderately disabled[48] but better than those in a study of patients with chronic LBP who were more severely disabled.[47] Levels on the TSK scale were similar to those reported previously for patients with chronic LBP.[43,73] The PSEQ and the TSK were the most responsive to change among the cognitive scales used. The pain responsibility subscale of the PLC also was responsive to change, but the pain control subscale was not responsive to change. Similar positive findings were previously observed for the PSEQ but not for any of the PLC subscales.[48] Changes noted in our study were comparable to and slightly better than the changes reported for patients with chronic LBP who were moderately disabled[48] and patients with chronic LBP who were more severely disabled,[47] possibly suggesting that a shift in beliefs is more likely to occur with therapeutic exercises in patients with chronic LBP with less disability. No previous study was found that reported on the level of improvement with exercise for the TSK.

Because the between-group differences we were able to demonstrate were present only for the RMDQ immediately following exercise, our results concur partly with those of studies of patients with subacute LBP[9] and chronic LBP[63,74–79] that directly compared one type of muscle conditioning exercise with another. None of these studies could identify any comparative benefit among the different types of exercise used, suggesting that for a general sample of patients with nonspecific LBP, patient engagement in activity through safe exercising and not particular types of exercises may be the key component for successful LBP management.

Conclusion

General trunk exercises alone may be better suited for patients with recurrent episodes of nonspecific subacute or chronic LBP but without any overt signs or symptoms of instability. In line with evidence from other studies on patients with nonspecific recurrent LBP, it could be suggested that a general exercise program provided in a group environment may be beneficial for successful management of patients with recurrent nonspecific subacute or chronic LBP.

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Appendix.

Exercises Used for Each Group and the Week Each New Exercise Was Introduced in the 8-Week Program

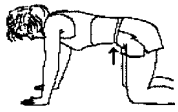
Some of the exercises are illustrated. Common components to both programs also are described. Arrows indicate that specific trunk muscle activation is required in that exercise.

Common Warm-up Exercise Components

Light Aerobic Work: Exercise bicycle for 5 minutes at moderate pace.

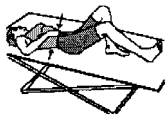
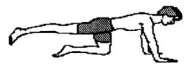
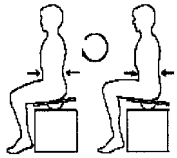
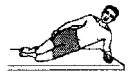
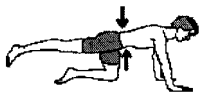
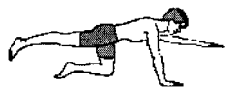
Stretching Exercises: *Back stretches:* Low back sustained rotation from supine position, single and double knee to chest from supine position, alternate spinal flexion-extension from 4-point kneeling position, trunk forward stretching while sitting on the heels and with trunk parallel to the floor, side bending in standing position with and without contralateral arm elevation.

Pelvic/leg stretches: Hip flexors stretch from the Thomas test position, hamstring muscle stretch from long-sitting position on the side of a treatment table for each leg individually, calf stretches with knee straight and bent from standing position, simultaneous hip abduction in sitting position and reaching forward with back straight (adductor muscle stretch).

Week	Stabilization–Enhanced Exercise Group Isolated lumbar stabilizing muscle training	General Exercise–Only Group Classic abdominal and back extensor training
1	*Development of the perception of the isolated isometric specific contraction of the stabilizing muscles* Transversus abdominis muscle from: 4-point kneeling and lying positions, trying to hollow the lower abdomen  Multifidus muscle from: stepping activity while standing and raising contralateral arm, trying to feel the contraction of the opposite-side multifidus muscle or from sitting position with therapist's hands over the muscle 	*Stage 1* Upper and oblique abdominals from lying position: with knees straight (hands filling space between low back and exercise mat) and knees bent  Back extensors: lifting trunk to neutral from prone position with pillow under stomach and arms by the side  Coordination: pelvic tilting from lying, sitting, and standing positions
2	*Precise repetition of the isolated isometric-specific co-contraction of the stabilizing muscles, increasing their contraction time* Transversus abdominis and multifidus muscles together from: sitting and standing positions 	*Stage 2* Upper and oblique abdominals from lying position: with knees straight, knees bent Back extensors: lifting trunk to neutral from prone position with pillow under stomach and arms by the side Exercises performed as illustrated for stage 1
	Integration of lumbar stabilizing muscle activity into light dynamic functional tasks	
3	*Control of neutral lumbopelvic postures* Isolated movement of adjacent body areas, maintaining lumbar spine stability (ie, moving only hip or thoracic spine) 	*Stage 3* Abdominals from lying position: heel slides, lower abdominal crunches  Back extensors: bridging, lifting trunk to neutral from prone position and arms in elevation 

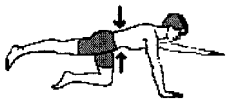
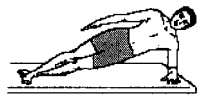
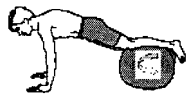
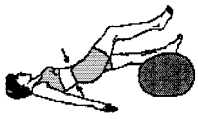
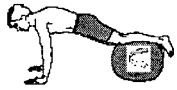
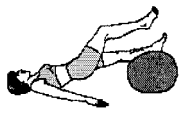
(Continued)

Appendix
(Continued)

Week	Stabilization–Enhanced Exercise Group	General Exercise–Only Group
4	*Control of neutral lumbopelvic postures and aggravating postures*	*Stage 4*
	Stabilizing muscle isometric co-contractions with addition of external load to lumbar spine Hip horizontal abduction, heel slides, leg slides from crook-lying position Aggravating postures* 	Abdominals from lying: heel slides, leg slides, lower abdominal crunches Back extensors: bridging, lifting trunk to neutral (prone position with arms elevated), single-leg extensions from prone and 4-point kneeling positions  
5	*Lumbopelvic control during movements and aggravating movements*	*Stage 5*
	Sitting on unstable base of support (hip extension movement only, lumbar spine only, thoracic only), 3-plane movement, co-contractions during normal-speed walking and other activities* 	Abdominals from lying position: straight leg lifts toward ceiling, cycling exercises, leg slides, lower abdominal crunches Obliques: hip lift from side-lying position Back extensors: as in stage 4  
	Integration of lumbar stabilizing muscle activity into heavy-load dynamic functional tasks	
6	*Isometric co-contractions with addition of heavier external loads to lumbar spine*	*Stage 6*
	Bridging exercise, co-contractions during leg cycling from supine position, single-leg extensions from 4-point kneeling position  	Abdominals from lying position: full abdominal crunches, straight leg lifts toward ceiling, cycling exercises, leg slides Obliques: hip lift from side-lying position Back extensors: alternate arm/leg extensions from 4-point kneeling and lying positions, single-leg bridging Swiss ball coordination exercises: alternate arm/leg lifts sitting on ball  

(Continued)

Appendix
(Continued)

Week	Stabilization–Enhanced Exercise Group	General Exercise–Only Group
7	*Increasing complexity and load of exercises maintaining lumbar spine stability*	*Stage 7*
	Single-leg bridging exercise, bridging exercise with an unstable base of support  Alternate arms/leg extensions from 4-point kneeling and lying positions and arm/leg lifts sitting on Swiss ball Functional co-contractions during walking (increasing speed) and other activities* 	Abdominals from lying position: same leg and arm lifting-lowering, full abdominal crunches, straight leg lifts toward ceiling, cycling exercises, leg slides  Obliques: advanced hip lift from side-lying position Back extensors: as in stage 6 Swiss ball coordination exercises: abdominal curls on ball from prone position, pulling legs toward chest 
8	*Coordination exercises*	*Stage 8*
	Single-leg bridging exercise with an unstable base of support, bridging exercise with rotatory self-resistance, simultaneous arm and leg movements from supine position maintaining lumbar spine stability, functional co-contractions during walking (changing speeds) and other activities* 	Abdominals from lying position: same leg and arm lifting-lowering, cycling exercises  Obliques: full oblique abdominal crunches, advanced hip lift from side-lying position Back extensors: as in stage 6 Swiss ball co-ordination exercises: oblique abdominal curls on ball from prone position, single-leg bridging 
	Total Time: 180 minutes, 40 seconds	Total Time: 99 minutes, 10 seconds

* Asterisk indicates integration of stabilizing muscles' co-contractions in aggravating postures (eg, gardening, ironing, vacuum cleaning, window cleaning).
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