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Evidence-informed management of chronic low back pain with lumbar stabilization exercises

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Abstract **EDITORS' PREFACE:** The management of chronic low back pain (CLBP) has proven very challenging in North America, as evidenced by its mounting socioeconomic burden. Choosing among available nonsurgical therapies can be overwhelming for many stakeholders, including patients, health providers, policy makers, and third-party payers. Although all parties share a common goal and wish to use limited health-care resources to support interventions most likely to result in clinically meaningful improvements, there is often uncertainty about the most appropriate intervention for a particular patient. To help understand and evaluate the various commonly used nonsurgical approaches to CLBP, the North American Spine Society has sponsored this special focus issue of *The Spine Journal*, titled Evidence-Informed Management of Chronic Low Back Pain Without Surgery. Articles in this special focus issue were contributed by leading spine practitioners and researchers, who were invited to summarize the best available evidence for a particular intervention and encouraged to make this information accessible to nonexperts. Each of the articles contains five sections (description, theory, evidence of efficacy, harms, and summary) with common subheadings to facilitate comparison across the 24 different interventions profiled in this special focus issue, blending narrative and systematic review methodology as deemed appropriate by the authors. It is hoped that articles in this special focus issue will be informative and aid in decision making for the many stakeholders evaluating nonsurgical interventions for CLBP.

Keywords: Chronic low back pain; Lumbar stabilization exercise; LSE

Description

Terminology

Therapeutic exercise for individuals with low back pain (LBP) has evolved over time. Recently, there has been a focus on exercises that aim to maintain stability in the lumbar spine [1]. This type of exercise approach has been termed lumbar stabilization, core stabilization, or segmental stabilization. Although no formal definition of lumbar stabilization exercises (LSEs) exists, this approach is aimed at improving the neuromuscular control, strength, and endurance of muscles central to maintaining dynamic spinal and trunk stability. Several groups of muscles are targeted, particularly the transversus abdominis (TrA), lumbar multifidi, and other paraspinal, abdominal, diaphragmatic, and pelvic musculature. Given the widespread clinical use of LSE, it is necessary to critically assess the evidence of their efficacy in patients with chronic low back pain (CLBP).

History

In the 1980s, Bergmark undertook a mechanical engineering approach to the study of the lumbar spine [2]. He wanted to assess the role of the trunk musculature in providing stabilization for the lumbar spine and the specific forces applied to the spine by different muscles, hoping to

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understand the biomechanical "rationale" for the complex anatomic features of the lumbar spine. Using a mechanical modeling approach, he divided the musculature acting on the lumbar spine into two groups: local and global. The global musculature (eg, erector spinae, rectus abdominis) was felt to transfer load between the thoracic spine and pelvis. The local musculature consists of muscles that act directly on the lumbar spine and are attached to the lumbar vertebrae (eg, multifidi). Functionally, the global musculature was felt to balance the outer loads on the body, enabling the local system to maintain force control within the lumbar spine and center postural activity at a range within the load tolerance of the spinal structures.

Panjabi then proposed a basis for understanding spinal stability, injury, dysfunction, and recovery [3] asserting that there are three interdependent subsystems that function to stabilize the spine: passive, active, and neural. The passive musculoskeletal subsystem includes the vertebrae, intervertebral discs, ligaments, zygapophyseal joints, and the passive components of the associated musculotendinous structures. The active musculoskeletal subsystem comprises the musculotendinous units attached to, or influencing, the spinal column [3]. The neural subsystem includes sensory receptors in the spinal structures, their central connections, and cortical and subcortical control centers. These three subsystems are interdependent and work together to maintain spinal stability and intervertebral motion. For example, an injury or breakdown in the passive subsystem, such as a fracture, disc herniation, or disc degeneration, may decrease the inherent stability of the spine and alter segmental motion patterns. Enhancement of the neural and active subsystems could then help compensate for this loss and partially restore stability.

A number of authors have assessed the role and activation patterns of the trunk musculature as they relate to the concept of spinal stability. Cresswell et al. reported a series of studies on intra-abdominal pressure and activation of trunk musculature [4–6]. Their studies indicated that intra-abdominal pressure was increased during functional tasks by muscles that did not create a significant flexion moment of the lumbar spine, particularly the TrA and diaphragm, and activation of the TrA was correlated with changes in intra-abdominal pressure. Further study indicated that muscles of the abdominal wall were activated before the erector spinae in a situation of expected ventral loading of the trunk (inducing a flexion moment on the trunk) and concurrent with the erector spinae in unexpected ventral loading. This finding suggested that abdominal musculature may play a role in enhancing spinal stability during trunk motion or loading. Hodges and Richardson [7] further pursued this line of research by studying the activation pattern of the trunk musculature associated with an alteration of spinal posture induced by movement of an upper limb. In individuals without LBP, the TrA was the first muscle activated and contracted before limb movement, regardless of the direction of motion, whereas other muscles tended to have firing patterns that were distinct for the direction of motion. This suggested that the TrA provides stability for the lumbar spine in anticipation of perturbations of posture. In individuals with LBP, however, the contraction of the TrA was significantly delayed and followed direction-specific patterns, indicating a potential for decreased spinal stability and fundamental problems with motor control. Similar findings were noted in later studies on the effects of lower extremity motion in those with and without LBP [8,9].

There have also been several studies on the lumbar multifidi in individuals with LBP. In 1994, Hides et al. [10] reported finding significant ipsilateral atrophy in the lumbar multifidi of individuals with unilateral LBP, whereas they noted very little asymmetry in these muscles in a control group of subjects without LBP. They subsequently followed-up patients with acute, first-episode LBP for more than 10 weeks and found that patients treated medically had limited recovery of multifidus muscle mass, whereas patients treated with a specific exercise program had more substantial recovery of multifidus muscle mass over the same time frame [11].

On the basis of these conceptual models and data from some of the above studies, Richardson and Jull described a specific exercise program to train co-contraction of the deep trunk muscles, particularly the TrA and lumbar multifidi, to enhance spinal stability in individuals with LBP [1]. This treatment program has been the basis for a large number of further clinical studies and other publications and for what is commonly used in "core stability" programs [11–24]. Other authors, particularly McGill and colleagues, have addressed additional aspects of stabilization training to emphasize broader and more integrative approaches and effects [20,25,26]. Small, early studies on the effects of these exercise programs indicated that they may have substantial benefit in the treatment of individuals with first-time acute LBP or with specific structural abnormalities in the spine [12,15]. In clinical practice, these programs are applied to a wide range of patients with LBP, although the popularity of these treatment programs is difficult to quantify. The number of recent studies conducted on this topic, along with the publication of a recent systematic review of stabilization exercises on LBP, suggests that these programs are increasingly popular [25,27–30].

General description

The exercise program of Richardson and Jull [1] addressing the TrA and multifidi is described in detail in their text, and formal training in this program is generally administered by a physical therapist. The initial aim of this program is to achieve isometric co-contraction of the local muscles of the trunk, with activation of the TrA and multifidi being considered the "basic functional unit of a movement skill" [1]. Patients are instructed to draw in the lower abdominal wall while simultaneously contracting the multifidi isometrically.

A number of techniques were proposed to facilitate the learning of this particular motor skill, including visual correction, specific verbal instructions, manual facilitation, and use of a pressure biofeedback unit; specific postures are also advocated to assist in motor learning. A strong emphasis is placed on the accurate performance of the maneuvers, and the patients are progressed into functional positions while maintaining muscle activation. Exercises can be advanced when the patient is able to maintain 10 isometric "holds" for 10 seconds without fatiguing. In their study using this training protocol, O'Sullivan et al. [12] noted that it took for some subjects 4 to 5 weeks of training just to obtain an accurate pattern of isometric co-contraction of these muscles.

This program has been modified by other investigators, and many have described progression through functional programs that incorporate previously painful motion patterns. Additional methods of facilitation, including the use of ultrasound, educational pamphlets, and video demonstrations, have also been applied [22–24]. Reflecting the nonstandardized and generally multifactorial nature of many physical therapy treatments, studies have varied in their use of co-interventions such as manual therapy techniques, general conditioning, and varying degrees of physical and cognitive-behavioral therapy. Settings also varied among studies that used either group classes or individual treatment approaches. Although the program by Richardson and Jull is the most widely studied, core stabilization may also be available through exercise physiologists, personal trainers, Pilates instructors, or other health personnel with an interest in this area.

It is difficult to describe a "typical" treatment course, but 6 to 12 sessions of physical therapy are relatively common for a straightforward clinical scenario. However, many patients have a number of mitigating conditions that may affect the frequency and duration of care.

Practitioner, setting, and availability

Stabilization training is widely available in physical rehabilitation settings in the United States and has been described by authors from multiple countries around the globe. Although the vast majority of patients with CLBP are treated on an outpatient basis, these skills can also be taught by therapists in inpatient settings.

Reimbursement

Pertinent Current Procedural Terminology (CPT) codes include 97001: physical therapy evaluation; 97002: Physical therapy reevaluation; 97112: neuromuscular reeducation 97530: therapeutic activities, direct (one-on-one), each 15 minutes; or 97110: therapeutic procedure, one or more areas, each 15 minutes, therapeutic exercises to develop strength and endurance. Insurance coverage for this type of treatment varies widely in the United States, with patients receiving coverage for anywhere from a few visits per year to an unlimited number of visits. Education in training techniques is available through a variety of organizations and medical societies offering postgraduate or continuing medical education, and formal training may be variably present in the primary curriculum of schools of physical therapy, among others.

Theory

Diagnostic testing required

Beyond evaluation to exclude the presence of "red flags" [31] that may indicate more serious pathology related to CLBP, there is no particular requirement for diagnostic imaging before initiating care with LSE.

Indications and contraindications

The use of core stabilization exercises has been described in a wide variety of clinical scenarios, including CLBP with or without specific anatomic conditions, such as spondylolisthesis. The only contraindications to LSE are spinal or medical conditions that preclude exercise for the trunk musculature such as acutely unstable spine injuries, significant acute neurologic compromise, or an unstable medical presentation. From a practical standpoint, it is not particularly advantageous to consider LSE during the acute phase of a significant structural injury. Isometric exercise of the trunk musculature may be an appropriate consideration once any acute condition has been stabilized. Exercise training should not be applied to patients with significant medical conditions or one of a variety of structural lesions in the spine that may be adversely affected by exercise treatment.

By extrapolating from Panjabi's model of spinal instability [3] and the work of many of the authors previously discussed, there may be a rationale for using LSE in almost any patient with CLBP, including those with ongoing pain and a clearly definable structural source or those without correlative pathology identified on standard imaging.

A functional assessment of strength, flexibility, balance, and agility deficits may allow a more precise prescription for LSE training. This intervention may be most effectively applied in a patient who presents with a reproducible, mechanical pattern of lumbopelvic pain that follows a specific plane of movement or functional task. Often these patients demonstrate altered activation patterns of stabilizing musculature or poor endurance of core stabilizing musculature with testing. With patients who have specific functional demands that are limited by CLBP, individualizing the progression of exercise through a task-specific approach designed to meet those physical demands may be the most effective application of core stabilization training.

More pragmatically, care of the patient with CLBP must include a thorough understanding of that individual and should follow the biopsychosocial model of chronic pain assessment and treatment. When treating individuals with substantial physical, social, or psychological barriers to functional recovery, LSE alone may not be sufficient to maximize improvement. In addressing overall function, the use of LSE training may be beneficial for individuals with CLBP, particularly in patients with clearly defined anatomic barriers to functional performance and well-managed social or psychological barriers to recovery. However, when those latter barriers become paramount, a multimodal behavioral modification approach to treatment takes precedence over unimodal LSE.

Table 2
Criteria for methodological quality assessment

1. Was the method of randomization adequate?
2. Was the treatment allocation concealed?
3. Were the groups similar at baseline regarding the most important prognostic indicators?
4. Was the patient blinded to the intervention?
5. Was the care provider blinded to the intervention?
6. Was the outcome assessor blinded to the intervention?
7. Were co-interventions avoided or similar?
8. Was the compliance acceptable in all groups?
9. Was the dropout rate described and acceptable in all groups?
10. Was the timing of the outcome assessment in all groups similar?
11. Did the analysis include an intention-to-treat analysis?

(from van Tulder et al. [34]).

Evidence of efficacy

Review methods

As noted previously, there have been a number of clinical studies and reviews published on LSE. To determine the evidence for the efficacy of this type of training in patients with CLBP, a systematic review of the literature was undertaken. The MEDLINE and Cochrane databases were searched for articles containing various combinations of the terms: LBP; exercise therapy; stabilization; multifidi; segmental control; balance training; core strengthening; clinical trial; randomized controlled trial; meta-analysis; and systematic review. The initial search identified 24 articles whose references were then reviewed to identify any additional relevant articles. A number of reviews of core stabilization and therapeutic exercise in LBP were then also reviewed for any relevant articles [25,27–30,32,33]. Three additional articles were then identified as being potentially applicable to this review.

These studies were then independently reviewed by two of the authors (CJS and SMW). Articles were chosen for inclusion in the study based on predetermined criteria that were felt to allow for evaluation of the best evidence (Table 1). Three articles met these criteria [22–24]. Following the guidelines for systematic reviews proposed by van Tulder et al. [34], these articles were then independently graded by the same two authors for quality and clinical relevance (Tables 2 and 3). The articles were graded as "high quality"

Table 1
Study eligibility criteria

Inclusion criteria	Exclusion criteria
1. Randomized controlled trial with stabilization included in the intervention group and no specific stabilization in the control group.	1. Duplicate reports.
2. Chronic low back pain, defined as at least 3 mo or 12 wk.	2. Abstract only.
3. English language.	3. Combined treatments where effect of stabilization exercise cannot be determined.
4. Outcomes to include pain, disability, quality of life, satisfaction, and/or functional measures.	4. No clinical outcome data.
5. Follow-up of 6 mo minimum.	

if they were felt to meet 50% or more of the applicable criteria for methodological quality and "low quality" if they met less than 50% of those same criteria. Consensus on all pertinent issues was readily reached by the two reviewers after independent ratings were made. Brief summaries of the findings of these three articles are provided below.

Randomized controlled trials

A multicenter study in the United Kingdom compared stabilization exercises (stabilization group) to conventional physical therapy (PT group) in patients 18 to 60 with current LBP, a previous episode severe enough to alter activities or result in medical treatment, and a minimum score on the Roland Morris Disability Questionnaire (RMDQ) of 5 [22]. Participants with psychological distress, prior spine surgery, or radiculopathy/compression with progressive neurologic deficit were excluded. Baseline demographics and characteristics were comparable, although two participants in the PT group were noted to have psychological distress, a protocol violation. Of the 97 patients who were randomized (47 stabilization group, 50 PT group), 70% in each group successfully completed the study. The stabilization group received structured endurance training of the deep abdominal and back extensors and functional progression from sitting to standing exercises. The PT group received active exercises, and minimal use of passive modalities. Both groups had a maximum of 12 weekly treatment sessions by a physical therapist, and could receive manual therapy (67% in stabilization group; 76% in

Table 3
Criteria for evaluation of clinical relevance

Criteria for evaluation of clinical relevance
1. Are the patients described in detail so that you can decide whether they are comparable to those you see in your clinical practice?
2. Are the interventions and treatment settings described well enough so that you can provide the same for your patients?
3. Were all the clinically relevant outcomes measured and reported?
4. Is the size of the effect clinically important?
5. Are the likely benefits of treatment worth the potential harms?

(from van Tulder et al. [34]).

PT group), modalities (traction and electrical stimulation to a small number), education, and advice. Analysis was by intention to treat and the primary outcome was the RMDQ; secondary outcomes included the visual analog scale, Oswestry Disability Index, Short Form McGill Pain Questionnaire, Short Form-36, and Distress and Risk Assessment Method questionnaire. Although both groups had clinically meaningful improvements in function, pain, and quality of life over baseline, there were no significant differences between groups [35,36]. Authors concluded that specific stabilization exercises do not provide additional benefit to patients with recurrent LBP in regard to pain or function when compared with conventional physical therapy treatment as described. This was a high quality and clinically relevant study.

A study compared specific spinal stabilization exercises, manual therapy, and minimal care for patients 18 to 65 with CLBP (>12 wk) at two sites in the United Kingdom [23]. Randomization was stratified based on age, gender, and degree of pain referral to the leg to determine if patients with greater leg pain (more distal referral) were less likely to improve. Patients with "chronic pain syndrome" (no description provided), Grade III or IV spondylolisthesis, spinal stenosis, fracture, progressive objective neurological deficit, specific medical conditions, or "anxiety neurosis," were excluded. The spinal stabilization group received 10 weekly group exercise sessions of 1 hour emphasizing neural and active (motor) control pathways and designed to address selective retraining of the TrA, multifidus, pelvic floor, and diaphragmatic muscles (authors referenced Panjabi [3] and Richardson et al. [14]). The manual therapy group received a maximum of 10 treatments from a physical therapist; no exercises could be prescribed for the TrA, multifidus, diaphragm, or pelvic floor muscles, nor was electrophysical therapy allowed. The minimal care group received the "Back in Action" patient education booklet from a physical therapist, which had previously proven ineffective in patients with CLBP. All participants also attended a 3-hour back school, which included advice and discussion of back exercises. Analysis was per protocol and the study had a high loss to follow-up. Of the 302 who started the study, 213 (70%) completed the treatment; the highest dropout rate was in the minimal care group, for which the last available data were carried forward. Outcomes included pain (back, leg, pain diagram, back pain in last 2 days), disability (Oswestry Disability Index), quality of life (Nottingham Health Profile), and medication use (specific drugs or classes not identified) and were collected at baseline, 3, 6, 12, and 24 months. Although improvements were noted from baseline within groups, there were no significant differences between groups. The authors concluded that spinal stabilization exercise was more effective than manual therapy or minimal care. Others have questioned the validity of this study, citing its high dropout rate and statistical shortcomings [37,38]. This was a low-quality study based on a number of factors including a high dropout rate, lack of an intention-to-treat analysis, and a focus on statistical assessment of within group results rather than comparative results between the treatment groups. The clinical relevance is also somewhat unclear because of some issues with patient demographics and reporting of outcomes.

A multicenter randomized controlled trial from Australia compared general exercise, motor control (stabilization) exercise, and spinal manipulative therapy (SMT) in Patients 18 to 80 with CLBP (including disc lesions, osteoarthritis, and leg pain) greater than 3 months [24]. Patients with neurological signs, prior back surgery, or spinal pathology, such as malignancy or inflammatory spine disease, were excluded. Baseline demographics were similar between groups. The general exercise group received an assessment by a physical therapist, supervised group training in stretching and strengthening major muscle groups, aerobic fitness, and encouragement to progress at their own pace. The motor control group received training in exercises designed to improve the function of specific trunk muscles felt to control intersegmental motion (TrA, multifidus, the diaphragm, pelvic floor) after the program described by Richardson et al. [14], with progression tailored to the individual patients. The SMT group received joint mobilization and manipulation as determined by the physical therapist. Both exercise groups received cognitive-behavioral therapy training from the therapists and encouragement to perform home exercises. All groups received up to 12 treatments in 8 weeks and were restricted from receiving other forms of treatment for those 8 weeks. Analysis was by intention to treat. Of the 240 patients who started the study, 223 (93%) were reported on at 8 weeks and 211 (88%) at 6 and 12 months; dropout rates were similar in each group. Outcomes included the Patient-Specific Functional Scale, global perceived effect, pain (visual analog scale), and the RMDQ. The motor control and SMT groups had marginally better outcomes than the general exercise group at 8 weeks, but all groups had similar outcomes at 6 and 12 months and there was no significant difference between the three groups for any outcome measure. The authors concluded that motor control exercises (stabilization) and SMT result in slightly better short-term function and perception of effect than general exercise for patients with CLBP, but not better medium or long-term results. This was a high-quality study and clinically relevant.

Harms

There are no serious harmful outcomes from the application of LSE in the studies reviewed for this text, which all excluded patients felt to be unfit for physical therapy treatment of the type described (eg, fracture, Grade III or IV spondylolisthesis, malignancy, inflammatory arthropathies, pregnancy, significant neurological loss, medical conditions that made them unsuitable for participation in exercise training and prior spine surgery [22–24]).

Summary

Over the past 15 years, LSE has become an important conceptual and clinical consideration in the management of patients with CLBP. Review of the available evidence suggests that LSE is effective at improving pain and function in a heterogeneous group of patients with CLBP. Using evidence-based criteria, there is moderate evidence that LSEs are effective at improving pain and function in a heterogeneous group of patients with CLBP, and strong evidence that this treatment is no more effective than a less specific, general exercise program. There is moderate evidence that LSEs are no more effective than manual therapy in this same population [34]. It should be noted that only three studies were deemed eligible for this review and only two of those were of high quality. Although there seems to be a relatively sound theoretical and experimental basis for considering this type of exercise training, more information is needed on the types of patients for which it may be best suited, the optimal setting for delivering care and training, the most effective exercises, and the optimal dose, duration, frequency, and progression.

One of the important issues to consider in assessing the literature on this topic is that of the patient group under study. The overwhelming majority of studies on LSE, including the three described above, use a mixed group of subjects with nonspecific CLBP, with or without radicular symptoms. These studies do not have the ability to determine if there is a specific subgroup of patients that may be more responsive to the use of LSE. In a diverse clinical setting in which multiple treatments seem to have equivalent effects, the question arises as to whether a more substantial treatment effect on a specific portion of the study population is being "washed out" by mixing multiple patient types into all of the treatment groups. This idea has certainly been postulated in prior studies on patients with CLBP and may well apply to the study of LSE. Given our limited ability to accurately and reproducibly arrive at a clear anatomic diagnosis or clinical categorization for the majority of patients with CLBP, there is no way to currently define the most appropriate treatment group for the application of LSE training. The very distinctly derived model of spinal instability and pain described earlier in this text might lead to the assumption that this model applies more accurately in a finite group of patients.

Until further data are available, LSE training may be considered a useful tool in the management of patients with CLBP, and clinicians will have to consider the individual characteristics of a given patient's clinical scenario to arrive at the most effective strategy for treatment.

As all of the above studies excluded patients with prior spinal surgery, the effects of stabilization training on this population are largely unknown, and this might also be an important area to explore in future studies, particularly given the model of instability used in the derivation of LSEs.

Future studies should evaluate the potential benefits of core training exercises that are more closely matched to the recreational and occupational demands of the rehabilitating individual, so-called multiplanar, functional core training. Although stabilization training has historically focused on the activation patterns of the TrA and lumbar multifidi, the physical demands on most patients will require a higher degree of coordinated muscle activation and control than would be obtainable through only isolated training of these muscles [26].

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