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INVITED REVIEW

Lumbar Stabilization

A Review of Core Concepts and Current Literature, Part 2

ABSTRACT

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Lumbar-stabilization exercise programs have become increasingly popular as a treatment for low-back pain. In this article, we outline an evidence-based medicine approach to evaluating patients for a lumbar-stabilization program. We also discuss typical clinical components of this type of program and the rationale for including these particular features based on the medical literature.

Key Words: Low-Back Pain, Spine, Exercise, Musculoskeletal

Researchers have hypothesized that changes in a spinal segment that allow for excessive motion cause poor spinal stability and back pain. Structural changes such as disc disease, muscular changes such as weakness and poor endurance, or ineffective neural control all contribute to this instability. Components that can be improved by exercise include (1) the deep musculature that provides intersegmental lumbar vertebral control, such as the multifidi, (2) muscles that increase intra-abdominal pressure to increase lumbar stability, such as the transversus abdominis, diaphragm, and pelvic floor, (3) global muscles that control trunk movement and provide co-contraction during activities such as walking and lifting, such as the latissimus dorsi, quadratus lumborum, and superficial spine flexors and extensors, and (4) the precise neural control of these muscles. Exercises that affect these areas are called lumbar-stabilization programs (LSPs). They are commonly used clinically and have been the subject of recent interest within the medical literature.

The theory behind these types of exercises is an increasing body of literature demonstrating that the biomechanics of those with nonspecific low-back pain (lbp) often differ from those who do not have back pain. For example, those with lbp tend to have delayed contraction of the transversus abdominis in anticipation of limb movement, whereas those without lbp tend to contract the transversus abdominis before other muscles, presumably to stabilize the spine so that unwanted spinal movement does not occur with limb movement.^{1,2} Many patients with chronic lbp have multifidi atrophy and weak spine extensors.^{3–6} Those with back pain have been found more likely to have deficits in spinal proprioception, balance, and ability to react to unexpected trunk perturbation than pain-free controls.^{5,7,8} These issues are more fully explained in part 1 of this article.⁹

LSPs are designed to correct these deficits. The purpose of this article is to review the literature regarding the efficacy of LSPs and to describe an evidence-based clinical approach to a patient's back pain to prescribe a LSP. A PubMed literature search using the key words "lumbar stabilization exercises and back pain" revealed 25 articles. Each of these was reviewed by the first author. Additional pertinent articles were found through these articles' references and are included in this discussion as appropriate.

Recent Meta-Analyses and LSPs

Many studies have shown that exercise is a vital part of the treatment of nonspecific lbp.^{10–12} Certainly, exercise is not a cure for all patients with back pain, but it has been shown to be an effective treatment for many patients. What is less clear is what types of exercise are the most beneficial. Many recent studies have looked at the effect of LSPs on pain and function. For example, a 2004 review of exercise and chronic back pain by Liddle and colleagues¹⁰ concludes that exercise decreases pain and improves function. The authors state, "Strengthening was the predominant exercise in 12 out of 16 trials, two thirds of which were of high exercise quality. The lumbar spine or lumbar spine and lower limbs were the most commonly targeted body site. Abdominal strengthening was often incorporated with strengthening of the lumbar spine to facilitate trunk stabilization."¹⁰ Similarly, a 2005 Cochrane review¹¹ on exercise therapy for the treatment of nonspecific lbp includes six randomized controlled trials of "exercise programs that included strengthening or trunk stabilizing exercises." It concludes that, overall, this type of exercise is effective for chronic lbp, particularly in healthcare settings.¹¹ A recent systematic review¹² of randomized controlled trials of exercise therapy for chronic lbp concluded that exercise treatment worked best if it consisted of an individually designed program delivered with supervision that included stretching and strengthening exercises.¹² Certainly, a prescription for physical therapy for an individualized LSP meets the criteria of including stretching and strengthening under supervision. The exercise protocols to improve lumbar stabilization vary from training of multifidi and transversus abdominis with isometric contractions to using weight machines designed to strengthen the prime movers of the spine.^{10,11}

The Literature Regarding Efficacy of LSPs

Several studies have shown that LSPs decrease pain and improve function. A promising study regarding the efficacy of LSPs was carried out by O'Sullivan and colleagues,¹³ who studied patients

with spondylolysis and spondylolisthesis. Patients were taught how to activate the deep stabilizers, and then the exercises were progressed by adding leverage through the limbs to challenge these muscles. Subjects attended therapy once a week for 10 wks. They were instructed to perform the exercises 10–15 mins/day and to activate these muscles regularly during daily activities, particularly in situations where they would feel pain. These patients were compared with a control group that received usual care as directed by their medical practitioner. All but one of the patients in the usual care group had a regular weekly general exercise program that consisted of a variety of exercises such as swimming, walking, and trunk curls, and eight of the subjects attended supervised exercise programs, but they were not specifically stabilization programs. The stabilization group had decreased pain and disability compared with the control group, which was maintained at 30-mo follow-up. Because this study was done on patients with two specific diagnoses, it is unclear whether these findings could be generalized to those with nonspecific lbp.

Another subpopulation studied to determine whether they would benefit from LSPs were patients after a microdiscectomy. In one study, 42 patients who had undergone microdiscectomy were randomized to dynamic stabilization exercises, a home exercise program of generalized exercises, or a control group with no exercises. Those in the stabilization group showed significant improvement in all parameters studied, including pain, function, strength, and flexibility. The other two groups showed less improvement.¹⁴

Studies^{15,16} have also found these exercises to decrease pain, improve function, and improve performance on functional tasks in patients with nonspecific lbp.^{15,16}

Hides and colleagues¹⁷ found that patient with acute first episode of lbp who received training in multifidi and transversus abdominis co-contraction recovered from the acute episode at the same rate as the control group but had much less chance of recurrence of lbp than those who did not receive this training. Although both the exercise group and the control group had improvement of symptoms at 4 wks, 1-yr and 3-yr telephone follow-up revealed that those in the control group were 12 times more likely to experience recurrence of lbp than the exercise group in the first year and nine times more likely in years 2–3. Although there are some weaknesses to this study, such as the small sample size, the marked differences between groups give credence to the theory that specific exercise training can prevent recurrence.¹⁸

Koumantakis and colleagues¹⁶ found that patients with recurrent lbp who underwent stabilization training and trunk-strengthening exercises

showed improvements in pain, disability, and pain belief scales after 8 wks of exercise; this was maintained at 3-mo follow-up. A weakness of the study was that there was not a control group.

Despite its clinical popularity, there is limited research showing the efficacy of specific spine-stabilization exercises. These types of exercises have a strong theoretical appeal, but more outcome studies are needed.

The Clinical Evaluation: Determining Who Is a Candidate for a LSP

The remainder of this article describes how clinicians can evaluate patients to individualize an exercise program that enhances spinal stabilization and how to choose which components of the exercises described in the literature might be appropriate for an individual patient. A discussion of the literature is included where applicable.

A complete physiatric evaluation of the patient with lbp takes into account the entire person. Pain is a complex symptom that can be affected by a variety of physical and psychological factors. Being aware of these factors allows the physician to develop a treatment plan; often, exercise is a part of this plan. To prescribe exercise effectively, the physician needs to determine (1) whether the patient is an appropriate candidate for an exercise program, (2) whether the program should include lumbar-stabilization exercises, and (3) the appropriate starting point for the patient so that an exercise prescription can be written.

Particular attention should be paid to certain portions of the patient's history to assess whether exercise is an appropriate treatment. Those found to have serious underlying pathology such as a tumor or fracture or progressive neurological deficits such as worsening muscle weakness or paresthesias are not appropriate for this treatment before other medical or surgical interventions. Patients in severe acute pain or during a significant exacerbation of chronic lbp may not tolerate exercise. Other interventions such as medication, injections, massage, or education regarding positions of comfort may be more appropriate until the pain is sufficiently controlled to allow them to exercise. Although there are some exceptions,¹⁹ generally, the literature has not found exercise to be helpful in decreasing the intensity or shortening the duration of acute lbp.¹¹ However, there is some evidence that an appropriate LSP may decrease recurrence of lbp when used in patients with acute onset of symptoms.¹⁸

Questions that help determine the patient's overall musculoskeletal and cardiovascular fitness should be asked so that an appropriate starting point can be determined. This can be confirmed in the physical exam. For example, an athletic indi-

vidual who regularly participates in sports and exercise will have a different starting point than an obese, sedentary patient. In addition, a complete functional history establishes a baseline to measure progress, which may be more accurate than simple pain measures. Therefore, the history should focus not only on pain but on what the patient is able to do currently and on what their back pain does not allow them to do.

Psychosocial issues should also be explored, including the presence of depression, anxiety, kinesophobia, and catastrophizing, which may contribute to the pain and require specific psychological treatment. These issues may also interfere with the patient's ability to fully participate in the exercises. For example, self-efficacy has been found to be a predictor of who will comply with exercises—an important factor for success in any exercise program.^{15,20,21} They are not, however, contraindications for a LSP. Interestingly, exercise can often assist in treatment of these psychosocial factors. Like other forms of exercise, lumbar stabilization and trunk strengthening have been found to improve patients' scores on measurements of fear of movement, pain locus of control, and self-efficacy.¹⁵ Kinesophobia is generally associated with poorer outcomes for exercise treatment. However, in one study, those with higher levels of kinesophobia actually improved more with a LSP than those with lower levels. It was suggested that this occurred because they had a positive experience with movement, and this experience helped them become less disabled.¹⁵

Patients' expectations regarding the effects of exercise should be explored. This may reveal unhelpful beliefs, such as that exercise will cause damage to the spine, and it may uncover barriers to exercise adherence. Both a belief that treatment will not be helpful and overly optimistic expectations of inexperienced exercisers have been linked to poor rates of adherence to exercise.²⁰ Physicians should try to break this cycle through education and by beginning the exercises at a level that is appropriate so that their patients will experience success. A thorough explanation of the reasons a patient has pain, why exercises are being prescribed, and the overall treatment plan should be discussed with each patient. Research has found that outcomes in lbp treatment improve if there is agreement between physicians and patients regarding diagnosis and the treatment plan.²²

The Physical Exam to Assess Lumbar Stability

The standard physical exam for back pain that is taught in most medical school includes palpation and range of motion of the back and a neurological exam of the legs. It is most effective in ruling out serious disease, cancer, or infection and to evaluate

for the presence of radiculopathy.²³ However, this exam is not helpful in determining what type of exercise program is most appropriate. To do this, additional examination is required. These additional components are described below.

Posture

The observation of gait and posture helps guide the rest of the physical exam's specific flexibility and strength testing. For example, a flat back posture is often associated with short hamstrings; increased lumbar lordosis is often associated with tight hip flexors. It has been shown that exercises can correct these postural muscle imbalances so that a patient will stand with a more neutral spine. Neutral spine is the position in which muscles should work most efficiently and in which spinal structures are not under chronic passive strain.²⁴ Posture should be observed in both standing and sitting

Range of Motion

After this evaluation, careful observation of patients' spinal motion should be done. Many clinicians believe that aberrant, faulty movement patterns during spinal range of motion (sometimes called poor qualitative range of motion, in contrast to just the amount of range, or quantitative range of motion), suggests dynamic lumbar instability and the need for stability training. Aberrant movement patterns suggestive of instability include a catch during spinal movement, a painful arc of motion, using support of the arms against the thighs during range of motion, and reversal of normal lumbopelvic rhythm. Poor qualitative range of motion was recently shown to be one of the factors on physical exam predictive of who would improve with a LSP.²⁵

Assessment of Spinal Mobility

Assessment of individual spinal segments may also assist in determining who will obtain pain relief from a LSP. Increased motion in a spinal segment with posterior to anterior mobility testing has also been found to be predictive of who will benefit from an LSP.²⁶ This test is performed with the patient prone. The clinician applies firm pressure with the heel of the hand over the spinous process and assesses the amount of movement this causes. This is a subjective measure with variable interrater reliability, but it is often used clinically. It should not be performed on anyone the examiner believes could have a fracture or gross instability of the spine. In a study in which researchers characterized patients as either generally hypo- or hypermobile with this test, subjects underwent five treatment sessions in which they were taught a variety of exercises to strengthen the spinal stabi-

lizers. They judged patients with a 50% improvement on the Oswestry Disability Index as being successful. For patients with hypermobility, 78% succeeded with stabilization exercises, *vs.* only 26% of those succeeding with hypomobility. In this study, 70% of patients were judged to be hypomobile (and, therefore, would theoretically not benefit from lumbar stabilization because they were already excessively stiff and stable), and 11% were judged to be hypermobile. A major weakness of this study was that only nine patients were in the hypermobile group.²⁶

A positive prone instability test is another clinical assessment of hypermobility; in one study, it was found to be predictive of who would benefit from LSPs. This test is performed as follows: the patient lies prone on the exam table with the legs over the edge of the table and the feet on the floor. At rest, the examiner applies posterior to anterior force over the vertebral body to see whether pain is provoked. Then, the patient uses his or her spine extensor muscles to lift the legs off the floor, and the test is repeated. This test should not be performed on any patient thought to have a fracture, with severe osteoporosis, or with any suspicion of a grossly unstable spine. A positive test is pain in the resting position with posterior to anterior force that is relieved when the spine extensors are engaged. This is thought to be indicative of these muscles temporarily stabilizing the spine and relieving pain.²⁵

Flexibility Testing

Clinicians should evaluate patients for common muscle imbalances that affect the patient's ability to achieve and maintain a neutral spine position. This includes testing the lengths of many muscles that act on the spine or pelvis, such as the gluteal muscles, hip external rotators, hamstrings, hip flexors, thigh adductors, latissimus dorsi, and quadratus lumborum. Techniques for checking these muscles are well described in physical therapy text books.^{27,28} Exercises to correct these imbalances would be a first step in the LSP prescription, because the ability to achieve and maintain neutral spine position is essential for a LSP to be done correctly and effectively.²⁸

Muscle Strength Testing

The purpose of a LSP is to (1) normalize function of the deep stabilizers such as the transverses abdominis and multifidi, (2) restore normal strength and endurance to the muscles that affect the spine, and (3) improve neural processing so that these muscles fire in a normal and efficient manner. Because these are the goals of treatment, it makes sense to evaluate the function of the muscles that affect the spine both

at the initial visit and at follow-up to determine whether the goal has been met.

Because one of the goals of a LSP is to teach the patient to engage the deep spinal stabilizers, one common test is to evaluate whether the patient can volitionally contract the multifidi and transversus. This is to determine whether deficits are present and to assess whether the patient learns to contract these muscles in therapy. It is common in patients with lbp to have difficulty engaging these muscles in isolation without overactivity of the more superficial global muscles. This motor pattern increases segmental compression and can lead to back pain.²⁹ The therapeutic goal is that patients learn to activate the deep stabilizers during therapy and then carry this activation over to daily activities. Hopefully, with enough practice, the activation will eventually become automatic.³⁰ Although imperfect, activation of the transversus abdominis is evaluated clinically by the examiner sinking the thumbs or first three fingers deep to the lower layer of muscles medially and inferiorly to the iliac spines and lateral to the rectus abdominis. In this region, the transversus is overlaid by the internal oblique muscle. The patient is told to draw the abdomen toward the spine without taking a deep breath. A normal result is to feel slowly developing tension of the deep muscle without observing substitution patterns such as flexion of the lumbar spine, a posterior pelvic tilt, or excessive depression or elevation of the rib cage, all of which suggest that the patient is using global muscles rather than the transversus. Richardson and colleagues³⁰ have found a good correlation between those who were able to perform this test well and those who activated the transverses normally with rapid limb-movement tests, but it is not a perfect linear correlation. Also, research has not yet proven that learning to isolate a contraction of the transversus volitionally carries over to automatic use of this muscle in daily tasks. In the future, more sophisticated methods such as ultrasound or EMG may be used to measure this muscular activity, even in the clinical setting, and these questions may be answered.

Activation of the multifidi is evaluated by palpating the deep muscles of the paraspinals while the patient is in a relaxed prone position and then cueing the patient to activate the transversus as described above, at the same time filling out the muscles of the spine without moving the pelvis or spine. This is often difficult to appreciate clinically, because the muscles being palpated are deep, and those with chronic lbp have been found to have atrophy of these muscles.³⁰ In the future, the use of ultrasound or fine-needle EMG may become more prevalent to evaluate these muscles in patients if it can be shown that this alters clinical outcome.

Besides function of the deep stabilizers, absolute muscle strength of the spine extensors and abdominal muscles are often evaluated in research studies as factors that may influence back pain. The literature describes many ways of testing the strength of these muscles using different handheld devices, isokinetic machines, and the patient's own body weight.^{27,31} The literature is mixed as to whether these tests are clinically valuable. One study did not find these measurements to correlate with clinical outcomes or to distinguish between those with and without back pain.³² Others have found that diminished isometric strength is one of several physical factors associated with back pain and increased disability.^{33,34} One reason for this variability in the literature may be that different patients have different strength requirements. Those who are extremely deconditioned may not have enough reserve of strength to perform daily activities. Their muscles would be found on tests to be weak, and this weakness contributes to their pain. Some patients may have enough strength for daily activities but require additional strength if they have heavy work demands or if they are athletes. On muscle testing, their muscles may be found to be in the average range, but they may actually be functionally weak, with the muscles not strong enough to meet the patient's functional demands. It can be very helpful to assess a patient's strength in abdominal musculature, spinal extensors, and other spine and pelvic stabilizing muscles such as the quadratus lumborum and gluteus medius.

Based on the literature, the best way to test the strength and coordination of these muscles is unclear. Manual muscle testing is one way, and techniques for each of these muscles are well described in physical exam texts.²⁷ This may be helpful for assessing asymmetry and for discovering whether the patient has particularly weak muscles, but it may not give enough information about muscle function. Besides traditional manual muscle testing of isolated muscles, the ability to maintain proper form during spinal stability challenges may be useful to check in the office. In addition to helping the physician determine whether patients are able to maintain a neutral spine position with challenges to that system, there is the added bonus of checking to see whether patients are properly performing their exercises and whether they are making gains as expected once the exercise treatment is underway. This could include activities as varied as assessing the patient's ability to obtain neutral spine in quadruped with one arm extended, to the ability to perform a side plank position.

Muscle Endurance

Researchers have hypothesized that muscular endurance is more important than absolute muscle

strength for proper lumbar stabilization, because only a small percentage of maximum muscular force is used to stabilize the spine during daily activities.³⁵ For example, researchers have found that decreased torso extensor endurance may assist in predicting those most at risk for future back pain.³⁶ McGill³⁷ describes three clinical tests for determining spinal stabilizer muscle endurance; these had high reliability when repeated over consecutive days. For all three tests, the time the patient can maintain the proper position is measured. One is a test of lateral musculature endurance in which the patient lies in full side-bridge position and supports himself on one elbow and the feet while lifting the hips off the mat to create a straight line between the shoulders to the feet. The second is a test of trunk flexor endurance in which the patient flexes the hips and knees to 90 degrees and isometrically holds the trunk at 60 degrees of flexion. A third test is of back extensor endurance in which the patient lies prone with the legs supported on a table and the feet secured, with the trunk unsupported. The patient holds the upper body in the horizontal position. Normative data are available for young healthy subjects but not for older patients. These maneuvers test the global musculature rather than the deep stabilizers. It has not yet been shown whether improvement in these tests correlates with symptomatic improvement or improved ability to stabilize the spine. However, they may be useful clinically in measuring progress in endurance and in motivating patients.³⁷

The trunk flexor-to-extensor ratio may be as or more important than absolute strength and endurance, because this has been shown to be abnormal in those with back pain.^{29,36} For example, an imbalance in trunk muscles such as long and weak abdominals and more dominant spine extensors can significantly influence the lordotic curve of the lumbar spine, which theoretically causes excessive loading of the zygoapophyseal joints and which may be a source of pain.³⁸ Determining this ratio clinically can be done by performing the tests for endurance testing mentioned above and then calculating a ratio by dividing the amount of time the patient can maintain trunk flexion by the amount of time the patient can maintain trunk extension. Normal values for young healthy patients are available.³⁷ In addition, physical exam techniques have been developed to assess for more subtle muscle imbalance and abnormal muscular dominance. These techniques can be helpful for developing an exercise plan.²⁸

Balance

Balance and spinal proprioception have also been found to be abnormal in those with chronic lbp.⁹ Balance can be tested in the office by deter-

mining whether the patient can perform simple balance maneuvers such as single-limb stance, a single-stance knee bend, or lunges in different planes, which will at least give some gross assessment of the patient's ability and suggest appropriate starting tasks for physical therapy. Spinal proprioception is more difficult to assess in the office, but it is important to be aware that patients may have difficulty with this and require extensive training and cues to accurately reproduce spinal positions required for exercises.

The Exercise Prescription

Based on the information obtained in the clinical evaluation, the physician should be able to analyze the patient's current abilities to participate in a stabilization program and the patient's specific deficits in the strength and flexibility of the muscles that act on the spine. These should be documented to guide the LSP, and a starting level should be chosen. Although these levels are not well described in the literature, we usually use the terms beginning, intermediate, and advanced. Other authors have used similar terms.³⁹ The time it takes to progress to the next level can vary. Some patients with limited functional goals never progress to the advanced stage because they obtain pain relief at the intermediate stage and are either unable or do not wish to progress to the advanced stage. Some examples of goals and exercises for these levels are outlined below.

Beginning

The initial goals of the LSP are to learn how to activate the transversus and multifidi and to be able to find and maintain a neutral spine position. After these are accomplished, patients are trained to incorporate them into daily activities. (This is sometimes called developing core awareness.) Examples of exercises are learning to contract the transversus in supine, side lying, and prone. This may require extensive monitoring, cues, and facilitation by the therapist, or it may be a one-time instruction, depending on the patient's skills. Then, gentle limb movements are added while the contraction is maintained, such as lying supine and lifting the leg or positioning in quadruped and lifting an arm. Part of this training includes discouraging stronger global muscles from taking over during these exercises. Several protocols and descriptions of these exercises exist in the literature.^{16,25,40} However, even in the beginning stage, the goal of a LSP extends beyond simple activation of the deep stabilizers. It seems that, at least in those with chronic lbp, a certain amount of muscular overload is required for exercise training to reverse common physiologic consequences such as

the chronic spinal extensor atrophy seen in some patients with lbp. Danneels and colleagues⁴⁰ found that gentle exercises designed to activate transverses alone did not cause paraspinal muscle hypertrophy, but the use of this technique along with more dynamic exercises involving limb movement did result in muscle hypertrophy. Another reason that training needs to move beyond simple activation is that although training these muscles is considered a standard part of a LSP and is a very common clinical focus, it has not yet been conclusively determined that these volitional contractions of the multifidi and transversus abdominis are clinically necessary. One study found that a dynamic program of strengthening exercises affecting lumbar stability improved patients clinically regardless of whether there was specific training in multifidi and transversus activation. Koumantakis and colleagues¹⁶ performed a randomized controlled trial in which both groups performed a generalized paraspinal and abdominal strengthening program that included many exercises commonly used by therapists to increase lumbar stabilization, such as side bridging, bridging with a Swiss ball, plank position with a Swiss ball under the feet, and alternating arm and leg extension in prone and quadruped. The control group did these exercises without additional cues, and the study group received training to learn to volitionally activate the transversus and multifidi and were told to do this during their daily activities. Both groups showed similar reductions of pain, decreased disability, and improvement on pain belief scales (Tampa scale of kinesiophobia, pain self-efficacy questionnaire) immediately after completing the 8 wks of exercises. These changes were maintained at 3-mo follow up in both groups. Weaknesses of this study include the group format in which exercises were taught. The authors state that the lumbar-stabilization group required more therapist cues and time, and patients may have not been sufficiently trained in the exercises. In addition, no tools such as ultrasound or EMG were used to confirm activation of the target stabilizers. It may be that those in the stabilization group were not actually successful in engaging their multifidi and transversus, or those in the general exercise group may have been activating these muscles on an unconscious level while they performed the exercises, as has been shown to occur in those without back pain.

In another paper, the authors discussed muscle strength testing results and activity-based functional assessment results of these two groups. Both groups showed improvement in muscle strength and in all the functional tests.¹⁶ It may be that specific training to activate the transverses and multifidi are not an absolute necessity for a successful LSP.

In addition to these exercises, individualized stretching and strengthening exercises can be given to address deficits found in the physical exam at the beginning level.

Intermediate

Once patients are able to perform these simple maneuvers, exercises can be advanced. The goal is to continue to stabilize the spine with increasing challenges to the muscles. Patients should be advanced when they are able to maintain a neutral spine with simple tasks and when load-bearing capacity has been restored so that they can tolerate additional lumbar compression.³⁷ Examples of exercises include moving the arms and legs simultaneously and through larger range of motion to challenge the muscles that maintain neutral spine. It is often difficult to tell to what level exercises were progressed in individual studies. On our review, it seems that multiple studies that showed efficacy with a LSP stopped at this intermediate level.^{13,16,17,25} Theoretically, there are reasons to progress patients beyond this level to include functionally relevant exercises in standing such as lunges, adding balance challenges with an exercise ball or foam roll, and incorporating diagonal patterns to increase strength and coordination. If patients have pain with this level of activity, exercises can be chosen that impose low spinal loads but still cause effective muscular contraction.^{41,42} Protocols describing these types of exercises are also available in the medical literature.³⁹

Advanced

The goal is to be able to perform high-level activities, work, and sports while still stabilizing the spine. Training on labile surfaces such as an exercise ball and rocker board will continue to challenge the musculature and train the body to handle unexpected perturbations. Weights, pulleys, and other equipment can be used for functional exercises such as lunges with a diagonal punch and more intense flexion and extension exercises. If the patient is an athlete, sports-specific activities are added.³⁷ Although we are not aware of any randomized controlled trials to support the use of these exercises, there is anecdotal evidence that they are helpful and are often used in sports medicine facilities and in the training of athletes. Various protocols are available in sports training sources.³⁹

Conclusion

There are compelling theoretical reasons to prescribe LSPs to treat patients with lbp. Multiple studies have found that they decrease pain and improve function. Certain features on the history and physical exam may help determine who will

benefit most from this type of exercise and assist the physician in determining the correct starting point. An appropriate exercise prescription, education regarding why the exercises should help, and realistic expectations should increase compliance with this treatment.

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