LUMBAR SPINE REHABILITATION

An update on the use of core muscle strengthening and lumbar spinal stabilization for patients with low back pain or other indications of spinal musculo-skeletal dysfunction.

by Elmer G. Pinzon, MD, MPH

Spinal rehabilitation is the discipline of medicine that guides the physical, psychological, and social recovery of individuals who have become partially or totally disabled because of spinal disease or injury. Because the muscles and joints of the spine are not easily observed, the need for rehabilitation from spinal disorders has been recognized slowly and rehabilitation gains have been more difficult to measure by objective standards.[1] Manual or manipulative therapy may be effective for the treatment of pain and restoration of movement in the short term, but it has not been shown to be effective in the long term.[2-5] On the other hand, core strengthening programs may improve function and decrease pain, but the effectiveness in the long term management of lower back pain has been hotly debated.[6-9] Despite this, strengthening programs continue to be recommended.[9-11]

With persistent reported findings, strengthening programs will still continue to be recommended.[9-11] With the consideration that some strengthening programs have been reported to be beneficial, it should be noted that outcome measures often have to do with return to work and not whether the client's pain quality has improved. Strengthening programs are often included in "functional programs" combined with behavioral models, or so ill-defined that positive effects cannot be separated from the strengthening exercise components.[12] There is rarely any follow up monitoring to see if any benefits are maintained or if the person has subsequent changes in work status. We also note that there may be significant improvements in symptoms or a variable return to work regardless whether any interventions are given or not.[13,14] Regardless of this, it does seem logical that the neuromuscular system can be rehabilitated when there is a musculoskeletal injury or neuromuscular dysfunction.

Muscle Physiological Contributions

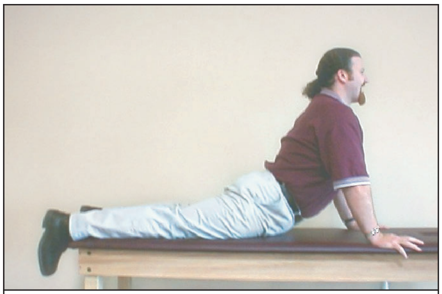
Muscles are composed of many minute

Muscle Group	Examples	Typical Function
Local Stability Muscles	• transversus abdominus • deep segmental lumbar multifidus • psoas major	• maintains segmental stability by controlling neutral joint position • controls segmental movement with muscle stiffness • activity is independent of direction of movement • provides continuous activity throughout movement
Global Stability Muscles	• oblique abdominals • spinalis • gluteus medius	• generates force to control range of movements • works eccentrically with contraction to control the range of motion • provides non-continuous activity, with activity as direction-dependent • produces movement with stability
Global Mobilizer Muscles	• rectus abdominus • iliocostalis • piriformis	• generates torque to produce large ranges of motion • produces power and speed, through concentric contraction and acceleration • increases muscle recruitment, when under load conditions or high speed movements • activity is direction-dependent, with non-continuous activity

TABLE 1. *Muscle groups of lumbar spine that provide spinal stabilization.*[1,26]

fibers organized into motor units. A motor unit is composed of the motor neuron and muscle fiber that it innervates. Human muscles are composed of predominantly two muscle fiber types: slow (tonic/aerobic, Type I) or fast (phasic/anaerobic, Type II). Skeletal muscles vary in metabolic characteristics and between individuals, which appears to be due to variable genetic differences. Therefore, the maximal contraction speed, strength, and fatigability of each muscle depends predominantly on the individual proportion of these fiber types, and how they are reinforced to increase their proportions to fit each individual person's needs.[15] The key characteristics of these motor units are as follows: slow motor units (slow speed of contraction, aerobic/oxidative metabolism, low contraction force, and fatigue-resistant) and fast motor units (fast speed of contraction, anaerobic/glycolytic metabolism, high contraction force, and fatique-nonresistant). Due to these individual characteristics, the recruitment of slow motor fibers would optimize postural holding or antigravity function and the recruitment of fast motor fibers would be optimal for the production of high force or when rapid movements are required.[16]

The definition of strength is the maximum force or tension generated by a muscle, and that the force generated is considered during specific movements.[17,18] Muscle hypertrophy is a local adaptation to the demands placed on the muscles and is the result of overload training.[15] Various factors are involved in muscle hypertrophy. Myofibrils thicken and increase in number. Additional sarcomeres are created by accelerated protein synthesis and corresponding decreases in protein breakdown, with proliferation of connective tissue cells and small satellite cells. This proliferation thickens and strengthens the muscle's connective tissue structure and improves the structural and functional integrity of both tendons and ligaments. These in turn may provide some protection from joint and muscle injury and therefore provides justification for using resistance exercise in prevention and rehabilitation programs.[17]


a. Lumbar flexion exercise


b. Lumbar extension exercise


c. Lumbar stabilization exercise


d. Abdominal crunch lumbar core strength


e. Lumbar stabilization exercise, starting position


f. Lumbar stabilization exercise, extended position

Spinal Stability Dysfunction

While there is no current measure of spinal instability nor a gold standard definition, Panjabi has introduced a model for spinal instability which has gained widespread popular acceptance.[19-22] The model is based on the concept that the majority of lower back pain is caused by mechanical derangement of the spine (i.e., clinical spinal instability).[23] He further categorized the stability of the spine to be dependent on three subsystems: passive (spinal column), active (spinal muscles), and control (neural influence). Panjabi stated that the three subsystems were interdependent and were capable of compensating for each other's limitations.[19,20] Therefore, lower back pain may occur as a consequence of these deficits in the control of the spinal segment when stresses on the spine cause excessive compression or stretch on neural structures or abnormal deformation of ligaments and pain sensitive structures. In turn, these deficits may potentially be caused by a dysfunction in any of the subsystems that cannot be compensated by the other subsystems. Further, clinical instability is a significant decrease in the capacity of the stabilizing system of the spine to maintain the intervertebral neutral zones within physiological limits so that there is no major deformity, no neurological dysfunction, or no incapacitating pain.

The link between muscle function, spinal stiffness, and a neutral zone of displacement provides the basis of the possible conservative management, through therapeutic exercise, of low back pain or spinal instability. By increasing the strength in the muscles that function to stabilize or mobilize the spinal column they will in turn maintain a neutral spine throughout work and leisure activities, as well as post-surgically. When considering dynamic stabilization, it is useful to consider the classification of muscles in relation to function. Stabilizer muscles are described as primarily monoarticular or segmental, deep, working to control movement, and having static holding capacities. Mobility muscles are described as biarticular or multisegmental, superficial, working concentrically with acceleration of movement and producing power.

Based on this concept, the new model of functional muscle classification has been proposed.[16,24,25] This model includes local stability muscles, global stability muscles, and mobility muscles. These three groups of muscles that provide spinal stabilization are further categorized as Local Stability Muscles, Global Stability Muscles, and Global Mobilizer Muscles[1,26] (see Table 1).

Further, the evidence of muscle stability dysfunction is defined as motor control deficits and decreased recruitment efficiency in the local system, and recruitment and functional changes in the global system. It occurs locally as a dysfunction of the recruitment and motor control of the deep segmental stability system resulting in poor control of the neutral joint position.[27] Dysfunction occurs globally, as an imbalance between the monoarticular muscle stabilizers and biarticular muscle mobilizers or movement producing muscles. These imbalances occur in terms of alteration in functional length tests and recruitment patterns of these specific muscles. The spinal stability dysfunctions are further classified in more detail[2] as depicted in Table 2.

Treatment Modalities

It has been noted that exercise can effectively augment treatments for the lumbar spine, especially when the physician and therapist work together as a concerted team with the same goals. Further information from the physician about specific goals for the patient, as well as the correct diagnosis for the cause of the problem and potential solutions for that agreed-upon problem(s), helps the therapist and patient conceive of a course of exercise to improve the patient's condition. Specifically, therapists create exercises to work in conjunction with the physician's purpose and plan. In turn, the physical therapist's evaluation will further identify areas of weakness, restrictions, and dysfunctions in body mechanics that require individual attention to resolve these problems. Therefore, specificity of exercise selection and a structured program with progression is critical in providing a successful outcome for each patient treated.

With the above stated impressions, a thorough systematic literature review of controlled trials supports no significant evidence that ergonomic interventions, back school, lumbar supports or other modalities, or risk factor modifications can prevent neck or back pain, or related disability.[28] The review did reveal evidence that exercise supports a positive impact on neck and back problems, and could reduce duration of lower back pain and disability. Therefore, the current evidence suggests that exercises seem to be the only effective prevention interventions, although the effects may be weak. Previous systematic review of literature that used abdominal strengthening exercises as treatment have revealed that outcomes where equivalent to, or worse, than back strengthening exercises.[29,30] There are at least two randomized trials suggesting that multidisciplinary care that includes a workplace visit can shorten the duration of disability related to lower back pain.

In the consideration for exercise treatment selection a few factors should be considered: types of movements that "minimize or centralize" pain, the need for improved mobility, the need for support strength of vertebral segments, forces on the disc, and exercise to restore function. Concerning McKenzie assessment as a comprehensive approach to the spine, patients perform repetitive lumbar end-range test movements and positions while monitoring their immediate subjective pain response.[31,32] The "centralization of pain" identifies pain-controlling exercises and posture strategies that patients then use to control or prevent pain from recurring in the future. The McKenzie assessment method emphasizes directional preference exercises which aim to decrease pain, encourage movement, and encourage independence. Specifically, the McKenzie system emphasizes identifying patient's directional preferences (flexion vs. extension, lateral movements); moves in the direction to minimize peripheral pain or centralize symptoms, and uses careful mechanical evaluation to select accurate movements for treatment. By identifying the correct mechanical syndrome — postural, dysfunction, and derangement — the well-trained, certified McKenzie practitioner will be able to identify the more difficult cases where the McKenzie treatments may be considered. One of the strongest advantages of McKenzie treatment is that it emphasizes patient education and active involvement of the patient in management of their own treatment to promptly minimize pain, restore function and independence, and therefore minimize clinic visits. Ultimately, the goal is for patients to treat themselves when provided with the knowledge and tools, and allow the patient the freedom to be in control of their own tailored, spinal self-treatment. By

Muscle Group	Dysfunctions	Summary
Local Stabilizer	• motor control deficit associated with delayed timing or recruitment deficiency • reaction to pain and pathology with inhibition • decreased muscle stiffness and poor muscle segmental control • loss of control of joint neutral position	changes in motor recruitment results in loss of segmental, local control
Global Stabilizer	• poor low threshold of tonic recruitment • poor eccentric control • poor rotation dissociation • if hypermobile, poor control of excessive range of motion	changes in muscle length and recruitment results in "under-pull" at a motion segment, resulting in global imbalance
Global Mobilizer	• myofascial shortening, limits physiological or accessory motion • overactive low threshold and low load recruitment • reacts to pain and pathology with spasm	changes in muscle length and recruitment resulting in "over-pull" at a motion segment, resulting in global imbalance

TABLE 2. *Muscle dysfunctions affecting spinal stability.*[2]

gaining experiential education and learning to self-treat their spinal problems, these skills and behaviors will minimize the risk of recurrence and allow patients to rapidly manage themselves when symptoms reoccur.[31,32]

Another type of exercise movement that minimizes pain is the Lumbar Spine Stabilization program.[33-35] It identifies functional loss characteristics (weight-bearing-sensitivity, position-sensitivity, pressure-sensitivity, and stasis-sensitivity). The exercise recruits core muscles to provide segmental spinal stabilization. By doing so, it retrains trunk muscles to function automatically to protect the spine. Some sample exercises are depicted in Figure 1.

Spine stabilization programs are needed in the work environment to assist in maintaining correct spinal curvature when lifting; it assists by providing the most optimal posture when in static positions, provides additional shock absorption to prevent compromising space between structures of the spine, and lastly, it provides a working knowledge of neutral spine mechanics for the patient. The indications for spinal stabilization strengthening includes: lumbar spinal/foraminal stenosis, compression fractures, spondylolisthesis, post-surgical pain syndromes, patients without a directional preference (i.e., not appropriate for the McKenzie program), and patients with acute/chronic lower back pain.

Types of spinal stabilization programs include:[33-36]

1) **Dynamic Lumbar Stabilization (San Francisco Spine Center).** The philosophy of dynamic lumbar stabilization, using the San Francisco Spine Institute model,[35] is built around the concept of "aggressive conservative care", in order to provide "stabilization training" to patients. The patient must learn to find the most pain-free, balanced, and neutral position for the spine and maintain it during movement. Through stabilization training requiring strength, flexibility, and coordination; the patient can correctly exercise and concentrate on avoiding stress or re-injury.
2) **Pilates method stabilization with core strengthening.** Pilates core stabilization strengthening is a series of non-impact exercises designed in the early 20th century by Dr. Joseph Pilates, to develop strength, flexibility, balance, and breathing control. Although no scientific research studies on Pilates exists, significant research focuses on the function and activity of the abdominal, back, and pelvic floor musculature.[36] This research in turn explains the effectiveness of Pilates and other trunk stabilization exercises. Four key muscles are emphasized in providing a synergistic role in trunk stabilization: transversus abdominis, lumbar multifidus, pelvic floor, and diaphragm. In turn, the pelvic floor musculature is given a strong role in trunk stabilization, as part of a central cylinder.
3) **Mat and ball exercises.** Mat exercises provide low-level exercises which are mainly used for muscle recruitment of spinal stabilizers, while ball exercises use a large plastic ball (e.g., Swiss ball) to provide a progression of dynamic movements for trunk and spinal strengthening.
4) **Maintenance of spinal neutral position.** Maintenance of spinal neutral stabilization involves attempting to avoid large segmental changes in the spine during movement and activity, by promoting a progression of forces during the performance of functional daily activities. By providing lifting and static positioning activities to maintain a neutral spine. This program allows the patient a working knowledge to carry on through a patient's daily routine.

Conclusions

Spinal-related pain is one of the most complex problems modern medicine faces today, and is considered one of the "last frontiers" in clinical medical practice. It is the primary complaint prompting medical consultation. Compartmentalization of pain problems into physiological, physical, and psychosocial categories may be useful diagnostically, but must be synergistically joined to achieve therapeutic success. The interventional pain specialist (often the PM&R musculoskeletal/spine specialist, anesthesiologist, orthopedist, or neurosurgeon) is a valuable and often crucial member of the pain management team. Injury and tissue-specific therapeutic exercise programs must form the basis of physical rehabilitation and functional restoration protocols. The program can combine a core of sedentary exercises coupled with the injury-specific exercises. Importantly, the protocol must expand to encompass psychotherapeutic intervention in chronic pain conditions. Neuromuscular reconditioning must be included to ensure a function-specific, task-oriented program. Essentially and most importantly, the program must be geared to enhance and foster functional recovery among the affected patient.[37,38]

This article has touched upon a few concepts involved in spinal stabilization and core strengthening which are involved in providing support for lumbar spinal rehabilitation. A key element of exercise training is gaining adequate control of dynamic lumbar spine forces. Training for strength and flexibility of the trunk and extremities is necessary for developing adequate postural control and stabilization skills. By learning these spinal stabilization skills, one may reduce repetitive injury to the intervertebral discs, facet joints, and supporting musculature. Training for flexibility is an essential component of spinal stabilization. With flexibility exercises divided into those designed to increase elasticity of musculotendinous units, it is critical that stretching be performed in a spine safe manner. Ultimately, most patients can successfully treat themselves when provided with the necessary tools and education. An individualized, self-treatment program tailored to the lifestyle of the patient puts the patient in control. The patient's self-management of these skills and behaviors will minimize the risk of recurrence and allow each patient to individually and promptly manage themselves when symptoms recur. ■

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