ACUTE AND CHRONIC low back pain affects a large percentage of patients who seek medical care. Lumbar motion segment (vertebra-disc-vertebra) instability is a possible cause of low back pain. Anatomic structures that may be compressed or stretched include spinal nerve roots, ligaments, zygapophyseal joint capsules, annular fibers of the intervertebral disc, and vertebral end-plates.\(^1\) Clinical instability is defined as a decrease in the capacity of the stabilizing system of the spine to maintain a motion segment within its physiological limits, which can lead to structural changes, neurological dysfunction, and incapacitating pain.\(^2\) The motion segment “neutral zone” is that portion of the range of physiological intervertebral motion within which the spinal motion is produced with minimal internal resistance.\(^2\) Neutral positioning of spine segments minimizes the overall internal stresses and the degree of muscular effort required to maintain their normal alignment. Unfortunately, no valid method for measuring the neutral zone has been established.

Lumbar stabilization exercise training is often implemented for patients who are believed to have lumbar segment instability. Clinicians should have a clear understanding of the rationale for administering any treatment to patients who have low back pain. The purpose of this report is to review the neuromuscular and biomechanical rationale for specific exercise techniques that are believed to facilitate dynamic stabilization of lumbar spine motion segments.

### Spine Stability

Spine stability is the result of passive connective tissue restraints, active muscle contraction, and neural control mechanisms.\(^1\) Passive restraints include the structure of the vertebrae, zygapophyseal joints, intervertebral discs, and ligaments. Neural control of muscle activation patterns is mediated by proprioceptive input to the spinal cord from ligaments, tendons, and muscles.

Bergmark\(^3\) hypothesized that two distinctly different muscle systems maintain spine stability, which were designated as global and local. The global muscle system consists of large muscles that provide general trunk stabilization against external loads, such as rectus abdominis, external oblique, and the thoracic portion of iliocostalis lumborum. The local muscle system consists of tonically active muscles that are directly attached to the individual vertebrae, which includes the lumbar multifidus (LM), transversus abdominis, and posterior fibers of the
internal oblique muscles of the lumbar spine. The deep intersegmental muscles of the spine, such as the LM, are located close to the center of rotation for spine segment movements, which contributes to maintenance of segment positioning within the neutral zone.

**Lumbar Stabilization Mechanisms**

Three mechanisms have been proposed as theoretical explanations for lumbar segment stabilization and specific stabilization exercise training techniques.\(^4^,\(^6\) The first theorized mechanism using mechanical models suggests that contraction of the deep abdominal muscles (transversus abdominis and internal obliques) increases intra-abdominal pressure, which exerts hydrostatic forces on the pelvic floor and the diaphragm that creates a compressive stabilizing effect on spine segments.\(^4\) Research findings again using mechanical models have since suggested that the intra-abdominal pressure created by the deep abdominal muscles provides a “stiffening” effect on the lumbar spine, rather than a compression force.\(^5\)

Tesh et al.\(^5\) evaluated two other lumbar segment stabilization mechanisms that had been proposed by previous researchers who had used mathematical models.\(^6\) The first theoretical mechanism identified tension of the thoracolumbar fascia (TF) as a factor that contributes to lumbar segment stability. The TF consists of three layers of fascia that encapsulate the back extensor muscles. The anterior layer is comprised of the fascia of the quadratus lumborum, which is attached to the anterior surfaces of the transverse processes of the lumbar vertebrae. The posterior layer of the TF consists of multiple laminae that arise from the deep abdominal muscles. The number of laminae is greatest in the distal portion of TF. The posterior layer inserts on the dorsal tips of the spinous processes, with the superficial fibers attached to the upper lumbar vertebrae, and the deeper fibers attached to the lower lumbar vertebrae (Figure 1). The stronger deep fibers of the TF posterior layer, combined with the greater number of distal laminae, provide the lower lumbar vertebrae segments with greatest mechanical support. The middle layer of the TF is attached to the lateral tips and the entire length of the transverse processes of the lumbar vertebrae, which joins with the posterior layer in forming a sheath around the erector spinae muscle group. From its insertion at the transverse process, the middle layer of the TF passes through the lateral raphe (i.e., the union of the posterior and middle layers) to merge with the aponeurosis of the deep abdominal muscles. Tesh et al.\(^5\) argued that the arrangement of the fibers of the TF suggests that the deep abdominal muscles primarily originate from the middle layer, which would not transmit significant tension through the posterior layer.

A second mechanism that could create tension within the middle and posterior layer of the TF is contraction of the erector spinae muscle group. Contraction increases the cross-sectional area of the muscle group, which could increase intracompartmental pressure within the paraspinal space. A closed compartment is formed by the middle and posterior layers of the TF, the vertebral column, and the intertransverse and interspinous ligaments. An increase in intracompartmental pressure may generate “hoop tension” in the middle and posterior layers of the TF, which could provide lumbar segment stability without deep abdominal muscle contraction.\(^5\)

The fiber arrangement in the posterior layer of the TF has a “net-like” configuration. Lateral tension generated by the deep abdominal muscles may produce a caudocranial force that has the effect of “drawing together” the tips of the spinous processes.\(^5\) Similarly, the orientation of the fibers of the middle layer of the TF may generate lateral tension that draws the transverse processes together.\(^5\)
**Specific Stabilization Exercise Theory**

The goal of spine segment stabilization exercise is to create a “stiffening” effect on the lumbar motion segments through cocontraction of the LM and deep abdominal muscles. Contraction of the muscles generate TF tension through their direct attachments to the structure and through elevation of intra-abdominal pressure. Although there is a lack of scientific evidence to substantiate this theorized stabilization mechanism, neither is there evidence that contradicts it.

When low back pain patients developed the ability to maintain the “neutral zone of lumbar motion” through exercise over a 12-month period, they experienced a significant decrease in low back pain in comparison to that which was experienced by control patients. This study defined maintenance of the “neutral zone” as a normal low back curvature. The emphasis on maintenance of the lumbar spine within the neutral zone was theorized to prevent harmful loading, tissue damage, pain, loss of motor control, and chronic degeneration of musculoskeletal structures. Postural awareness training may augment the therapeutic benefits derived from lumbar stabilization exercise training.

The primary action of the LM is posterior rotation of spine segments, which opposes the flexion moment produced by contraction of the abdominal muscles. To a lesser extent, the erector spinae muscles also oppose the flexion action of the abdominal muscles. A literature review performed by MacDonald et al. suggests that the deep portion of the LM can control the motion of a single spine segment in a manner that does not restrict gross movement of the lumbar spine. Emphasis on selective training the deep portion of the LM for segment stabilization ignores the hoop tension segment stabilization mechanism, which requires erector spinae activation to raise intracompartmental pressure and generate tension in the middle and posterior layers of the TF.

The role of the lumbar paraspinal musculature in segment stabilization needs further investigation. There is evidence that lumbar stability is increased by activation of the lumbar segmental muscles. Coordination of global and local muscle activation levels during functional activities may be an important factor for segment stability. Frequent generation of low-intensity tension by the deep abdominal muscles has been theorized to add new collagen to the TF, which could enhance its segment stabilization function.

**Summary**

Lumbar segment stabilization may be facilitated through specific exercises that activate the deep abdominal muscles. Hypothesized mechanisms of segment stabilization include elevated intra-abdominal pressure, deep abdominal and LM co-contraction, and development of hoop tension within the TF. An increased neutral zone of a spinal segment beyond its normal physiological limits may be a better indicator of spinal instability than excessive range of motion in the lumbar spine. A valid and reliable method for quantifying spinal segment displacement has not been developed, but no contraindications to the initiation of lumbar stabilization exercises for patients with acute or chronic low back pain have been identified.

**References**


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