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What's All the Buzz About Spinal Stability? Part One: Biomechanics and Neurophysiology

By Craig Liebenson, DC

The concepts of stability and instability are integral to modern musculoskeletal care. According to Panjabi, three subsystems work together to maintain spine stability:¹ the **central nervous subsystem (control)**, an **osteoligamentous subsystem (passive)**, and a **muscle subsystem (active)**. He says: "The neural subsystem receives information from the transducers, determines specific requirements for spinal stability, and causes the active subsystem to achieve the stability goal."

The spine or any joint becomes injured or irritated by end-range overload. This can involve either macrotrauma or repetitive micro-trauma. Motor control is a key component in injury prevention. Impaired motor control consists of failure to control a joint's "neutral range," usually by a dysfunction or incoordination of the agonist-antagonist muscle co-activation. The eminent researcher Professor Stuart McGill states, "Evidence from tissue-specific injury generally supports the notion of a neutral spine (neutral lordosis) when performing loading tasks to minimize the risk of low back injury."²

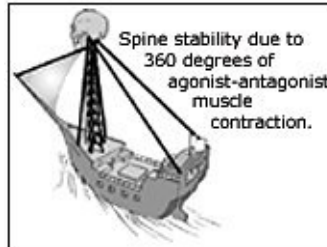
The spinal column, devoid of its musculature, has been found to buckle at a load of only 90 newtons (about 20 pounds) at L5.^{3,4} However, during routine activities, loads 20 times greater are encountered on a regular basis.(Load profiles of various activities are shown below.)

Spinal Load Profiles

- Without muscles, the spine buckles at 90N.²⁰
- Routine activities of daily living involve \approx 2000N.¹
- According to McGill, recommended subacute exercise training < 3000N.²²
- National Institute for Occupational Safety and Health (NIOSH) limit for repetitive tasks: 3300N.¹⁸
- NIOSH work demand limit: 6400N.²³⁻²⁵

- Competitive weight lifters manage loads in excess of 20,000N (4,480 lb).²⁶

Panjabi says, "This large load-carrying capacity is achieved by the participation of well-coordinated muscles surrounding the spinal column."¹



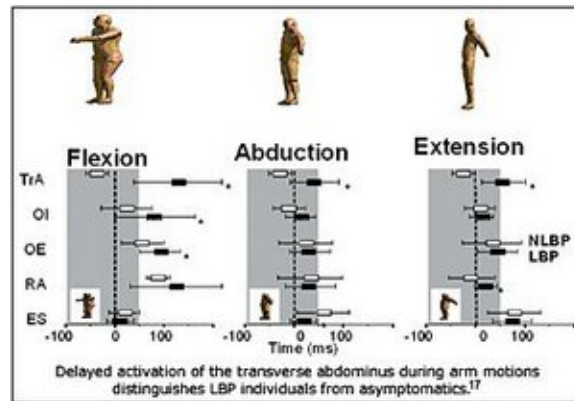
Surprisingly, the motor control system functions well when under load. Muscles stabilize joints by stiffening, like rigging on a ship:

According to Cholewicki and McGill,⁵ spine stability is greatly enhanced by co-contraction of antagonistic trunk muscles (e.g., abdominal and extensor muscles). Co-contractions increase spinal compressive load, as much as 12% to 18%, or 440N, but they increase spinal stability even more by 36% to 64%, or 2,925N.⁶ But when load is at a minimum, such as when the body is relaxed or a task is trivial, the motor control system is often "caught off guard" and injuries are precipitated.

Low back injury has been shown to result from repetitive motion at end range: According to McGill, it is usually a result of "a history of excessive loading which gradually, but progressively, reduces the tissue failure tolerance."²

Inappropriate muscle activation sequences during seemingly trivial tasks (only 60 newtons of force), such as bending over to pick up a pencil, can compromise spine stability and potentiate buckling of the passive ligamentous restraints.⁷ This motor control skill has also been shown⁷ to be compromised under challenging aerobic circumstances.⁸⁻¹⁰

A persuasive body of literature from Australia has demonstrated how altered motor control is related to back pain. Hodges and Richardson reported that a slow speed of contraction of the transverse abdominus during arm or leg movements was well-correlated with LBP.^{11,12}

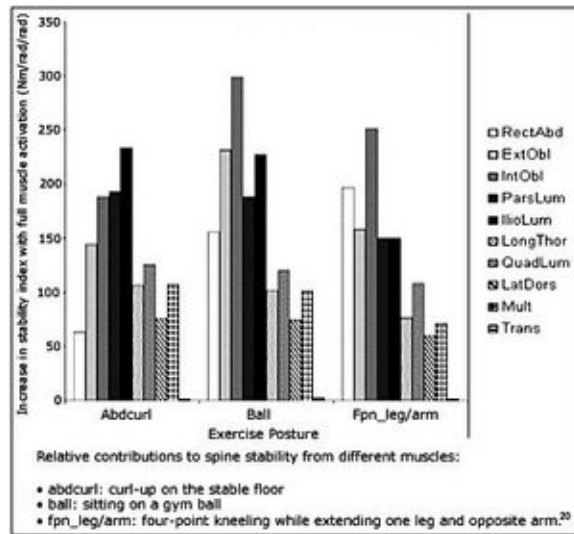


O'Sullivan, et al., found that synergist substitution of the *rectus abdominus* for the agonist transverse abdominus during an abdominal "drawing-in" maneuver strongly correlated with chronic back pain, and that specific rehabilitation that improved this dysfunction was superior to a more general exercise approach.¹³

The multifidus in the low back has been shown to be atrophied in patients with acute low back pain.¹⁴ The acute patients' atrophy was unilateral to the side of pain and at the same segmental level as palpable joint dysfunction. Recovery from acute pain did not automatically result in restoration of the normal girth of the muscle. However, it has been demonstrated that segmental spinal stabilization exercises can prevent multifidus muscle atrophy in acute LBP subjects.¹⁵ Recent research has demonstrated that such exercises have a secondary preventive effect by reducing recurrences.¹⁶

Delayed activation of the transverse abdominus during arm motions distinguishes LBP individuals from asymptomatics.¹⁹

The Australian research clearly shows that motor control errors correlate with LBP, but it has been misinterpreted as proving that certain individual muscles have a unique role in producing stability.¹⁷ Recent studies have shown that all muscles function as stabilizers, depending on the task.¹⁸ Plus, the relative output varies throughout the movement so that discussion of the most important muscle is restricted to a transient instant in time.



Conclusion

Spinal instability potentiates joint disorders. Spine stability requires that the central nervous, joint, and muscle systems all work together. The joints are primarily passive, while the muscles are the active components that execute the commands of the nervous system. Part two of this series will discuss assessment and treatment approaches for identifying spine instability and promoting stability.

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