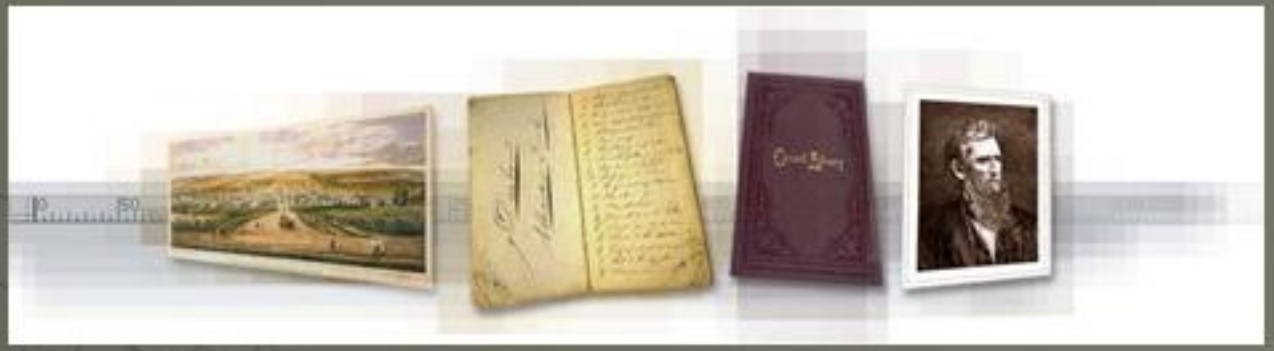

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# Motor Control Problems in Patients With Spinal Pain: A New Direction for Therapeutic Exercise

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## ABSTRACT

Recent research into muscle dysfunction in patients with low back pain has led to discoveries of impairments in deep muscles of the trunk and back. These muscles have a functional role in enhancing spinal segmental support and control. The muscle impairments are not those of strength but rather problems in motor control. These findings call for a different approach in therapeutic exercise, namely a motor learning exercise protocol. The specific exercise approach has an initial focus on retraining the cocontraction of the deep muscles (ie, the transversus abdominis and lumbar multifidus). Initial clinical trials point to the effectiveness of the approach in patients with both acute and chronic low back pain in terms of reducing the neuromuscular impairment and in control of pain. (J Manipulative Physiol Ther 2000;23:115-7)

**Key Indexing Terms:** Low Back Pain; Motor Control; Exercise; Transversus Abdominis; Lumbar Multifidus

## INTRODUCTION

The current era of evidence-based practices has made all health care practitioners reflect on current practices for the management of spinal pain. Many exercise programs for the patient with spinal pain have traditionally focused on strength, endurance, fitness, and functional capacity training. These general programs are appropriate in late stages of rehabilitation and are of value for the deconditioned patient and for increasing general muscular support of the spine. Nevertheless, it is our contention that they may not necessarily directly address the physical impairments in the neuromuscular system associated with the onset of low back pain, as well as those associated with persistent and recurrent spinal pain. Recent research suggests that a key impairment in the muscle system is one of motor control rather than one of only strength. It is reasoned that such impairments need to be addressed specifically before, or at least in conjunction with, more general exercise programs prescribed for patients with low back pain.

A different and specific type of exercise termed *segmental stabilizing training* has been developed that may more directly address some key physical impairments in the neuromuscular system.[1] This exercise is based on research in biomechanics, neurophysiology, and research in physiotherapy. Segmental stabilizing training is aimed toward controlling pain and protecting and supporting the spinal segment from reinjury by re-establishing and enhancing muscle control to compensate for any loss of segmental stiffness caused by injury or degenerative change. The exercise approach is based on the specific function of particular trunk muscles for segmental support and control and proven impairment in these muscles in patients with low back pain.

### Discussion

Panjabi's[2] model to explain the development of spinal pain provides a reasonable explanation as to why, when the spinal segment is compromised, exercises designed to improve the functional supporting role of the muscle system may help increase spinal segmental stability. It centers around the concept of spinal stability. Spinal stability is accomplished by the interdependent function of 3 subsystems: the passive subsystem (osseoligamentous structures), the active subsystem (the spinal muscles), and the neural subsystem (the control of these muscles by the central and peripheral nervous systems). The systems are interdependent, and although their interaction is complex and to a large extent ill-defined in scientific studies, the model presents a clear link between the passive subsystem and the neuromuscular systems.

There has been growing interest in how the neuromuscular system supports and controls the spinal segment. Bergmark[3] described 2 functional muscle systems linked to spinal stabilization as the local and global muscle systems. The muscles of the local system are deep and, anatomically, are closely related to the individual vertebrae. They are capable of increasing spinal segmental stiffness. Muscles of the global system are primarily the larger torque-producing muscles and are anatomically more remote from the joint but important for controlling spinal orientation and balancing external loads.

Research is now starting to reveal how the central nervous system prepares and modulates the muscle system to support the lumbar spine and its segments for functional activity and load.[4-8] Support is growing for the functional differentiation

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between global and local muscles in relation to spinal control.[9,10] More pertinently, links are now emerging between low back pain and motor control deficits in muscles of the local system, notably the transversus abdominis and lumbar multifidus.[7,11-13] These muscles appear to lose their normal anticipatory function in patients with low back pain, exhibiting delays in activation and thus a loss of their normal preprogrammed function for support.[7,8] In contrast to patients without low back pain, the transversus abdominis appears to be unable to function independently of the other abdominal muscles in patients with low back pain[10] and demonstrates phasic activity rather than the tonic activity required for its supporting function. Lumbar multifidus has been shown to react by inhibition at a segmental level in acute episodes of low back pain.[11,12]

### Spinal Segmental Stabilization Training

The specific therapeutic exercise program of spinal segmental stabilization training aims to address and reverse these problems in motor control in key muscles of the local system and restore normal synergistic function between the local and global muscle systems. The clinical evaluation and retraining methods for patients with low back pain are described in detail elsewhere.[1] In brief, the program is a motor learning exercise protocol. The initial and pivotal focus is on retraining the cocontraction of the transversus abdominis and lumbar multifidus, muscles that form part of the local muscle system of the lumbopelvic region. This initial focus still recognizes that both local and global muscle systems are required for spinal stabilization and support. In the clinical situation the motor skill aligned to a normal pattern of deep muscle activation is an action of drawing in the abdominal wall. When performed with a normal motor pattern, this action activates the deep transversus abdominis in cocontraction with the deep fascicles of lumbar multifidus. During the retraining process, these local muscles are activated cognitively, as independently as possible from the global muscles. Facilitation of the deep muscle motor pattern with relative independence from global muscle activity requires a high level of clinical skill. Teaching and training often proceeds with the aid of technical devices, such as surface electromyography, pressure biofeedback, and ultrasound imaging.[1] The contraction is practiced repeatedly with the aim of restoring the muscles' automatic stabilization function. As this is achieved, training then focuses on the integration of activity of the local and global muscle systems.

Two directions of research are currently being followed in the process of investigating this exercise approach. The first direction is through clinical trials of the effectiveness of the approach on pain and function in patients with low back pain. The second is through investigating the effects of the exercise on the muscle impairments.

Two randomized, controlled, clinical trials have been conducted to date by O'Sullivan et al[14,15] on patients with low back pain. The first trial included patients with low back pain with a radiologic diagnosis of spondylolysis or spondylolisthesis, and the second included patients with a clinical and radiologic diagnosis of lumbar segmental instability. In each trial the group treated with the specific motor learning exercise program over a 10-week training period demonstrated significant reductions in pain and increased functional levels, which were not achieved by the respective control groups. In the 3-year follow-up of the trial involving the spondylolisthetic group, results were maintained.

The second research direction is investigating whether the specific exercise program can reverse the muscle impairments and problems in motor control demonstrated in the local muscle system. Hides et al[12] demonstrated in their clinical trial that the focused retraining of the deep muscle cocontraction could reverse the inhibition of the segmental multifidus demonstrated by patients with a first episode of acute low back pain. Multifidus size did not return to normal in the control group, who received medical management only, even when symptoms resolved (usually within 4 weeks). Asymmetry in muscle size was still present in this group, even at the 10-week follow-up, despite their return to normal function activities. The finding would support the need to specifically address the local muscle dysfunction.

Two single case studies[16] have been undertaken to investigate whether cognitive training of the specific exercise program can reverse the automatic timing delays in the transversus abdominis. The laboratory test of motor control with fine-wire electromyography, as described by Hodges and Richardson,[7] was used as the outcome measure. Results revealed that after a 10-week training period, the delays in both patients were reduced, although not fully reversed. Nevertheless, a reduction in reported pain levels by both subjects was commensurate with this result.

### Future Directions

Research is in progress to fully understand the neurophysiologic and mechanical mechanisms of deep muscle control of the spinal segment.[17,18] More knowledge is needed to understand the nature of these motor-control problems in the deep muscles in patients with low back pain and particularly their implications for persistent and recurrent low back pain. A vital direction being followed in clinical research is the development of new noninvasive measures of the patterns of muscle coordination between the deep and superficial muscles of the trunk and low back.[1] This is revealing problems in the functional integration between the local and global muscles, which is allowing new clinical models for the muscle dysfunction in low back pain to be formulated.[19] These in turn may better rationalize the prescription of therapeutic exercise for patients with low back pain.

Further clinical trials need to be undertaken to more widely test the effectiveness of the specific motor learning exercise program. It is unknown at this time whether this program is the most appropriate or whether other exercise regimens are equal or superior in reversing the problems in motor control of the deep muscles. Nevertheless, the current approach is based on the relationship between the inability or ability to cognitively cocontract the transversus abdomin-

is and the lumbar multifidus and the presence or not of timing deficits in transversus abdominis in automatic laboratory tests of motor control.[20]

## CONCLUSION

Although much is left to be learned, one factor is becoming clear from our clinical research and practice with patients with low back pain. There is considerable variability in the nature and degree of the motor control problems presenting in patients with low back pain. In the future, links may be found between certain variables in the patterns of motor control exhibited by patients with low back pain and the tendency for severity or persistence of the condition. In the short term, this variability between patients highlights the need for an individual problem-solving approach to the neuromuscular dysfunction in patients with low back pain in the clinical situation. A one-size-fits-all approach to the prescription of therapeutic exercise is not rationally based.

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