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The Role of Paraspinal Muscle Spindles in Lumbosacral Position Sense in Individuals With and Without Low Back Pain

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Abstract

Study Design. A two-group experimental design with repeated measures on one factor was used.

Objectives. To investigate the role of paraspinal muscle spindles in lumbosacral position sense in individuals with and without low back pain.

Summary of Background Data. Proprioceptive deficits have been identified in patients with low back pain. The underlying mechanisms, however, are not well documented.

Methods. Lumbosacral position sense was determined before, during, and after lumbar paraspinal muscle vibration in 23 young patients with low back pain and in 21 control subjects. Position sense was estimated by calculating the mean absolute error, constant error, and variable error between six criterion and reproduction sacral tilt angles.

Results. Repositioning accuracy was significantly lower in the patient group than in healthy individuals (absolute error difference between groups = 2.7°, $P < 0.0001$). Multifidus muscle vibration induced a significant muscle-lengthening illusion that resulted in an undershooting of the target position in healthy individuals (constant error = -3.1°, $P < 0.0001$). Conversely, the position sense scores of the patient group did not display an increase in negative directional error but a significant improvement in position sense during muscle vibration ($P < 0.05$). No significant differences in absolute error were found between the first and last trial in the healthy individuals ($P \geq 0.05$) and in the patient group ($P > 0.05$).

Conclusions. Patients with low back pain have a less refined position sense than healthy individuals, possibly because of an altered paraspinal muscle spindle afference and central processing of this sensory input. Furthermore, muscle vibration can be an interesting expedient for improving proprioception and enhancing local muscle control.

Neuromuscular dysfunction in the presence of low back pain (LBP) has been studied extensively in relation to trunk muscle strength and endurance. 1,2,34,46 However, trunk muscle strength and endurance does not guarantee the relief of painful symptoms. 7,46 Furthermore, inefficient muscular stabilization of the lumbar spine results in an increased risk of injury to the spine. 9,36 Recently, the focus has no longer been on the global trunk muscles but on the local system for controlling segmental spinal stability. The local muscles are capable of enhancing the inherent unstable condition of the motion segment. 10,29,42,51 However, a neuromotor dysfunction of the transversus abdominis 23,24 and the lumbar multifidus muscle 22 has been demonstrated in patients with LBP. Therefore, resolution of motor control problems in the local muscles of the lumbosacral spine is currently an important part of exercise therapy for patients with LBP. 43 The underlying mechanisms, however, are still poorly understood.

Reduced proprioception in the spine in patients with chronic LBP has been established for standing posture and four-point kneeling. 19 Possibly as a result of reduced proprioception, deficits in reaction time, 32,33 postural control, 33 and postural stability 31 have been shown in such patients. However, the specific structures responsible for a loss of proprioception were not identified.

Quint et al 42 stated that the importance of a neural control strategy in the stabilization of the spine cannot be overemphasized. The neural controller must not only select the appropriate muscles to activate, but must also decide on the appropriate activation level. Proprioception may be an important part of the neural controller, because it encompasses the sensation of position and movement of joints; the sensations of force, effort, and heaviness associated with muscle contractions; and the sensations of perceived timing of muscular contractions. 18

Receptors in joint, skin, and muscle can theoretically contribute to these sensations. However, results in muscle-tendon vibration and microneurography studies have demonstrated a major role of muscle spindles in proprioception. 12,20,28,44 Muscle-tendon vibration is a powerful stimulus for muscle spindle primary afferents. 8,45 The effect of vibration is to introduce a bias into the muscle spindle output. The vibrated muscle is usually perceived to be longer than it actually is. 20,28,44 However, vibration frequencies lower than 40 Hz induce a shortening illusion in limb muscles. 12 Little is known about whether the cognitive effect of vibration of trunk muscles is the same as for peripheral muscles. In a previous study, 5 healthy young individuals showed a significant muscle lengthening illusion during multifidus muscle vibration, which caused them to undershoot their target positions. This vibration-induced error demonstrated that multifidus muscle spindle input is critically important for lumbosacral repositioning accuracy during sitting. In addition, joint receptors have been shown to be mainly active at extreme joint angles, 21 whereas muscle spindles fire throughout the range of motion. 18,28

The neutral zone, a segmental region of low stiffness, is often expanded in patients with LBP, 37 and the stabilizing function of trunk musculature is especially important around the neutral spine posture. 10,36,42 If proprioceptive acuity in the lower back is decreased because of dysfunction of muscle spindles, local muscle control and thus segmental stability is at risk. Instability may make the spine more vulnerable to injury and recurrence of LBP. Accordingly, it can be hypothesized that muscle spindles are a causal factor in the association of muscle dysfunction with spinal instability.

In the current study, an active pelvic-sacral tilt repositioning task was used in combination with muscle vibration during sitting. The sitting posture was chosen, because it is a functional activity, and patients with LBP perform pelvic rotation easier during sitting than during standing. Position sense measurements have been shown to be more reliable in sitting 3 than in standing, and proprioception has not been assessed in patients with LBP when seated. 19 The authors tested the hypothesis that patients with LBP are less able to identify accurately muscle spindle afferent information from lumbar multifidus muscle than healthy persons, making it more difficult to reposition the lumbosacral spine accurately and consistently.