

Sensorimotor control of the spine

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FROM ABSTRACT

The spinal viscoelastic structures including disk, capsule and ligaments were reviewed with special focus on their sensory motor functions.

Afferents capable of monitoring proprioceptive and kinesthetic information are abundant in the disc, capsule and ligament. **[IMPORTANT]**

Electrical stimulation of the lumbar afferents in the discs, capsules and ligaments seem to elicit reflex contraction of the multifidus and also longissimus muscles.

The muscular excitation is pronounced in the level of excitation and with weaker radiation 1 to 2 levels above and below.

Similarly, mechanical stimulation of the spinal viscoelastic tissues excites the muscles with higher excitation intensity when more than one tissue (ligaments and discs for example) is stimulated.

Overall, it seems that spinal structures are well suited to monitor sensory information as well as to control spinal muscles and probably also provide kinesthetic perception to the sensory cortex. **[Spinal structures firing to the brain]**

THESE AUTHORS ALSO NOTE:

"Low back pain is one of the most common medical problems of the middle-aged population, and from society's point of view, it is the most costly musculoskeletal disease in industrialized countries today."

"Low back pain is thought to arise from damage to the intervertebral disc or the zygapophysial joints, either directly through traumatic injuries or disc prolapse, or indirectly via degenerative processes that transmit unfavourable loading patterns to other spinal structures, e.g. ligaments, tendons and supporting musculature as well as to the sacroiliac joint."

[IMPORTANT: The DISC and FACET as the primary sources for low back pain.]

Disc and facet problems can cause local or referred pain and can cause pain together or independently.

The authors refer to "derangement in the lumbar intervertebral disc" as the disc problem. **[IMPORTANT, as it reminds me of Clarence Gonstead.]**

The authors also use "structural derangement" as causing pain. **[IMPORTANT, as they use these terms as a chiropractor would use SUBLUXATION.]**

The sacroiliac joint can be painful because of direct "derangements" or "affected indirectly via derangement in the lumbar spine or its supporting structures."
[IMPORTANT, again derangements v subluxations.]

Lesions and inflammation in the avascular supporting structures of the spine and sacroiliac joints will disturb the proprioceptive function of the different receptors and result in increased and prolonged muscle activation that may cause pain. **[WOW!]**

"Irritation of low threshold nerve endings in the sacroiliac joint, intervertebral disc or the zygapophysial joint tissue may trigger a reflex activation of the gluteal and paraspinal muscles that may become painful over time."

These authors measured the electromyographic response of the multifidus musculature to nerve stimulation in the peripheral part of the annulus fibrosus lumbar intervertebral discs, the capsule of the zygapophysial joint and the sacroiliac joint.

THE LUMBAR INTERVERTEBRAL DISC

The intervertebral disc is an intrinsic source of pain from mechanical or chemical disturbances. **[AGAIN, mechanical disturbances.]**

It is well established that the disc is innervated and can cause pain (6 references).

5 types of nerve endings are found in the disc.

In adults the greatest number of nerves are in the lateral region of the disc, followed by the posterior region, and the fewest number in the anterior region.

The nerve endings in the lumbar discs are from the sinuvertebral nerves and branches of the lumbar ventral rami and the grey rami communicantes (sympathetic nerves).

"Each lumbar sinuvertebral nerve supplies the disc at its level of entry into the vertebral canal and the disc above."

Many of the nerves in the disc are associated with blood vessels and have a vasosensory function.

THE ZYGAPOPHYSIAL JOINTS

The zygapophysial joints are responsible for the mechanical guidance of the motion segment.

Sensory innervation to the zygapophysial joints is from the posterior ramus of the spinal nerves.

The posterior joint capsule is reinforced by deep fibers of the multifidus muscle.

THE SACROILIAC JOINT

The sacroiliac joint is richly innervated.

“Instability and/or subluxation” can cause sacroiliac pain. **[WOW, subluxation]**

The primary innervation to the sacroiliac joint is from the L4-S1 nerve roots.

The innervation is with both pain afferents and mechanoreceptors.

THE SUPPORTING MUSCULATURE

The lumbar multifidus fascicles are arranged polysegmentally, anchored below to the mamillary process, then radiating to the spinous process.

The muscles that act directly on a particular vertebral segment are innervated by the medial branch of the dorsal ramus nerve of that segment.

Low back pain is often caused by tense and painful paraspinal muscles that reduced flexibility in the lumbar spine. **[GATE THEORY]**

NEUROMUSCULAR INTERACTION BETWEEN THE SPINAL STRUCTURES

This research involved eighty pigs. The authors used needle electrodes inserted into the deepest and most medial multifidus fibers, bilateral to the L2, L3 and L4 spinous processes.

“Stimulation of the disc annulus fibrosus induced responses in the multifidus on multiple levels and on the contralateral side, whereas stimulation of the zygapophysial joint capsule induced reactions predominantly on the same side and segmental level as the stimulation.” **[Great clinical application: disc problems result in bilateral reduced movement, while facet problems result in ipsilateral reduced movement.]**

There are interactive responses between an injured or diseased disc or zygapophysial joints and the paraspinal musculature.

The reflex activation of the multifidus musculature reduces the motion of the lumbar spine. **[Gate Theory again]**

“The mechanically-induced stretch reflex of the zygapophysial joint capsule” resulted in a reduced motor unit activity. **[Adjustment restoring position and movement]**

“These results indicate that the zygapophysial joint has a regulatory function, controlling the intricate neuromuscular balance in the lumbar motion segment.” **[WOW!]**

Irritation to the ventral area of the sacroiliac joint caused responses in the gluteus maximus and quadratus lumborum muscles.

Irritation to the sacroiliac joint capsule caused muscular responses in the multifidus.

“These results indicate a regulatory function for the sacroiliac joint, namely its involvement in activation of the spinal and gluteal muscles, which help control locomotion and body posture, as well as provide stability on the segmental level in the lumbar spine.”

“Normal locomotion and posture require multiple levels of neural control.”

“Descending signals from the brainstem activate complex reflex systems in the spinal cord, where the myotactic units with their receptors and polysynaptic circuits are the building blocks.”

“Afferent information is essential in the modification of muscle activation to make it well coordinated and functional.”

[Chiropractic adjustments improve or normalize this afferent information].

“Mechanoreceptors responses to normal loading and movements probably have a primary effect on modulation and modification of descending signals.”

[This means the information is not just segmental, but suprasedgmental, as taught in neurology diplomate class].

“Injury, certain mechanical loading patterns, degenerative processes and/or inflammation may cause perturbations in the proprioceptive function of different receptors and result in increased or prolonged muscle activation by triggering reflex activation of the involved muscle groups, which over time can cause pain.” **[Again, this is consistent with the need to remove subluxation and reduce inflammation].**

REFLEXES FROM SPINAL LIGAMENTS

Reflexes originate from ligaments of the joints of the extremities.

Spine ligaments are associated with complex proprioceptive sensory inputs from nearby discs and capsules. **[WOW, subluxation again]**

Stimulation of the supraspinous ligaments caused an EMG discharge in the multifidus muscles.

Compared to other joints, the spinal motion segment has more innervation and is more complex, consisting of an intervertebral disc and two zygapophysial joints. **[This is why spinal adjusting has greater consequences than extremity adjusting].**

“Normal locomotion requires multiple levels of neural control. To support the body against gravity, maintain posture and to propel it forward, the nervous system must coordinate muscle contractions at many joints. At the same time, the nervous system must exert active control to maintain balance of the moving body, and it must adapt the locomotion pattern to the environment and to the overall behavioral goals. The spinal circuits activated by descending signals from higher centers accomplish this. Neural circuits in the spinal cord play an essential role in motor coordination. Spinal reflexes, where the ‘myotactic units’ are the building blocks, provide the nervous system with a set of elementary patterns of coordination that can be activated, either by sensory stimuli or by descending signals from the brain stem and cerebral cortex.”

[WOW, great paragraph. It gives the neuro-biomechanical substrate for the power of the segmental adjustment.]

Muscle spindle and Golgi tendon mechanoreceptors provide proprioceptive information essential for controlling muscle tone, and thereby joint stability.

“The neurological feedback from passive viscoelastic structures **[disc, facet capsules, spinal ligament]** provides sensory information needed to regulate muscle tension, and hence, the stability in the lumbar spine.”

“The functioning of the motor system is intimately related to that of the sensory system.”

“The proper moment-to-moment functioning of the motor system depends on a continuous inflow of sensory information.”

“Sensory information influences motor output in many ways and at all levels of the motor system.”

Motor reflex responses and programmed voluntary responses are dependent upon spinal cord sensory input.

[Again, the model: subluxation alters the quality of the sensory input into the spinal cord, thereby altering both reflex and voluntary response functions.]

“The nerve endings in the outer annulus fibrosus of the disc, in the capsule of the zygapophysial joints, and in the ligaments are most likely part of a proprioceptive system responsible for optimal recruitment of the paraspinal muscles.”

“Mechanoreceptors are thought to play an important role in the function of monitoring position and movements of joints by regulating and modifying muscle tension.”

Descending signals that initiate muscle action are modified by the sensory input from the proprioceptive nerve endings. **[Again the model: sensory input to the spinal cord from proprioceptors not only influences reflexes, but also influence higher centers in the brain and brainstem.]**

Overload forces on specific parts can be detected by proper functioning **[non-subluxated]** joint sensory receptors and inhibit the involved muscles and thereby prevent injury.

This is why heavy physical spinal loading does not "have the impact on degeneration of the spine as earlier assumed." **[WOW!]**

Importantly, "damage done to ligaments and perhaps other passive structures does not necessarily have to result in a lot of pain," but it can still result in inappropriate muscle activation. **[The asymptomatic subluxation complex]**

"The sacroiliac joint is a true synovial joint with an articular shape and a very limited amount of motion."

The sacroiliac joint has motion range from 0.5-1.6 mm for translation and up to 4 degrees for rotation.

"Stimulation of the outer annulus of the disc or zygapophysial joint, both of which have been shown to contain nerve endings, causes activation of paraspinal musculature, not only on the same segmental level, but also on different levels."

This interaction stabilizes the segments to each other and helps maintain posture.

"A lesion in one location may cause alterations in muscle activation in other than the actual segment and also on the contralateral side."

[WOW, this is great. This is why we treat the subluxation, regardless of side or level, rather than treating the pain.]

"The afferent input from sacroiliac joint receptors, as well as mechanoreceptors in the intervertebral disc and zygapophysial joints, will contribute to different degrees of muscle activation and may constitute an integral regulatory system."

"Changes in loading on the sacroiliac joints may result in altered activation of the stabilizing muscles, and thus play an important regulatory function in stabilization and movement of the upper body during postural changes."

"Instability of a spinal motion segment, as a result of degeneration of the disc or zygapophysial joints, is believed to be manifested as 'slipping' as a result of laxity in the motion segment."

However, "this kind of hypermobility does not seem to occur, but the motion pattern is greatly altered."

[IMPORTANT: The 2001 AMA Impairment Guides uses stress radiographs to document "slipping hypermobility." However if this "slipping hypermobility" does not occur but rather causes "altered motion patterns" one could argue that videofluoroscopy would be more important for assessment of these joint problems.]

“Change in length and loading of the ligaments [**subluxation complex**] may result in altered firing patterns and changes in the coordination pattern of the muscles.”

Decreased disc height from degeneration results in less efficient adaptation of the surrounding nerve endings causing less optimal neuromuscular reflexes.

THIS ARTICLES WAS PRECEDED BY THIS EDITORIAL, IN PART

The sensory function of ligaments

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In December 2000, 50 people from three continents met in Copenhagen, Denmark to discuss an important topic: the sensory function of ligaments.

“The ligaments of every joint provide such a complex sensory feedback mechanism, further fortifying the fact that feedback from ligaments is an integral part of joint motion.”

“The coordination of muscle function around joints and joint movement is influenced by many factors: afferent inputs from ligaments, muscles, tendons, skin, vision, etc., are mixed with earlier experience stored in the cortex and cerebellum, and these inputs are used to update or change the pre-programmed motor functions which secure an optimal coordination of muscle function in relation to the desired motor activity.”

“The effects of the sensory inputs are modified, dependent on the ongoing activity in all parts of the system.”

KEY POINTS FROM DAN MURPHY

(1) The afferent input to the spine from the disk, facet capsules, spinal ligaments and sacroiliac joints is important for the following reasons:

- (1)(A) They establish and control local muscular reflexes.
- (1)(B) They regulate and control local voluntary muscle efforts.
- (1)(C) They fire to the cerebellum and to the sensory cortex of the brain.
- (1)(D) They modify descending motor commands from the brain and brainstem.

(2) Low back pain arises from structural derangements of the disc or the facet joints.
[SUBLUXATION]

- (3) The disc, the facet, and the sacroiliac joint are all richly innervated and can cause pain.
- (4) Abnormal sensory input from the disc, facet capsule, spinal ligaments and the sacroiliac joint can cause muscle contraction, reduced motion, and pain.
- (5) Abnormal sensory input from the disc, facet capsule, spinal ligaments and the sacroiliac joint can cause muscle alterations in muscle activation and pain at other segments and on the contralateral side.
- (6) Injury to ligaments and other passive spinal structures may not result in pain, but can still cause inappropriate muscle activation.
- (7) Abnormal afferent input from the disc induces multiple levels and contralateral multifidus contraction.
- (8) Abnormal afferent input from the facet capsule induces ipsilateral multifidus contraction.
- (9) Mechanical stretching of the facet joint capsule reduces motor unit contraction and restores mobility.
- (10) The facet joint has a regulatory function in controlling the intricate neuromuscular balance in the lumbar motion segment.
- (11) Spinal joint instability may not manifest as "slipping hypermobility" on stress radiographs, but may rather manifest by displaying abnormal motion pattern.