Dynamic Chiropractic

CHIROPRACTIC TECHNIQUES

Lumbar Spine Manipulation and Water Diffusion in the Intervertebral Disc (Part 1)

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Lumbar spine manipulation has been shown to be an effective treatment to decrease low back pain,[1] but the exact mechanisms by which it decreases pain have been the subject of considerable conjecture and research. It was originally believed biomechanical changes, such as alterations in the juxtapositional relationship of the vertebrae or the correction of joint pathomechanics, were responsible for clinical improvement in LBP after spinal manipulation. More recent research into the biomechanical changes that occur after lumbar manipulation has demonstrated a decrease in lumbar spine stiffness.[2]

In addition to biomechanical changes, other research has shown neurophysiologic changes after spinal manipulation are likely responsible for some of the beneficial clinical effects often seen after manipulative therapy. Spinal manipulation has been shown to activate peripheral, spinal cord and supraspinal regions by stimulation of mechanoreceptors.[3] Let's explore a physiologic mechanism you may not be aware of that occurs in lumbar discs after lumbar spinal manipulation: water diffusion.

It is becoming increasingly evident that while we can identify physiological changes after spinal manipulation, these changes must be correlated with clinically meaningful changes in pain reduction or an improvement in function in order to be considered clinically relevant. Let's briefly review intervertebral disc physiology, with an emphasis on the importance of proper disc diffusion; followed by a brief explanation of diffusion-weighted MRI and summary of research evaluating water diffusion in the intervertebral disc after lumbar mobilization / extension exercises in one study and lumbar / pelvic manipulation in two other studies.

Disc Physiology and Nutrition

The intervertebral disc is the largest avascular structure in the body.[4] There are approximately 8,000 cells/mm3 of disc material.[5] The cells of the lumbar disc can be up to 20 mm from the closest blood vessels.[6]

Diffusion to the cells at the center of the nucleus pulposis from the vertebral body can take up to six hours in a healthy lumbar disc.[6] Because of this vast distance, nutrients (oxygen, glucose, amino acids and sulfate) and waste products (lactate) rely mostly on passive diffusion to maintain proper cell viability.[7]

The outer parts of a normal disc have higher levels of glucose and oxygen, while the center of the disc has higher levels of lactate, and therefore, a lower pH level.[8] The main and most important pathway for diffusion into the nucleus pulposis occurs from capillaries in the vertebral body via diffusion through the cartilaginous endplate.[4,7] The main pathway for diffusion through the outer annulus is from blood vessels in the outermost part of the annulus periphery.[7] Proper diffusion is required for the production of procollagen and proteoglycan synthesis,[5] as well as to maintain proper pH values that promote cellular integrity.[7]

Proper cellular activity depends on intact mechanical pathways to the intervertebral disc and proper vascular health. Cartilaginous endplate calcification and sclerosis of subchondral bone can impair diffusion to the intervertebral disc.[7] Additionally, atherosclerosis of the abdominal aorta and smoking decrease blood flow to the spine and have been associated with increased disc degeneration. This illustrates the importance of maintaining vascular integrity of blood vessels near the intervertebral disc.[7]

The likely clinical effect of decreased diffusion of nutrients to the cells of the disc is cell death and disc degeneration. As discs become more degenerated, nutrient supply to the cells decreases further. While the cause of disc degeneration is multifactorial and includes genetic influences, repetitive mechanical loading and smoking, among other factors, reductions in disc nutrition have been proposed as the final common pathway.[6,9]

Disc Water Diffusion Impacted by Mobilization and Exercise

Diffusion-weighted MRI is a noninvasive technique that measures water diffusion in tissues including the intervertebral disc.[10] Diffusion-weighted MRI quantifies the rate of water moving through tissues by generating an apparent diffusion coefficient (ADC).[11] The ADC is calculated with special software by averaging the signal intensity of the same tissue slice over time and has shown high reliability.[12]

Research has suggested decreased water diffusion of the intervertebral disc is associated with a decrease in nutrient supply, which promotes the degenerative process.[10] Degenerated discs of the lumbar spine generally have lower ADC values,[13] although mildly degenerated discs are not significantly different than severely degenerated discs. However, some severely degenerated discs may have a lower ADC because of clefts that develop within the disc.[13] Bulging and herniated discs have a lower ADC compared to normal discs.[10] The ADC of normal discs is reduced in the lower lumbar spine compared to higher levels of the lumbar spine.[13]

The first study on disc diffusion after lumbar joint mobilization followed by lumbar prone press-ups was published in 2010. Twenty adults (12 females, eight males; ages 22-54 years, mean age of 30.4 years) were recruited through convenience and eligible for participation in this study.[14] All subjects had an LBP intensity of at least 2/10 on the numerical pain rating scale (NPRS). Exclusion criteria included contraindications for MRI / lumbar joint mobilization, nerve root compression, visual lateral shift, pregnancy, history of inflammatory joint disease, osteoporosis, discitis or spinal neoplasm.

Additionally, subjects had to meet the classification for extension-based treatment; specifically, an increase in LBP or peripheralization with lumbar flexion and with prolonged sitting to a greater extent than lumbar extension or walking. This was tested by evaluating subjects' pain response as they performed five repetitions of lumbar flexion and extension. Individuals with normal or increased mobility with L5 PA pressures were excluded, thus retaining only those who had hypomobility of the L5/S1 motion segment.

Lumbar T2-weighted sagittal views were obtained to evaluate for L5-S1 disc degeneration and to rule out contraindications for treatment, which consisted of two sets of 30-second PA joint mobilizations from L5-L1 at the highest patient tolerance without pain, ranging from grade I-IV on the Maitland scale. The subjects performed three sets of 10 prone press-ups immediately after the lumbar spine joint mobilizations according to the McKenzie method. After the treatment, diffusion-weighted MRI scans were performed and ADC values obtained for the L5-S1 disc.

Data analysis demonstrated that five males and five females had an immediate reduction of their LBP by at least 2 points on the NPRS and were classified as immediate responders. The remaining three male and seven female participants comprised the not-immediate responders. Significantly, six of the immediate responders had LBP duration of less than two months and nine of the 10 not-

immediate responders had LBP longer than six months.

The ADC of the L5-S1 disc of immediate responders increased by a mean of 4.2 percent, while the ADC of the disc in not-immediate responders decreased 1.6 percent, which was statistically significant. Thus, improvement in LBP following lumbar mobilization /prone press-ups was accompanied by an increase in water diffusion of the lowest lumbar disc.

Water Diffusion Following Lumbar Spine Manipulation

A more recent study, the first of its kind, published in the January 2014 issue of the *Journal of Orthopedic & Sports Physical Therapy*[12] explored the diffusion of water through lumbar intervertebral discs after lumbar spine manipulation. Nineteen subjects (13 women and six men, ages 20-45) were recruited to participate in this study. They had to have LBP rated at least 2/10 on the NPRS during the testing, Exclusion criteria included possible pregnancy, signs of nerve root compression, inflammatory joint disease, osteoporosis, neoplasm, discitis, previous lumbar spine surgery and spondylolisthesis. Subjects were also excluded if they had hypermobility at any lumbar spine segment.

Lumbar T2 MRI was performed to evaluate for lumbar DDD and rule out contraindications to spinal manipulative therapy. Diffusion-weighted midsagittal lumbar MRI was performed before and immediately after lumbar spine manipulation.

Lumbar spine manipulation was performed by a physical therapist with a certification in manual therapy. (The actual technique used is very similar to a side-posture push technique commonly used by chiropractors.) The L5/S1 segment was manipulated on both sides; subjects then received an immediate diffusion-weighted MRI and were asked to rate their pain on the NPRS.

Participants whose NPRS decreased by at least 2 points (minimal detectable change) after their spinal manipulation were classified as within-session responders; all others were classified as not-within-session responders. For 12 participants (three men, nine women), NPRS decreased by at least 2 points and were classified as within-session responders; while seven participants (three men, four women) did not experience a 2-point decrease in LBP and were classified as not-within-session responders. Statistical analysis showed within-session responders had a statistically significant increase in ADC, with large effect sizes at levels L1-L2 (5.9 percent increase), L2-3 (4.3 percent increase) and L5-S1 (7.3 percent increase) compared to nonresponders, whose MRIs revealed a decrease in ADC.

In summary, participants with at least a 2-point decrease in LBP intensity, as measured by the NPRS, after a single session of lower lumbar spine HVLA spinal manipulation had an increase in water diffusion (ADC) at the central aspect of L1-2, L2-3 and L5-S1 discs. Within-session responders also had fewer levels of disc degeneration and a lower BMI compared to nonresponders. It is not known why spinal manipulation was able to increase water diffusion through certain levels of lumbar discs in participants who had less LBP after a single session of spinal manipulation. The study authors hypothesized changes in lumbar muscle tone may have changed the external forces on the lumbar discs, which could affect water diffusion gradients.

The study authors also noted that pressure gradients, chemical forces and structural barriers may all affect water diffusion through the lumbar discs. Because a decrease in LBP after spinal manipulation was associated with an increase in water diffusion through the lumbar discs, they suggest spinal manipulation may have altered central and/or peripheral chemical activity that affects neurotransmitters or inflammatory mediators.

They caution that study participants had relatively low levels of LBP and disability, which limits the generalizability of this study. Furthermore, each participant only received a single spinal manipulation and the long-term effects of the treatment are unknown. Nonetheless, the results of this research shed new light on another mechanism that may be responsible for the analgesic response following lumbar spine manipulation.

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Editor's Note: Dr. Lueck reviews a second study on water diffusion following lumbar spine manipulation in part 2 of this article, scheduled to run in the Jan. 1, 2016 issue.

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