Dynamic Chiropractic

BACK PAIN

The Effect on Spinal Ability That May Occur as a Result of Disc Hydration

ABSTRACT

The loss of disc hydration has apparent effects on spinal mobility. Spinal mobility involves movement of the motion segment. The motion segments and their biomechanical relationship to one another is discussed. The motion segments include the intervertebral disc, the ligamentum flavum, the articular facets and spinous ligaments.

Key Words: motion segment; intervertebral disc; disc hydration; spinal mobility.

All spinal mobility involves movement of the motion segment; as such this must include the intervertebral disc. This essay examines spinal mobility which intricately involves movement of the motion segment and the loss of normal movement of the motion segment resulting from the loss of disc hydration.

Kapandji offers a classification of the motion segment. According to Kapandji, the anterior pillar consisting of the vertebral bodies is essentially a supporting structure and plays a static role in the motion segment. The posterior pillar, on the other hand, consists of the vertebral arches which controls much of the movement of the segment.

The complete active component of the motion segment would consist of the vertebral discs, the intervertebral foramen, the articular facets and capsules, the ligamentum flavum, and the interspinous and supraspinous ligaments.

The mobility of the motion segments underlies the mobility of the vertebral column. Nevertheless, the overall range-of-motion of the column is not necessarily a sum of all of the individual motion segments, since each segment may not contribute to its total range of movement.[1]

Individual motion segments of the vertebral column behave differently in their classification and range-of-motion depending, of course, on their location. Motion segments exhibit certain characteristics under differing biomechanical loads. Motion segments are more resistant under compression than tension due to the hydrostatic pressure within the disc. As the load increases, the more resistant the segment becomes. For instance, motion segments are rather resistant in lateral flexion as compared to when they are in flexion. When subjected to a constantly applied load, and then attempting to maintain this load, the discs slowly lose a certain amount of fluid and gradually change their height until deformation is reached. Hence, the disc loses its capacity to attenuate shock and can no longer distribute the load uniformly as the disc becomes less viscoelastic.

Spinal mobility involves a functional mechanism that allows us to perform a wide range of tasks each day of our lives. During spinal motion, the amount of movement is largely attributed to the size of the disc. Mobility is dependent upon the fluidity, elasticity and thickness of the disc. For example, fluid pumping in and out of the disc in response to changing loads is thought to be vital for the transfer of nutrients and wastes within the disc which speeds up the diffusion process.

Since fluidity, elasticity and thickness of the disc is important for mobility, there are variances from area to area.[1] The size of the disc increases from the cervicals (3mm) to the lumbars (9mm). The shape of the disc also varies from area to area. In the cervical spine, the discs are more rounded, while in the lumbar spine they are more kidney shaped.[1]

The nucleus pulposus occupies 50-60% of the disc volume and 30-50% of the total disc area. It is highly hydrated in children (90% water) and gradually decreases with age (70% water in adults). On the other hand, the annulus fibrosus occupies 40-60% of the disc volume. It is 60-70% water and changes with age are not as apparent as in the nucleus. The matrix of the disc consists of a mucopolysaccharide substance which is basically collagen fibres embedded in a proteoglycan-water gel. Most of the properties of the disc are therefore largely due to the matrix.[1]

Water inflates the tissue and forms 70-80% of the tissue volume. It provides a medium for the transport of dissolved nutrients in and out of the disc. There are several different types of molecules within the disc. The high osmotic pressure of the molecules inflates the disc by drawing water in and therefore maintaining the disc's hydration in the face of high external loading. These different types of molecules within the disc are the main compression resisting component of the disc. Due to their closely packed and interpenetrating network, these molecules impart a low hydraulic permeability to the tissues, slowing the rate of fluid loss. Again, the transfer of nutrients and wastes within the disc speeds up the diffusion process reacting to changing loads while fluid is pumping in and out of the disc.[2]

With the loss of disc hydration, the motion segments of the spine undergo a deformative process. With the progressive loss of disc height, the facet joints degenerate or dislocate. Because the facets carry a large compressive load (i.e. 33% of load), facet joint degeneration alters spinal mobility.

As motion segments, the interspinous and supraspinous ligaments function to allow smooth physiological motion, and allow fixed postural attitudes with minimum energy expenditure. These ligaments protect the spinal cord by restricting motion to well-defined limits. They protect the spinal cord in traumatic situations, and absorb high loads and limit displacement.

The ligamentum flavum has the most elastic fibres of any ligament; this feature of the ligamentum flavum minimizes the changes of impingement of the spinal cord. A vital structure in the motion segment movement, the ligamentum flavum, a strong ligament, has a pre-tension of 10 times that of the longitudinal ligament. Because of a loss of disc hydration, the ligamentum flavum will continue to lose its elasticity and begin to fail in maintaining its load carrying ability. It appears that the ligamentum flavum and other spinal ligaments often fail when a load is applied rapidly, especially in this instance where the loss of shock absorption capacity of the disc exerts extra tension upon the motion segments.

A loss of hydration to the disc and the disc's attempt to maintain its normal loading capacity often subjects the vertebral end plates to large pressures. As the fluid pressure in the nucleus pulposus increases due to external loading, much force is placed on the end plate. Experiments have determined that the vertebral end-plate will often fracture before the disc actually herniates, provided the disc is a healthy one.[1]

A disc deformation resulting from a loss of disc hydration may also be a reason for the mechanical etiology of low back pain. Compression injuries may ensue and would be characterized by the rupture of the end plate. Loss of disc height often alters the facet joint's mechanical ability which provides a great deal of torsional strength of the motion segment.

Adams and Hutton claim that on average the disc loses about 11% of its fluid during 4 hours of loading. When pressure as such is on the disc and maintained, fluid is gradually expressed from the tissue.[1]

Conclusion

Spinal mobility involves movement of the motion segment, the intervertebral disc is a vital component of the motion segment and if altered structurally by loss of disc hydration further alteration among the motion segment undergoes pathomechanical movement. Age changes often observe the intervertebral disc undergoing alterations. At age six years, the nucleus pulposus is gelatinous and well hydrated. At age 17, the nucleus is still gelatinous and well hydrated. At 55 years of age, the nucleus is fibrous and becomes dehydrated. At 75 years of age, the nucleus is fissured and resorption takes place.[2]

Due to dehydration, the biomechanics of the spine begin to become static as opposed to dynamic. Disc resorption is a sequelae to internal disruption. Loss of height, loss of end plate destruction and soft tissue mass and oedema occurrences take place. With narrowing of the disc, low back pain is a major complaint. A possible ruptured intervertebral disc with subsequent herniation of the nucleus pulposus into the spinal canal causes inflammatory or direct mechanical nerve root pressure.

Overview of the motion segments cooperating at normal variance, when disrupted, become static pathomechanics. Hence, spinal immobility and nervous system disorder ensue.

References

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