Orthotics and the Proprioceptive System

Joint Mechanoreceptors

Surrounding and protecting all joints are tough, fibrous tissues which contain a variety of sensory nerve endings. The input from these specialized sensors keeps the nervous system informed as to the location of the joint, and also the degree of stretch, compression, tension, acceleration, and rotation. (6) These joint mechanoreceptors are classified by their anatomy and their neurological function. (7) Type I mechanoreceptors are found in higher densities in the proximal joints. They sense the position of a joint by signaling the joint angle through normal ranges of motion. These help determine postural (tonic) muscle contractions. Type II nerve endings adapt to changes in position, and are most active at onset and termination of movement. These are more densely distributed though the distal joints, and affect phasic muscle actions. Type III mechanoreceptors are high threshold, which means they require considerable joint stress at end ranges before firing. These receptors serve a protective function similar to the Golgi tendon organs. Type IV receptors are free nerve endings located in the ligaments, joint capsules, and articular fat pads which respond to pain stimulus. They can generate intense, non-adapting motor responses in all muscles related to a joint, resulting in the protective muscle contractions that restrict joint movement.

Foot Involvement

These six specialized nerve sensors are found throughout the musculoskeletal system, in all skeletal muscles and in every ligament, joint capsule, and articular connective tissue. With many small joints, lots of connective and articular tissues, and both intrinsic and extrinsic muscles, the feet are particularly well-supplied with proprioceptive nerve endings. Mechanoreceptors in the joints along with the muscle spindles of the foot muscles are responsible for the positive support reflexes and a variety of automatic reflexive reactions. (8) These include the flexor/extensor reflex, which converts the lower limb into a firm, yet compliant pillar. Weightbearing compresses the joints and muscles, evoking reflexive activity in the extensors and inhibition of the flexor muscles. (9)

The first research to demonstrate how altered proprioceptive input predisposes to recurring injuries was performed on patients with chronically sprained ankles. (10) Freeman et al. called this phenomenon “articular de-afferentiation” to recognize the importance of inappropriate afferent signals from injured ankle and foot proprioceptors. They pointed out that, “Since articular nerve fibers lie in ligaments and capsules, and since these fibers have a

lower tensile strength than collagen fibers, it seems inevitable that a traction injury to a ligament or capsule will lead to the rupture of nerve fibers as well as collagen fibers". (11)

Conclusion

Except for the spine, the foot is the anatomical region which contains the most proprioceptive sensory receptors, and the foot has very distinctive nerve circuits which must be considered.

Because of the magnitude of sensory input, the feet are frequently involved in clinical conditions which will respond to specific treatment approaches that include the proprioceptors – such as custom orthotics. Structural support and shock absorption for the musculoskeletal system is provided by the corrective orthotics, thereby reducing physical stressors on the muscles and joints of the feet, legs, and pelvis. Greater understanding of the proprioceptive system of sensory receptors in the muscles and joints has enabled us to more accurately assess and treat many complex musculoskeletal problems. When custom-fitted orthotics are included, treatments can be more effective and responses will be more comprehensive and longer-lasting.

References

1. Kuhn DR, Shibley NJ, Austin WM, Yochum TR. Radiographic evaluation of weight bearing orthotics and their effect on flexible pes planus. J Manip Physiol Ther 1999; 22(4):221-226. 2. Stude DE, Brink DK. Effects of nine holes of simulated golf and orthotic intervention on balance and proprioception in experienced golfers. J Manip Physiol Ther 1997; 20:590-601. 3. Stude D, Gullickson J. Effects of orthotic intervention and nine holes of simulated golf on gait in experienced golfers. J Manip Physiol Ther 2001; 24(4):279-287. 4. Stude D, Gullickson J. Effects of orthotic intervention and nine holes of simulated golf on club-head velocity in experienced golfers. J Manip Physiol Ther 2000; 23(3):168-174. 5. Gatterman MI, ed. Chiropractic Management of Spine-Related Disorders. Baltimore: Williams & Wilkins, 1990:413. 6. Slosberg M. Effects of altered afferent articular input on sensation, proprioception, muscle tone and sympathetic reflex responses. J Manip Physiol Ther 1988; 11:400-408. 7. Wyke BD. The neurology of joints. Ann R Coll Surg Engl 1967; 41:25. 8. Freeman MAR, Wyke BD. Articular contributions to limb muscle reflexes. J Physiol 1964; 171:20. 9. Panzer DM, Fechtel SG, Gatterman MI. Postural complex. In: Gatterman MI, ed. Chiropractic Management of Spine-Related Disorders. Baltimore: Williams & Wilkins, 1990:263. 10. Bosien WR, Staples OS, Russell SW. Residual disability following acute ankle sprains. J Bone Joint Surg Am 1955; 37:1237. 11. Freeman MAR, Dean MRE, Hanham IWF. The etiology and prevention of functional instability of the foot. J Bone Joint Surg Br 1965; 47:678-685.