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Improving Proprioceptive Balance with Orthotic Support

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Recently published research has shown that custom orthotic support can help improve structural alignment,¹ balance,² gait,³ and athletic performance.⁴ This is quite an extensive list of benefits. How can all of these claims be justified from the use of a single adjunctive therapy?

There is a reason so many changes (both in physical function and in symptoms) are reported with the use of custom-fitted orthotics. This large universe of improvements is due primarily to the sense of proprioception - one of the most important neurological systems of the body. A quick review of the mechanisms and components of proprioception will help us comprehend how patients can demonstrate such a large variety of improvements. Being able to explain this to patients (using simpler terms, of course) will help them understand the reasons you are recommending they wear in-shoe orthotics.

Specialized Sensory Organs

Proprioception is defined as "sensing the motion and position of the body."⁵ Specialized nerve endings are present throughout the soft tissues of the musculoskeletal system, which interact with the central nervous system and coordinate our body movements, our postural alignment, and our balance. Athletic activities, in particular, rely on this delicately controlled and finely-tuned system of receptors and feedback loops, as well as the validity of the information which is sent into the spinal cord. This coordination normally allows for appropriate motor responses - and in some special cases, artistic physical performances.

Proprioceptive sensory organs are found in two distinct groups, which are located in either muscles and tendons, or within the connective tissues (ligaments and capsules) of joints (**see Table below**). These specialized nerve fibers provide information regarding the status and function of the musculoskeletal system with a constant flow of information to the spinal cord, the cerebellum and the brain.

When there is a communication breakdown, or when improper information is supplied by one or more of these sensors, efficiency of movement decreases. This is harmful and possibly injurious to the muscles and joints, and results in problems with postural coordination and/or joint alignment. Beyond being just an annoyance, faulty coordination or misalignments can also be the source of chronic, unresolving pain.

Location of Nerve Endings

The most important sensory nerve endings for controlling the muscular system are the muscle spindle fibers and the Golgi tendon organs. Muscle spindle fibers are found interspersed within the contractile fibers of all skeletal muscles, with the highest concentration in the central portion (belly) of each muscle. Muscle spindles respond to changes in muscle length. A complex circuitry of these nerve endings, with interconnections in the dorsal horn of the spinal cord, maintains muscle tone and, most importantly, the appropriate tension in the muscles on opposite sides of each joint. Without this basic "wiring," proper joint alignment can't be maintained and relaxed, and upright posture is almost impossible.

Golgi tendon organs are located in the junctions of muscles and their tendons. These protective nerve endings exert a powerful inhibitory effect on contraction of the muscle fibers. They are stimulated by strong stretching of the muscle/tendon junction (as when the muscle fibers are contracting too strongly). Golgi tendon organs transmit their information to the spinal cord and cerebellum through large, rapidly conducting nerve fibers, and they can rapidly inhibit a muscle contraction in order to protect the tendon.

Joint Mechanoreceptors

Surrounding and protecting all joints are tough, fibrous tissues that 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, "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

Sensory Organs for Proprioception	
muscles and tendons	muscle spindle fibers Golgi tendon organs
joint ligaments and capsules (mechanoreceptors)	type I - low threshold, slow-adapting type II - low threshold, fast-adapting type III - high threshold, slow-adapting type IV - nociceptive (pain endings)

Conclusion

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

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