Dynamic Chiropractic – November 1, 1999, Vol. 17, Issue 23

The Role of the Plantar Fascia, Gastroc-Soleus Complex and the Windlass Effects of the Dynamic Foot

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The Achilles tendon is a continuum of coalescence between the two heads of the gastrocnemius and the soleus muscles. After attaching to the calcaneus, the Achilles tendon becomes an immovable band that continues beneath the plantar portion of the calcaneus and projects distal as the plantar fascia. Doctors may remember their time in the dissection labs and their frustration at trying to clean and separate these very strong structures.

To be more specific, the Achilles becomes the plantar fascia after leaving the regions of the medial and lateral tuberosities of the calcaneus. The plantar fascia continues distally as numerous divergent and oblique bands that insert into the medial and lateral portions of the metatarsal heads and, far more important to the gait cycle, the proximal aspects of the phalanges. This insertion is of vital importance to the windlass action of the plantar fascia.

You'll recall the windlass effect of Hicks is a separate entity entirely; however, one functions in a harmonious relationship with the other during toe-off.

At the end of the late midstance phase of gait, the foot can be described as a loose bag of bones. That is, it is relaxed so that the foot can accommodate to the terrain upon which it is placed. At this point, the plantar fascia is at ease. After this phase of gait, the foot undergoes what is often described as a twisted osteoligamentous plate adaptation. This twisting (understanding that the entire leg is also involved but not discussed in this article) involves the subtalar joints (posterior, middle and anterior, and the physiological joint, aka the talocalcaneonavicular joint) and the transverse tarsal joints (talonavicular and calcaneocuboid). The calcaneocuboid articulation has been described in current literature as one of two joints that undergo a "self-locking mechanism" that attempts to prevent overpronation at the late midstance phase of gait. The other is the sacroiliac joint as it changes function from form closure to force closure during formation of the right and left oblique axes.

During the gait cycle, the triceps surae muscle complex has three possible actions or functions: 1) concentric contraction - shortens and develops tension; 2) eccentric contraction - creates tension as it is being stretched; and isometric contraction - tightens with no change in length.

Reviewing the function of the gastroc-soleus complex from heel strike to toe-off reveals the following sequence of events. During normal walking gait, the triceps surae complex is active for approximately 20%-50% of the stance phase of gait. The gastroc-soleus complex or triceps surae complex (G-S) ceases activity before the toe-off stage. The G-S complex is not used for toe-off during walking or, for that matter, running. If we consider the tibia in relation to the foot fixed upon the ground, we note that the ankle mortise (talocrural) joint undergoes dorsiflexion during the period from heel strike through the late midstance phase of gait. The angle between the tibia and the talus remains relatively unchanged from the mid-midstance phase through the late midstance phase of gait.

Since the talocrural joint is the major player affected by the G-S complex, the complex undergoes first an eccentric contraction and then an isometric contraction, i.e., it develops tension as it is being stretched for the first portion of the stance phase. It then maintains the same length as the muscle further tenses.

The G-S complex acts to stabilize the leg by restraining the forward motion of the tibia in a line of progression, therefore allowing the leg to act as a solid support for the body as it maintains its line of progression. During isometric contraction, the calcaneus rises off the surface and the toes undergo passive dorsiflexion. Tension is created by this dynamic motion in the plantar fascia (the windlass effect) which assists in the formation of the twisted osteoligamentous plate and resultant stability as the converging axes of the transverse tarsal joint converge.

The main points to recall from this process are that the maintenance of the line of progression and the passive dorsiflexion (ground reactive forces) load the plantar structures, contribute to the stability of the supination foot and prepare it for toe-off. The foot is now in position for the remaining sequence of events (including the windlass effect of Hicks) to complete the event known as toe-off.

Running is quite different. The G-S complex becomes active at the end of swing phase and continues to be active for the first 50% of the stance phase of gait. Initially, the muscle undergoes an eccentric contraction to counteract the sudden load of the tibialis anterior muscle in preparation for heel strike. During the stance phase of gait, the G-S complex undergoes an eccentric contraction to stabilize the lower extremity. Instead of isometrically contracting, as in walking, the G-S complex ceases to be active and plantarflexion of the ankle begins. By mediating the rate of dorsiflexion of the ankle and flexion of the knee (coupled with internal rotation of the tibia) during the stance phase of gait, the G-S complex also acts as an integral part of the shock-absorbing mechanism of the limb. Because the G-S complex works mainly by eccentric contraction, it is paramount that it be able to stretch and permit the elastic deformation required by running.

The important points in this case are that if the muscle complex can undergo the plastic deformation required, tension then develops smoothly in the entire G-S complex, the Achilles tendon and the plantar fascia linkage system. G-S complex tears in the absence of direct trauma give credibility to this statement. A smooth elastic deformation of the complex should take place without prematurely activating the stretch reflexes within the muscle and tendon unit, which would cause an abnormal, completely unsynchronized and out of phase contraction. Abnormal or compensatory gait patterns with mismatched sensory motor input would result and, with time, would become the patient's normal gait pattern. This would allow for many adaptive compensations of the knees, hips, pelvis and spine to become active and symptomatic.

If we are to truly treat the "cause" of the patient's ailment, the doctor of chiropractic should be aware of the many fascial slings and continuities that exist in the body and their biomechanical impact upon the neuromusculoskeletal system.

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