Biomechanics of the Plantar Fascia

What are the Biomechanics of the Plantar Fascia?

The plantar fascia is a thick fibrous band that runs the length of the sole of the foot. The plantar fascia helps maintain the complex arch system of the foot and plays a role in one's balance and the various phases of gait.

Plantar fasciitis represents the fourth most common injury to the lower limb and represents 8-10% of all presenting injuries to sports clinics (Ambrosius 1992, Nike 1989). Rehabilitation can be a long and frustrating process. The use of preventative measures and early recognition of danger signals are critical in the avoidance of this problem. Patients, and sometimes doctors, often confuse the terms plantar fasciitis and heel spurs. Plantar fasciitis refers to the syndrome of an acute inflammation of the band of tissue that runs from the heel along the arch of the foot to the toes.

Understanding the anatomy and mechanics of the foot and accepting that there are physiologic limits to the amount of stress soft tissues can sustain helps explain why the plantar fasciitis/osis happens. The understanding of the anatomy and mechanics of the foot also helps one design a successful rehabilitative program and gives clues for early identification of who is at risk in time to initiate preventative measures.
Anatomy

The foot is an architectural marvel. Both feet together contain one fourth (52 of 208) of all the bones in the body. Structurally there are three arches (transverse, longitudinal, lateral) that provide support, stability and aid in locomotion.

The three-arch system contains an elaborate support system of ligaments, tendons and muscles - the largest of which is smaller than one's thumb. Ground impact forces of running or jumping can multiply the stress on the foot 3-22 times one's body weight. Any muscular imbalance, ligamentous laxity or aberrant mechanical action (due to injury, flat feet, high arches, blisters, etc.) predisposes the foot to injury and pain.

**The subtalar joint** also known as the Sinus Tarsi is made up of two bones, the superior talus (ankle) and the calcaneus (heel). There are two ligaments that hold these bones together. They are the cervical and also the anterior ligaments. They are similar to the ligaments in the knee that we all hear about in athletic injuries. Pronation is when this joint loses its height due to the relaxing of the cervical and talonavicular ligaments. When this happens, the hip joint on the opposite leg can clear the ground during its swing phase.

Subtalar laxity of supporting ligaments can destabilize the foot creating a situation of exaggerated or prolonged pronation during ground contact. Excessive motion due to weak ligaments in the sinus tarsi is referred to as excessive pronation. The lack of motion in the subtalar joint due to arthritis is generally called supination. Both excessive motion and lack of motion
will result in pain. This pain can be anywhere in the body. Many feet, knee, hip and low back problems can be traced to an unstable subtalar joint.

**During the mid-stance/pronation phase**, the arch flattens to absorb the shock of ground contact. Again the elastic qualities of the plantar fascia are tested. There is a limit to how much repetitive trauma this tissue can sustain before micro-tears (osis) happen with pain usually presenting on the calcaneus.

**Osseous anatomy** of the foot is logical because form follows function. The largest bone in the foot is the heel bone (calcaneus). It is also the tenuous attachment point of the Achilles tendon. The Achilles tendon is made up of three muscles: the gastrocnemius, soleus and the plantaris.

**The gastrocnemius muscle** will become the plantar fascia when it enters the foot. It has long been believed that the forceful contraction of the gastrocnemius muscle allows one to run and jump. We now know that this isn’t true. Actually the gastrocnemius muscle helps stabilize the foot and ultimately the back by contracting and shortening the distance between the heel and the back. On the other hand, the soleus muscle helps to hold the heel to the leg at the beginning of heel strike while stabilizing the talus in the ankle mortise.

**The plantar fascia** acts as one of the tension elements assisting the plantar ligaments to equalize the stress generated during stance. It plays a role in both facilitating the "lock in" of the arch when you are standing on the foot and when you begin to toe-off. In biomechanical terms, this happens at the beginning of heel strike and is called supination.

During mid-stance, the arch collapses or pronates. Pronation helps dissipate the ground reactive shockwaves and lowers the stance leg so that the opposite limb can swing through its cycle. This is what helps us move forward.
As you can see, walking is NOT a process of falling forward. You can learn more about this by reading Dr. S. Gracovetsky’s work, *The Spinal Engine: A Unified Theory of the Spine*.

During the third phase of ground contact, called toe-off, the plantar fascia is tight over the bottom or plantar surface of the base of the toes. Due to the limited elastic qualities of the plantar fascia, the arch is slightly raised, creating a rigid lever to better apply the results of the forceful gastrocnemius contraction. This is called the windlass effect.

A newer theory that actually makes more sense is BioTensegrity. Simply put, this theory is based on R. Buckminster Fuller’s idea that the most efficient structural unit is self-supporting using stress and tension elements. In the body, this would be bones, muscles, and ligaments. For a fuller explanation of this complex but eloquent equation, please see Dr. Steve Levine’s website [http://www.intensiondesigns.com/itd-biotensegrity/biotensegrity/papers/geometry_of_anatomy.html](http://www.intensiondesigns.com/itd-biotensegrity/biotensegrity/papers/geometry_of_anatomy.html)

The foot must sustain tremendous forces during your life. Any and all measures you take to improve the shock absorptive qualities of your joints, intrinsic strength of your muscles and proprioceptive balance of your body will only enhance your ability to live comfortably.