Big Toe Mechanics - How much of a difference can it actually make?

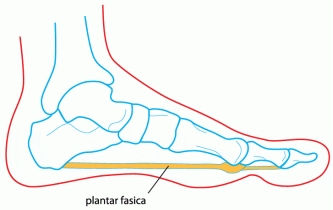
The terms that you hear, toe off, heel strike, mid-foot, gait, arch support. Could all of these things be dependent on the movement of your big toe? When looking at how to optimally load your foot/ankle and in turn calf/hamstring/quad and hip during running, the answer is yes.

How can a person's toe's range of motion cause issues 2-3 joints away from it?

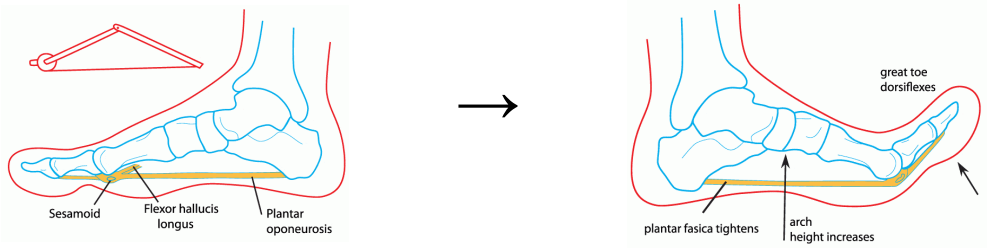
There are two biomechanical mechanisms we need to understand before going any further.

Explained simply.

Windlass effect - When the foot moves from perfectly flat to heel-off -> toe-off phase the toes bend (toe extension), this tightens and winds the plantar aponeurosis (plantar fascia) tightening the tissue relationship from the bottom of the toe, through the bottom of the foot, up the achilles tendon through the calf, into the hamstring and up to the gluteal/hip region.



Arch-Spring mechanism - thought of conceptually as a bow and arrow on the underside of the foot, the medial longitudinal arch (MLA) can be imagined as the wooden portion and the plantar fascia as the bowstring. As you shorten the bowstring, the MLA's angle increases and gets "taller". This can also be related back to the windlass effect, as you toe-off, and start the "winding" of the plantar fascia, the MLA height increases forming the arch-spring.



In order to take full mechanical advantage, you need to have proper range of motion for your big toe/great toe which for a runner needs to be a minimum of 50° of dorsiflexion with an optimal range of 65°-70°.

Taking into account that the differential of loading shows that 2/3 of plantar fascia strain is attributed to great toe extension vs 1/3 of strain caused by achilles tendon force, this can demonstrate that when plantar fascia becomes injured, maybe we need to look at the toe rather than **always** the achilles.

Cheng, H. Y. K., Lin, C. L., Wang, H. W., & Chou, S. W. (2008). Finite element analysis of plantar fascia under stretch—the relative contribution of windlass mechanism and Achilles tendon force. *Journal of biomechanics*, 41(9), 1937-1944.

Without that proper range of motion there will be a lack of arch-spring mechanics and a detriment of the windlass effect which has a negative effect involving the biomechanical chain involving the foot, ankle, knee and hip complexes. Biomechanically you have built in mechanisms to close pack joints, tissue and allow for energy capture and dissipation while moving and in activity which will make for more efficiency when exercising.

Gait is complicated but If we isolate the ending portion toe-off phase only we see the following:

What Kappel-Bargas et al (1998) reported however, is that the subjects fall into 3 categories, they either have immediate movement of the arch on toe-off, normal movement, or delayed movement. Anything outside of normal will result in an ineffective windlass mechanism throughout the foot which leads to the speculation that early arch activity would cause increased rear foot angle while predisposing the arch to higher tensile loads, and delayed onset of the arch activation would increase the mid foot pronation throughout the cycle resulting in a nonoptimal recycling movement during running.

Kappel-Bargas, A., Woolf, R. D., Cornwall, M. W., & McPoil, T. G. (1998). The windlass mechanism during normal walking and passive first metatarsalphalangeal joint extension. *Clinical Biomechanics*, 13(3), 190-194.

As stated in the study titled, *Influence of the windlass mechanism on arch-spring mechanics during dynamic foot arch deformation*: “When the windlass mechanism was engaged, the arch elongated more, and absorbed and dissipated more energy than when it was not engaged. This engagement of the windlass altered the rotational axis of the mid-foot, which probably oriented the arch-spanning structures closer to their resting length, increasing their compliance. This study provides novel evidence for an interplay between the windlass and arch-spring mechanisms that aids in regulation of energy storage within the foot.”

Broken down this states that the more efficient the windlass mechanism is working for you, the less energy loss you will experience and the quicker you can recycle your gait pattern for the next foot strike.

This is re-demonstrated in the study titled *Arch-rivals? The rolls of the windlass and arch-spring mechanisms in running.* “…the windlass mechanism made the arch more compliant, absorbing more energy when the windlass mechanism was engaged, compared to when it was not. This result suggests that the windlass mechanism’s function is to passively reduce arch apparent stiffness by changing its shape.”

“The purpose of the recoiling arch has previously been suggested to propel the body’s centre-of-mass forward and upward, despite the relatively small magnitude of arch rise. Using a simulated arch without recoil, I identify that the arch-spring does not contribute directly to lifting the centre-of-mass. Instead, the recoiling arch increases the time available for the ankle to plantarflex and provides a mechanical advantage to the ankle plantar flexor muscles.”

So, what is the takeaway from all of this biomechanical research and terminology? Broken down into steps, here is our takeaway.

(1) Proper great toe extension allows for **(2)** appropriate tensile stretching/winding of the plantar fascia leading to an **(3)** efficient windlass mechanism throughout the foot. With the proper windlass mechanism you have **(4)** optimal arch-spring loading, while you are in the swing phase of your gait cycle **(5)** the recoil of the arch increases your bodies ability to prepare and reuse as much energy stored within the tissues of your foot in preparation for the next foot strike. **(6)** Heel plant and restart at great toe extension

If you are missing step 1, it's hard to get through to step 6!

If you or someone you know needs help on their road to recovery, give us a call at (331)-215-4919 or message us here for appointment availability!

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