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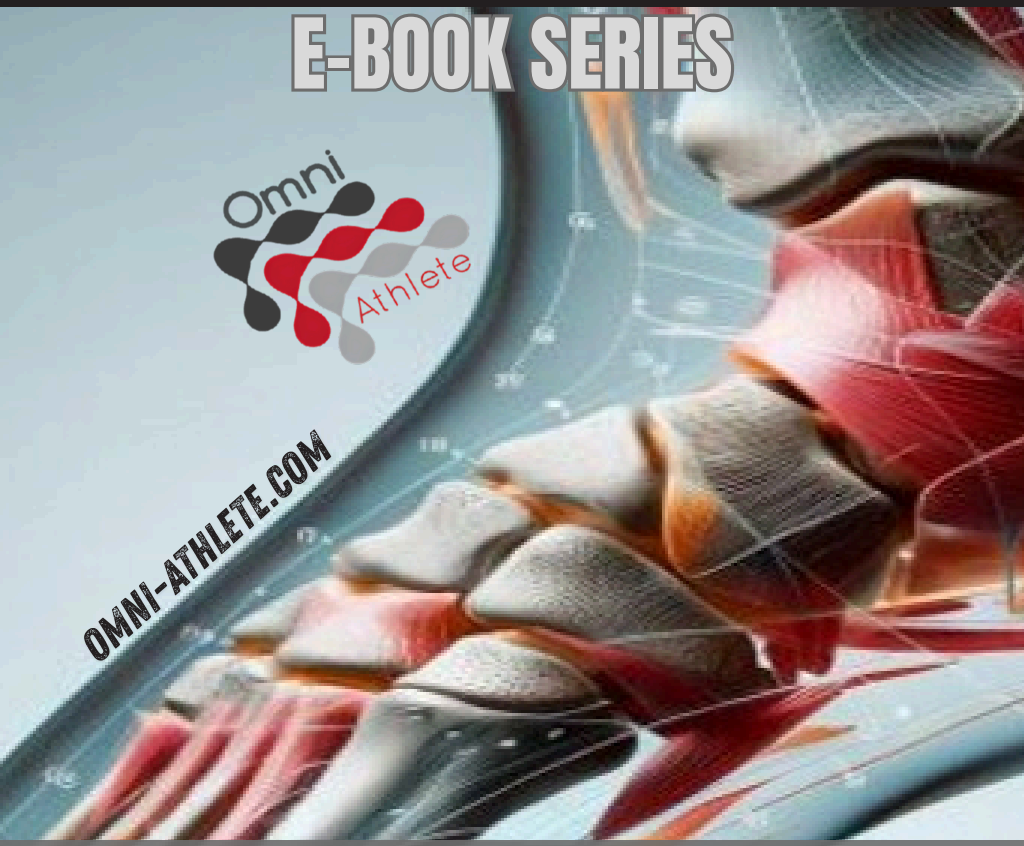


3 KEY MECHANISMS FOR FUNCTIONAL ADAPTABILITY AND STRUCTURAL INTEGRITY OF THE FOOT

by Antonio Robustelli

Functional Adaptability and Structural Integrity

The foot is a highly complex structure, characterised by modular components, highly interacting between them and with an unpredictable behaviour.

Functional adaptability refers to the ability of the foot to immediately adapt and modulate the level of tissue stiffness, compliance and flexibility based on the speed of movement, the material of the shoe and the type of surface over which is moving.

Structural integrity refers to the capacity to manage shock absorption, pressure (re)distribution and force transmission under high loads and through a wide range of dynamic locomotor activities.

The foot is able to conform to variations in load and surface and to maintain effective force transmission between the lower limb and the ground.

3 Key Mechanisms for Functional Adaptability and Structural Integrity

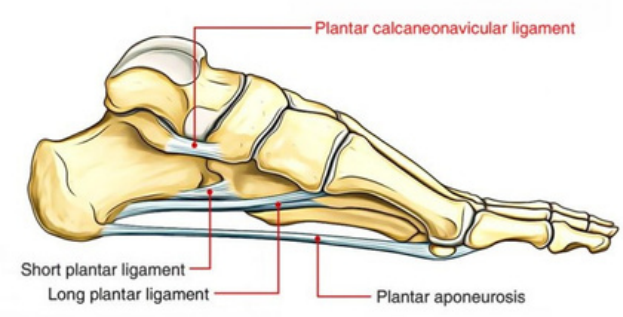
In order for the foot to accomplish its tasks of acting simultaneously and/or sequentially as a brake, spring, buffer, and stiff conduit to ensure proper high shock impact absorption, braking strategies, stabilization and propulsive force generation, it relies on three key mechanism.

The mechanisms are as follows:

1. Windlass Mechanism
2. Longitudinal Arch
3. MTP Joint

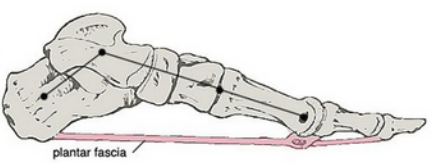
1 WINDLASS MECHANISM

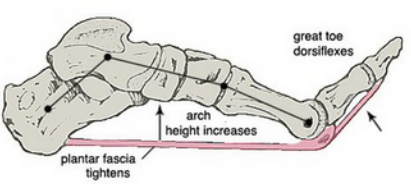
Plantar aponeurosis and windlass mechanism represents two key contributors to foot stiffness during human gait.



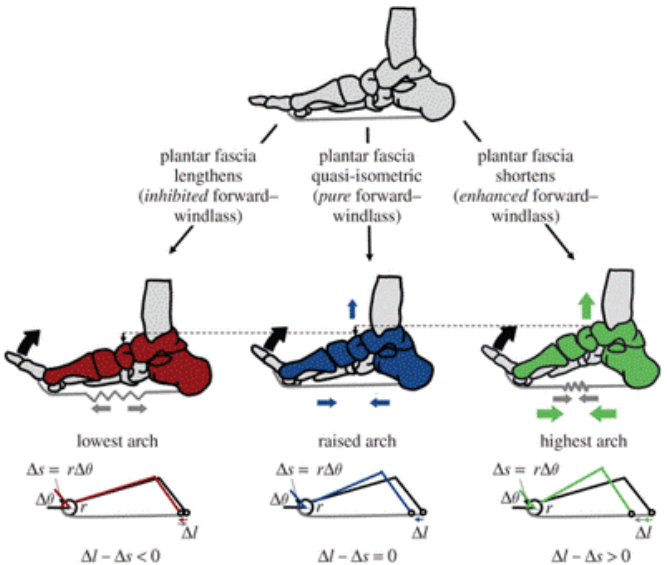
Windlass = tightening of a rope/cable

The windlass mechanism is a mechanical model describing how the plantar fascia is supporting the foot during weight-bearing activities. It is fundamental in the end-phase of midstance, transitioning into the propulsive push-off.





The extensibility of the plantar fascia can inhibit or enhance the forward-windlass mechanism's effect on arch deformation (Welte *et al.*, 2021).



Plantar fascia lengthened at the end of mid-stance and into push-off = inhibition

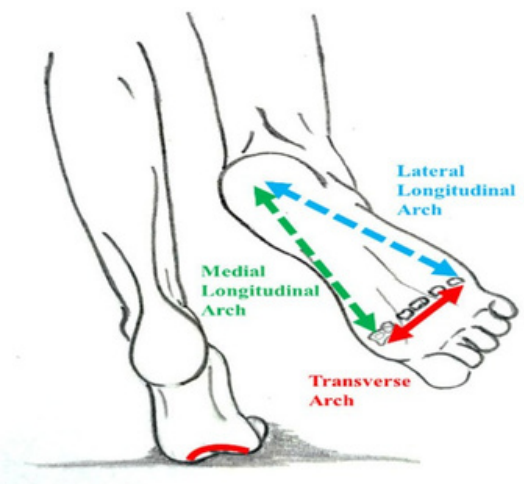
Plantar fascia in a quasi-isometric contraction at the end of mid-stance and into push-off = normal function

Plantar fascia shortened at the end of mid-stance and into push-off = **the athletic foot**

2 LONGITUDINAL ARCH

Humans adjust the stiffness of the longitudinal arch in coordination with the ankle joint to help regulate the overall stiffness of the leg spring during running.

The longitudinal arch can be considered as a mechanism to optimize the leg's mechanical response.



(Holowka *et al.*, 2021)

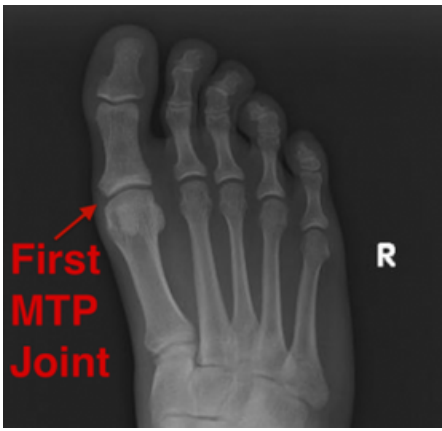
- SOFT SURFACES
  Stiffer longitudinal arch to enhance force transmission
- HARD SURFACES
  More compliant arch to dampen damaging GRFs

3 MTP JOINT

The hallux should dorsiflex to a minimum of 40 degrees to prevent a reduction in stride length resulting from premature heel rise.

Insufficient dorsiflexion (50° – 65°) may result in the following:

- Premature heel rise
- Reduced stride length
- Impaired propulsion
- Difficulty transferring weight across the transverse tarsal axis (defined as the line between the first and second metatarsals)



What compensatory strategies does the body implement in the presence of inadequate dorsiflexion of the big toe?

1

HIP FLEXION

2

KNEE FLEXION

And how does it affect the lower posterior chain?

- Early heel rise shortens stance phase
- Increased knee flexion generates greater sagittal plane shear forces during propulsion
- Hip flexor issues: tendonitis, bursitis, inhibition

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