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Short Communication

# The Role of Transverse Arch in Foot Stiffness and Its Clinical Implications

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**Abstract** : The human has the most evolved arched feet. Initially, a transverse arch developed in feet like the carpal arch till modern human arches evolved, which included a longitudinal and transverse arch.

**Keywords** : Arch of foot, Foot stiffness, Longitudinal arch

The longitudinal arch is a unique load-sharing four-layered structure (plantar fascia, intrinsic plantar muscles, plantar arch extrinsic muscles, and plantar ligaments) to serve the propulsive functions [1]. The arch supports the foot with the stiffness essential to perform as a lever that transfers the forces generated by calf muscles as the feet thrust against the ground. The arch also preserves sufficient elasticity to work like a spring to store and then release mechanical energy. It works synergistically to increase longitudinal arch stiffness during weight-bearing activities [2]. However, the role of the transverse arch is still enigmatic, and researchers were clueless about a persistent transverse arch if it has no functional importance.

Venkadesan et al. published "Stiffness of the human foot and evolution of the transverse arch" in Nature and discussed the role of foot stiffness in evolution of bipedalism [3]. The researcher explained very well that foot stiffness which is essential for propulsion during movement is not solely from longitudinal arch as believed earlier. They emphasized that transverse arch contributes to more than forty percent of foot stiffness. The transverse arch not only supports the lateral longitudinal arch but also prevents forefoot bending [3]. They presented a different view on the transverse tarsal arch and how it contributes to foot stiffness. This finding not only enables us to understand the foot evolution but also provides insight into the biomechanics of the transverse arch. Venkadesan and colleagues demonstrated the transverse arch's (at the base of the metatarsal bones) contribution in foot stiffness almost equal to the longitudinal arch (Fig. 1). The authors explained the biomechanics of foot stiffness by transverse-arch curvature, which prevented the foot bending [3]. The authors examined human cadaveric foot specimens after cutting ligaments of the transverse tarsal arch. The foot's vertical deformation was evaluated after loads were applied. Cutting the transverse ligaments have reduced foot stiffness by forty percent. The plantar aponeurosis (stretched between two ends of the longitudinal arch) was incised which reduced the foot stiffness by twenty-three percent. The transverse ligament

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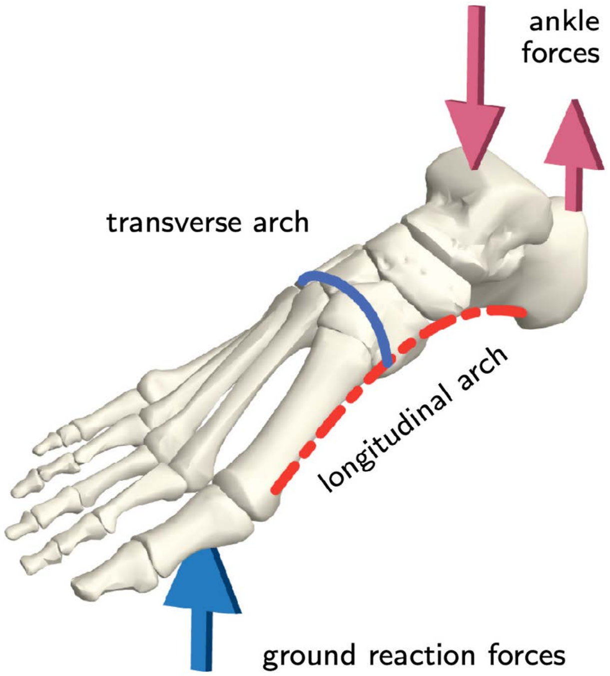


**Fig. 1.** Schematic diagram of Arches of foot and their biomechanics [3] (Permitted Springer Nature).

assembly is stretched by spreading out of the metatarsals at the ball of the foot upon a load bearing [4]. The researchers imply that the ligament stretching is possible because of transverse-arch curvature. Thus, the transverse arch has crucial role in midfoot stiffness modulation. The view, as mentioned earlier, could explain the mystery of why orthopaedic surgeries provide pain relief for some patients and not for others in case of arch pain [1].

The majority of the flexible flat foot are asymptomatic because of the existing transverse arch. It has been suggested that flat feet (low longitudinal arch) have a relatively high transverse arch, which provides adequate foot stiffness. The rigid flat foot has no transverse arch, which might cause hyper-pronation of the foot leading to peroneus tendinopathies. It may be leading to deformities like ankle valgus and hallux valgus [4]. The collapse of transverse arch leads to tarsal coalition and vertical talus. Zeidan et al. (2020) have examined the transverse arch in subjects using high heel. They found that using high heel leads to shortening of transverse arch due to windlass mechanism [6]. Similarly, Zeidan et al. (2019) have compared the transverse arch height in normal feet and hallux vulgus feet. They revealed that the length and height of transverse arch are more in hallux vulgus as compared to normal foot [7]. The future research should examine the linkage between the degrees of flat-footedness and their transverse arches. The estimation of the transverse arch curvature in living people to understand foot biomechanics better might be the key to building corrective orthotics [1]. This finding has practical implication in designing the prosthetics, robotics and foot health. Also, in the future, shoe store employees might be able to scan customer's feet and provide personalized recommendations based on the contour of the feet [5]. It is understandable that modulation of transverse-arch curvature could be the strategy of treatment for various foot disorders. The adjustment of longitudinal and transverse arches of designed prosthetic limbs or legged robots would mimic human foot functionally. Thus, it highlights that the foot is three-dimensional, and researchers should think about transverse arch while designing the prosthetics or implants.

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