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Role of the tranverse arch in stiffness of the human foot¹ MARCELO A. DIAS, Aalto University, DHIRAJ K. SINGH, MAHESH M. BANDI, Okinawa Institute of Science and Technology, MADHUSUDHAN VENKADESAN, Yale University, SHREYAS MANDRE, Brown University — Human ancestors evolved from walking, around 6 million years (Ma) ago, to regular endurance running, around 2 Ma ago. Simultaneously, the feet evolved from a relatively flat structure like that of current day Chimpanzees (or our hands), to the modern human foot with two arches, a longitudinal and a transversal arch. The feet play a crucial role in locomotion by providing sufficient stiffness for propulsion, and being soft and pliable to absorb impacts and store energy elastically. Here we show that the transverse arch could play a central role in stiffness modulation. We first treat the foot as an elastic shell that is with intrinsic curvature. Calculations, numerics and physical experiments all show that for a foot-like shell, the stiffness has a power-law dependence on transverse curvature beyond a critical value. On the other hand, for purely longitudinally curved feet, or transverse curvature below the critical value, lead to low stiffness like a flat plate. Discrete realizations of a continuum shell, more closely resembling the human foot, also exhibit curvature induced stiffening. These results shed light on the role of the quintessentially human feature of a doubly arched foot, and suggest mechanical consequences of disorders such as a collapsed arch.

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