Shedding light on the complex evolution of human feet

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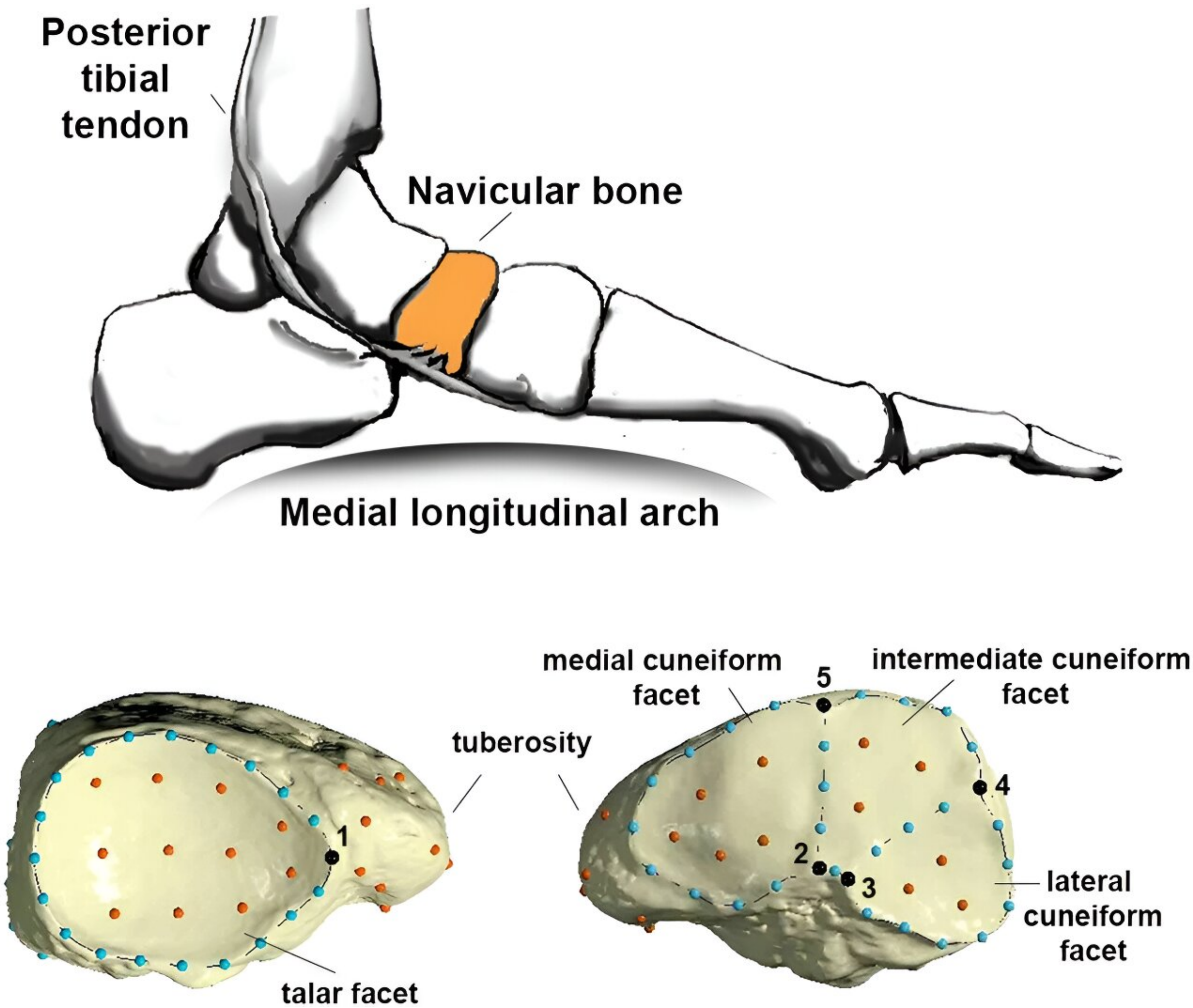

Anatomical position of the navicular (orange) in the medial column of the foot (top). Along the bottom, renderings of an archaeological *H. sapiens* navicular (from the Frassetto identified human skeletal collection – University of Bologna) is illustrated in proximal (bottom left) and distal (bottom right) views. Placement of landmark and semi-landmark configurations are shown: five fixed landmarks (black), 46 curved semi-landmarks (light blue) describing corresponding articular surface contours, and 34 surface semi-landmarks (orange) on articular surfaces and the navicular tuberosity. Credit: *Communications Biology* (2023). DOI: 10.1038/s42003-023-05431-8

An extensive study, published in *Communications Biology*, sheds new light on the complex evolution of our feet.

"The human foot is one of the most complex masterpieces of evolution, a work of art in biomechanics: not only does it allow us to walk, run and jump, but it is also a true witness of our past and our present," says Rita Sorrentino, researcher at the Department of Biological, Geological and Environmental Sciences at the University of Bologna and first author of the study.

The research, involving researchers from the Rizzoli Orthopaedic Institute and the University of Pisa, focused on the medial longitudinal arch of the foot: a unique characteristic that differentiates our species—Homo sapiens—from non-human primates.

The longitudinal arch and the flat feet problem

The longitudinal arch is a functional adaptation that allows the foot to switch from a shock absorber function to a lever during the phases of contact and detachment with the ground, a mechanism that allows us to have an efficient bipedal walk.

Despite its importance, however, it is still unclear when this characteristic appeared in the course of our evolutionary history. The topic of "flat feet" complicates the picture even more: it is a widespread condition that consists of a more or less pronounced flattening of the medial longitudinal arch.

"Not all flat feet are the same, and yet there is not a worldwide clinical definition of flat feet in human beings," explains Alberto Leardini and Claudio Belvedere, scientists from the Laboratory of Movement Analysis and Functional Evaluation of Prosthesis of the Rizzoli Orthopaedic Institute and among the authors of the study.

Scientists have focused, in particular, on the role of the navicular bone in order to find answers, the keystone of the medial longitudinal arch of the foot.

"The results of this research highlight the variation of navicular morphology among flat-footed people and people with a well-developed longitudinal arch," explains Maria Giovanna Belcastro, professor at the Department of Biological, Geological and Environmental Sciences at the University of Bologna and research coordinator. "More specifically, people who developed flat feet during adulthood show differences concerning the navicular bone shape compared to those with regular arches or with inborn flat feet."

This development raises questions about the nature of inborn flat feet, suggesting that they may represent a normal variant of foot morphology and thus highlighting the importance of bone morphology in the structure of the foot arch.

Feet and lifestyle

Scientists also focused on differences within modern Homo sapiens population groups. Indeed, the results suggest that the development of the longitudinal arch may be influenced by factors such as the type of footwear, lifestyle, and prevailing locomotion strategies.

"We have observed that individuals belonging to hunter-gatherer groups, who live without footwear, show feet that are more flexible in mobility and relatively flatter than those of populations using modern footwear," explains Damiano Marchi, professor at the University of Pisa, one of the discoverers of Homo naledi and one of the coordinators of the study.

"These differences may come from different cultural lifestyles and practices: the feet of hunter-gatherer populations could, therefore, represent a form closer to that of our prehistoric ancestors."

Comparing fossils

The investigation also compared the structure of our feet with fossils of ancient Homo sapiens and other human species of the past.

"Some of the fossils analyzed, such as those of Homo floresiensis, Australopithecus afarensis, and Homo naledi, show features in the navicular more similar to those of large non-human primates, suggesting an adaptation to both an arboreal and bipedal lifestyle," explains Stefano Benazzi, professor at the Department of Cultural Heritage at the University of Bologna, one of the study coordinators.

"At the same time, the Homo habilis fossils seem to have a configuration more similar to the feet of modern humans, indicating a possible presence of the longitudinal arch; however, this does not exclude the possible presence of a flat foot similar to today's congenital flat feet, given the morphological similarity and proximity of the navicular to that of individuals with a developed longitudinal arch of the foot."

The research ultimately offers a new perspective on the evolution of the human foot and its variability, contributing to our understanding of how this body part has adapted to bipedal locomotion.

Sorrentino explains, "Our foot is a true witness to our past and our present, a fascinating chapter in the great history of human evolution. The results of this investigation provide a comprehensive overview of the morphological variability of the human foot throughout evolution and raise important questions about congenital flat feet, suggesting that they may represent a normal variant of human foot morphology."

More information: Rita Sorrentino et al, Morphological and evolutionary insights into the keystone element of the human foot's medial longitudinal arch, *Communications Biology* (2023). DOI: 10.1038/s42003-023-05431-8

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