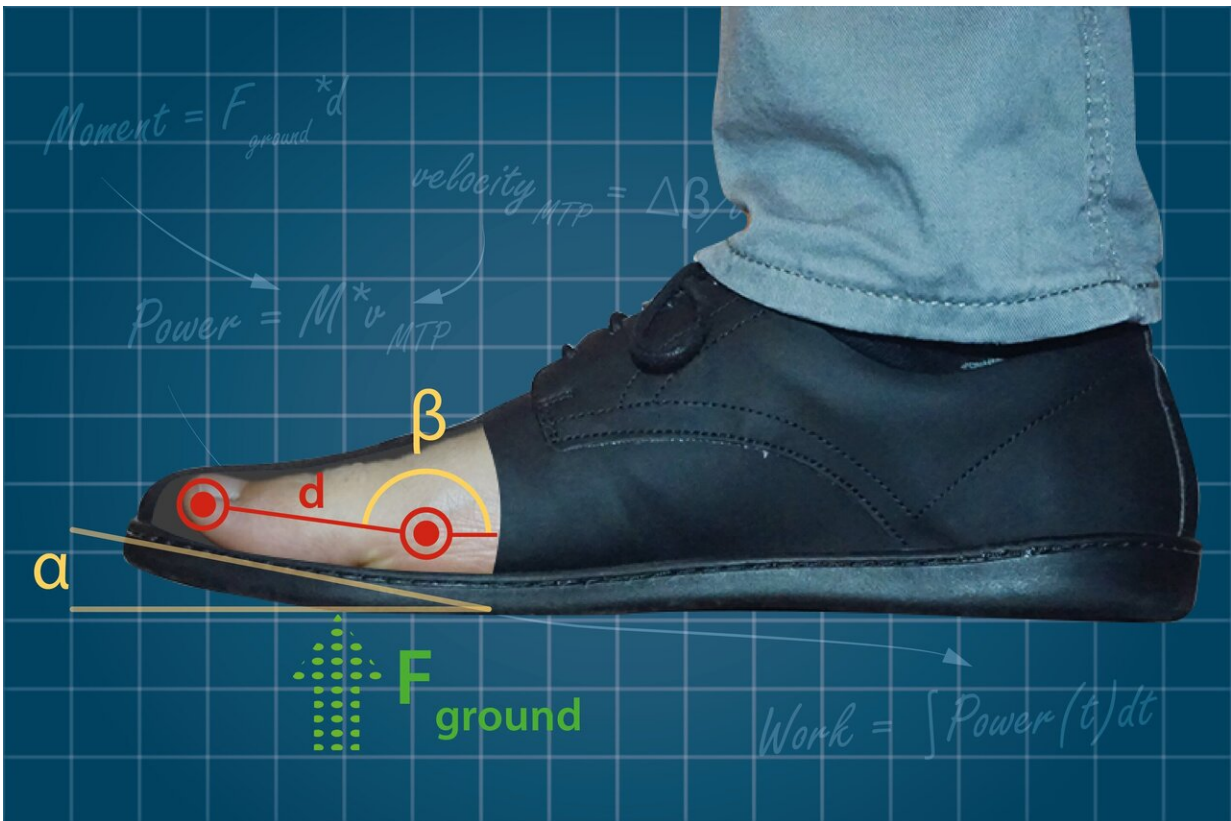


Curve at tip of shoes eases movement but may lead to weaker muscles, problems: study

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Graphic of a toe spring. Credit: Freddy Sichtung

The toe of most shoes, especially sneakers, bends ever so slightly upward. While that curve, called a toe spring, can make stepping more comfortable and easier, it may also weaken feet and potentially open

them up to some common (and painful) foot-related problems.

That's the conclusion reached by Harvard evolutionary biologist Daniel E. Lieberman, his former undergraduate student Oliver B. Hansen '19, and two former post-doctoral researchers, Freddy Sichtung and Nicholas B. Holowka, who studied toe springs and their effect on the biomechanics of walking. Their research is detailed in a new edition of *Scientific Reports*.

The scientists found that the more curved a toe spring is, the less power the [foot](#) inside the shoe has to exert when pushing off from the ground while walking. That means [foot muscles](#) are doing less work, and this, the researchers hypothesize, may have consequences.

"It stands to reason that if the foot muscles have to do less work, then they're probably going to have less endurance given that many thousands of times a day you push off on your toes," said Lieberman, the Edwin M. Lerner II Professor of Biological Science and senior author on the paper.

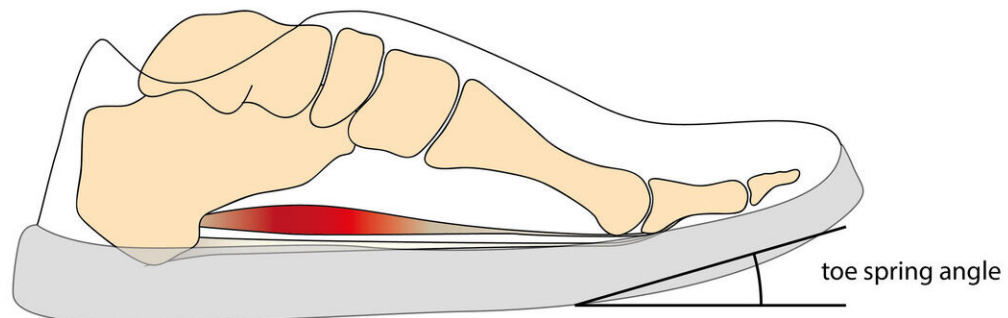
The researchers say this potential weakness could make people more susceptible to medical conditions like [plantar fasciitis](#)—a common, hard to repair, and painful inflammation of the thick, web-like band of tissue that connects the heel bone to the toes.

"One of the biggest problems in the world today of people's feet is plantar fasciitis," Lieberman said. "We think that what happens is that people are relying on their plantar fascia to do what muscles normally do. When you get weak muscles and the plantar fascia has to do more work, it's not really evolved for that, and so it gets inflamed."

The scientists say their next step is to validate their hypothesis in future studies.

"From an evolutionary perspective, wearing modern shoes that have arch supports, cushioning, and other supportive features is a very recent phenomenon," said Sichtung, who's now a professor of human locomotion at Chemnitz University of Technology in Germany and served as the paper's first author. "Several lines of evidence suggest that weak foot muscles may be partly a consequence of such features. In our research, we were interested in a nearly ubiquitous element of modern shoes that has not been studied before: the upward curvature at the front of the shoe."

He means the toe spring, of course, which constantly flexes the toe box above ground and has become nearly ubiquitous in modern footwear, especially in athletic shoes.



The toe of most shoes, especially sneakers, bends ever so slightly upward. This is called a toe spring. Credit: Freddy Sichtung

The project started after Sighting and Lieberman met at a conference in Boston, and (of course) went for a run by the Charles River where they talked about foot biomechanics and plantar fasciitis. That led to Sighting coming to Lieberman's Skeletal Biology and Biomechanics Lab in 2018 to work on the project with Holowka, who's now an assistant professor of anthropology at the University of Buffalo, and Hansen, a former Crimson rower who graduated with a concentration in human evolutionary biology. Hansen worked on the paper as part of his senior honor's thesis.

In the experiment, 13 participants walked barefoot and in four pairs of custom-made sandals on a specially designed treadmill. The treadmill is equipped with force plates and an infrared camera system to measure how much power is put into each step. The sandals each had varying degrees of toe spring angles—from 10 degrees to 40 degrees. They were designed to mimic the stiffness and shape found in commercially available shoes.

It became clear while analyzing the data that the propulsive force generated by the metatarsophalangeal or MTP joints (that's where the toes connect to the rest of your foot bones) decreases as the curve of the toe spring on the specially-made sandals increased. MTP joints are one of the key features that have evolved so that humans can walk and run on two feet so effectively and efficiently.

"By reducing moments at the MTP joints, toe springs likely relieve the intrinsic foot muscles of some of the work necessary to stiffen these joints," the researchers wrote in the study. "These small differences in muscle work likely add up to substantial differences over time when considering that the average individual in industrialized countries takes 4,000 to 6,000 steps per day. Thus, habitually wearing shoes with toe springs could inhibit or de-condition the force generating capacity of intrinsic foot muscles."

The researchers make clear in the paper that more research is needed on all fronts and that their study does not directly link toe springs with plantar fasciitis or other common foot problems. The study also included only habitual [shoe](#) users whose feet may already have been adapted to shoes with toe springs.

"This study isolated just one element of our shoes," said Hansen. "More research is needed to investigate how toe springs interact with other elements of shoes such as stiff soles or cushioning. This could give us a more complete picture of how shoes affect our biomechanics."

Still, they say the unrecognized biomechanical effects of toe springs on foot function merits further consideration.

"Walking in shoes with comfortable features such as a toe spring has its costs," Sichtung said.

Don't expect toe springs to go anywhere anytime soon, though.

"We like comfort," Lieberman said. "That's why we sit in chairs and take elevators."

More information: Effect of the upward curvature of toe springs on walking biomechanics in humans, *Scientific Reports* (2020). [DOI: 10.1038/s41598-020-71247-9](https://doi.org/10.1038/s41598-020-71247-9), www.nature.com/articles/s41598-020-71247-9

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