Medical Xpress

Foot and ankle structure differs between sprinters and non-sprinters

January 24 2012

The skeletal structure of the foot and ankle differs significantly between human sprinters and non-sprinters, according to Penn State researchers. Their findings not only help explain why some people are faster runners than others, but also may be useful in helping people who have difficulty walking, such as older adults and children with cerebral palsy.

According to Stephen Piazza, associate professor of kinesiology, the research is the first to use magnetic resonance imaging to demonstrate that sprinters have significantly longer bones in their forefeet than non-sprinters and reduced leverage in their Achilles tendons than non-sprinters.

"We made the most direct measurement possible of leverage in the Achilles tendon and found that sprinters' tendons had shorter lever arms -- or reduced leverage for pushing their bodies off of the ground -- compared to non-sprinters," said Piazza.

Piazza explained that there may be a trade-off between leverage and tendon force when rapid muscle contraction is required.

"Imagine a wheelbarrow with 30-foot handles. Such long handles would provide you with great mechanical advantage compared to what you would get from a wheelbarrow with three-foot handles, but rapidly producing the same rotation of this wheelbarrow would be more difficult because you'd have to move the ends of the handles really fast. It is easier for your hands to generate these lifting forces when they move a

few inches rather than a few feet in the same amount of time," said Piazza. "The Achilles tendons are like your hands; they are better able to lift your body (the wheelbarrow) when the handles are long enough to provide sufficient leverage without being so long that they prevent rapid force generation by the calf muscles."

According to Josh Baxter, graduate student, shorter Achilles tendon lever arms and longer toe bones permit sprinters to generate greater contact force between the foot and the ground and to maintain that force for a longer time, thus providing advantages to people with sprinter-like feet.

To conduct their research, the scientists studied two groups of eight males, for a total of 16 people. The first group was composed of sprinters who were involved in regular sprint training and competition. The second group consisted of height-matched individuals who never had trained or competed in sprinting. To be included in the sprinter group, individuals were required to currently be engaged in competitive sprinting and have at least three years of continuous sprint training. Of the eight sprinters, six competed in the 100-meter dash, with personal-best times ranging from 10.5 to 11.1 seconds. The other two men reported 200-meter personal best times of 21.4 and 24.1 seconds.

The researchers took MRI images of the right foot and ankle of each of the subjects. They then used specialized software to analyze the images. The scientists found that the Achilles tendon lever arms of sprinters were 12 percent shorter than those of non-sprinters. They also found that the combined length of the bones in the big toes of sprinters was on average 6.2 percent longer than that of non-sprinters, while the length of another foot bone, the first metatarsal, was 4.3 percent longer for sprinters than for non-sprinters. Their results are reported in the current issue of the *Proceedings of the Royal Society B*.

In addition to imaging the feet and ankles of sprinters and non-sprinters,

the scientists also developed a simple computer model to investigate the influence of foot and ankle dimensions on muscle contributions to forward propulsion at various speeds. They found that longer forefeet and smaller Achilles tendon lever arms allowed the calf muscles to do more work, which is the goal during the acceleration phase that occurs at the start of a sprint race.

Baxter said that although the results might lead to tests that tell whether a person has the potential to be a sprinter, other factors such as body type, the dimensions of the limbs and the presence of fast-twitch muscle fibers also are important in determining if competitive sprinting is within the realm of possibility for an individual.

"In addition it is unclear whether the differences in foot and ankle skeletal structure are adaptations to sprint training or are hereditary," said Baxter. "There is evidence that human skeletal strength and form are altered by certain types of athletic training."

Piazza added that the results have implications beyond just understanding what makes sprinters run so fast.

"Our results may be useful in helping people who have difficulty walking, such as older adults and children with cerebral palsy," he said. "If we can better understand how the shapes of bones influence not only muscle leverage but also the ability to move, it may be possible to surgically alter the foot bones of people who lack mobility to help them move better. The results even might lead to screening tools for the general population as well; an MRI could determine if you are at greater risk for loss of mobility. If so, you might be more motivated to maintain your ankle strength with a strength-training program."

The MRI measurements made in the study were carried out at the Penn State Social, Life, and Engineering Sciences Imaging Center (SLEIC).

Others involved with the research include Penn State undergraduate student Thomas Novack, graduate student Herman van Werkhoven and SLEIC staff member David Pennell.

Provided by Pennsylvania State University