Starting Off on the Wrong Foot

The human body is amazingly capable…despite the fact that, in many places, it's engineered all wrong.

Take for example, our lower leg. Our foot has 26 bones, and our ankle, 7. Far more moving parts than needed to walk or run, making us much more prone to injury.

How did this happen?

Well, we evolved from earlier hominins who evaded predators and found food in the trees.

Those ancestors needed a grasping foot, like a chimpanzee's—with a big toe like an opposable thumb and a flexible ankle like a wrist.

As we climbed down from the trees and onto land, our feet had to evolve.

The foot and ankle became rigid to make a propulsive lever. The arch developed as a shock absorber. The big toe moved forward in line with the others.

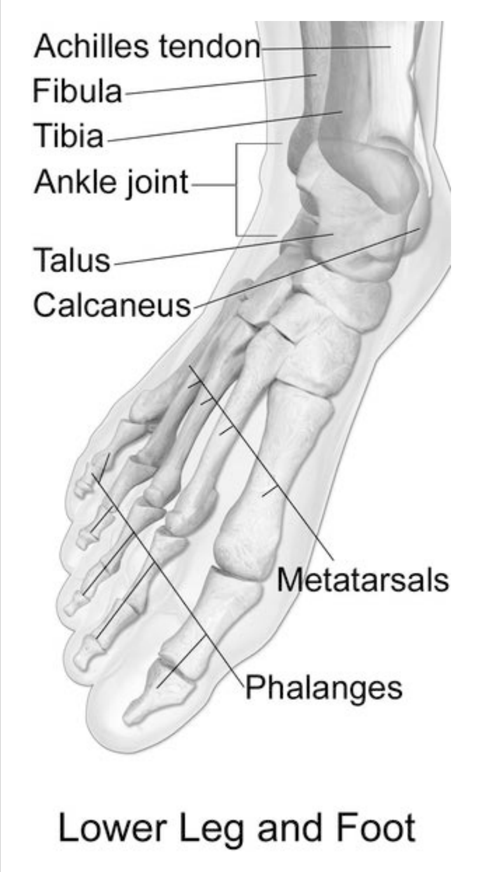
This worked well enough. Even though they're built on an old structure more like hands, our flawed feet carried us into the modern day.

Now, look down at your feet and imagine a different design: a streamlined lower leg wrapped in ligaments, not muscles; a fused ankle ending in one or two large, simple toes with just one bone in each.

Sounds weird—but this is the structure that propels ostriches and horses to speeds over 40 miles an hour, absorbing more stress while using comparatively less energy.

Different structures, borne from different evolutionary pressures.

We'll look at other curious cases of human evolution in future *EarthDates*.



Anatomy of the human foot and ankle.

Credit: Blausen.com staff (2014), WikiJournal of Medicine; doi:10.15347/wjm/2014.010 (CC BY 3.0 [https://creativecommons.org/licenses/by/3.0]), via Wikimedia Commons

Background: Starting Off on the Wrong Foot

Synopsis: If you could design the most efficient foot for balancing, walking, or running upright, it wouldn't have 26 bones in it, like the human foot. How did our feet evolve to support us?.

- Of all Earth's animals, only humans and birds are truly bipedal. The natural stance of other animals depends on four or more legs.
  - Humans are plantigrade, meaning they stand flat on their feet.
  - Birds are digitigrade, meaning they stand on their toes.
- The human foot serves as a stable platform when we are standing, and as a propulsive lever when we are walking or running—so why does it need 26 bones?
  - The human lower leg is far more complex than it needs to be. As a result, human feet and ankles suffer a wide variety of maladies such as sprains, compression fractures, flat-footedness, plantar fasciitis, bunions, tendonitis, and bursitis.
  - As primates, humans evolved through a series of evolutionary steps. Early hominins adapted to stay safe from predators by living in trees and required a flexible grasping appendage like we see in today's chimpanzees and apes—and in our own wrists and hands.
  - As human ancestors evolved to walk upright on two legs about 5 million years ago, the grasping foot was eventually remodeled into the rigid lever that propels us forward today.
    - To provide a stable platform for propulsion, the foot had to become stiff and develop an arch to act as a shock absorber. The big toe had to shift from an opposable orientation (like our thumbs) to alignment with the other toes.
  - Human ankles have seven bones and intervening ligaments that all move together. Our ankles would be stronger and less prone to injury and would function just as well if these bones were simply fused together into one bone.
    - Healed broken ankles have been observed in fossils dating back 3 million years.
- Birds evolved to be bipedal around 230 million years ago, so they had a big head start on humans. If we could redesign our legs and feet to optimize upright balance and locomotion, we might choose a design more like that of an ostrich.
  - Ostriches can run faster than most birds can fly. Running at 37–44 mph (60–70 kmh), an ostrich could do an entire Olympic marathon in just 40 minutes, three times faster than human champions require.
  - Instead of using energy-consuming muscles for stabilization, ostrich joints are stabilized by ligaments, greatly improving their endurance.
  - Like other birds, the ostrich's anatomical ankle is midway up its leg and looks like an inverted knee. Its actual knee is up at its chest, and the thigh is a short horizontal bone connecting to the hip. The musculature of the ostrich's leg is high up, close to the body, while the lower leg is very light and easy to swing, providing for both a faster pace and a longer step length.
  - Ostriches have just two toes, with soft soles to dampen stress. The larger toe acts as a spring-loaded shock absorber, while the second is used like an outrigger. Each toe is a single bone.
  - They are perfect running machines; however, they are also top-heavy and can be knocked off balance—if you can catch them!
  - Some robots are designed to move like ostriches.

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References: Starting Off on the Wrong Foot

Human Evolution: Gain Came with Pain | sciencemag.org
The Scars of Human Evolution | AAAS
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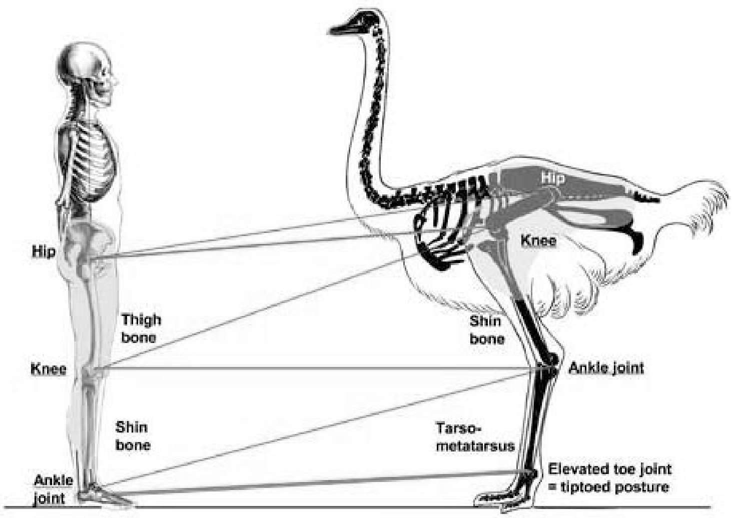
- Birds aren't the only creatures that run on their toes.
  - Mammals evolved from a common ancestor with five toes, but some animals ended up with hooves.
    - The hoof of a horse is actually the toenail of the enlarged middle toe of the horse. The side toes disappeared over millions of years.



A comparison of the anatomy of human and ostrich legs. Red lines connect anatomical points; green lines connect functionally equivalent joints.

Credit: Nina Schaller, via ScienceinSchool.org

Horse hooves are the toenails of the enlarged middle toe of the horse.

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