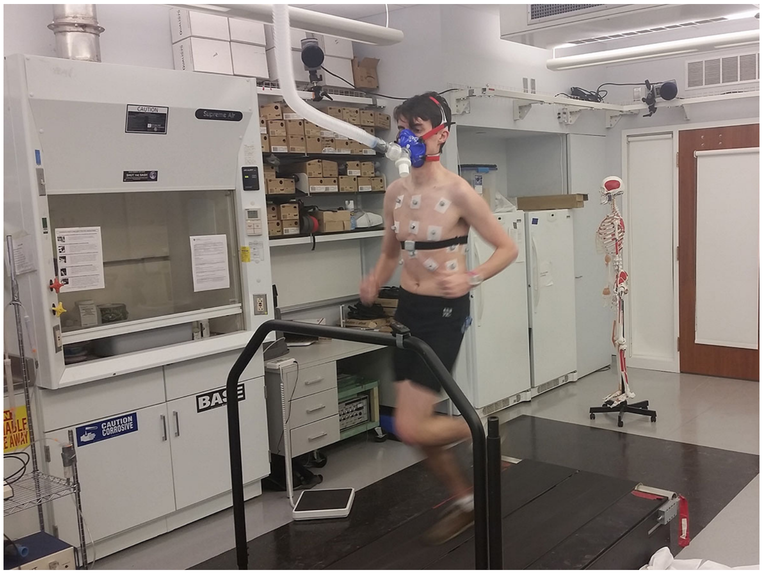
INSIDE JEB

Flexible rib joint frees running humans



A runner on a treadmill. Photo credit: Éamon Callison.

We may only have two legs, but when it comes to walking and running we have more in common with wildebeest and wolves than we do with our nearest cousins. 'Chimpanzees rarely sprint and do so only for short distances of less than 100 m', says Éamon Callison from Harvard University, USA. Yet, humans are prodigious walkers and runners; some, like the most extreme migrants, even complete ultra-marathons covering thousands of miles. One of the keys to long-distance running seems to be a good breathing rhythm. 'Humans normally rely on contracting the diaphragm to suck in air when breathing quietly', says Callison. However, when we really push ourselves, our rib cages begin to heave, dragging in as much air as possible to keep our muscles pumping. This made Callison and Daniel Lieberman, also from Harvard, wonder whether our rib cages have adapted over the millennia to help us inhale large volumes of air during exertion. Teaming up with Nicholas Holowka, also from Harvard, they decided to compare the rib cages of running humans and greyhounds with those of goats, which rarely break into a trot.

Attaching reflective markers to the torsos of 10 healthy young athletes, three greyhounds and three goats, Callison and Holowka filmed their chests as each participant ran at a series of paces, from a leisurely saunter to a full-out sprint, on a treadmill. 'It was pretty easy to explain to our human volunteers what we needed them to do. Convincing our goats and dogs was another story; that required a fair bit of training and several boxes of treats', chuckles Callison. Then, the duo reconstructed how the runners' chests moved as they began breathing more heavily. Not surprisingly, the goats' chests did not contribute at all to inhalation; they relied entirely on their diaphragm to pull in air even when running their hardest. And, when the duo analysed the movements of the dogs' rib cages, they found they only expanded forward. However, the rib cages of human athletes expanded sideways in addition to expanding forward, increasing the volume of air they could inhale by up to 2.5 l. Our rib cages were definitely more flexible than those of other extreme animal athletes, so the team took a closer look at the joint where the rib attaches to the spinal column to find out whether they could find differences between the endurance athletes and less-active animals.

Fortunately, Harvard is well equipped with museums, so the team visited the nearby Museum of Comparative Zoology and the Peabody Museum of Archaeology to compare the rib cages of modern humans with those of animals ranging from chimpanzees and dogs to wolves, black bears and rhinos. Using photographs taken from various angles of the tip of each rib and the vertebra with which it interlocks, Callison painstakingly generated detailed 3D reconstructions of the joints. Comparing the shape of the bone surfaces that slide past each other as the ribcage flexes, it was clear that they were much flatter and the joint less flexible in the skeletons of goats than in those of dogs and humans. 'More-curved joints should allow the ribs to move more when taking larger breaths', says Callison.

Finally, the team looked back in time and compared the joint from our most ancient human ancestors (2.9 million year old *Australopithecus afarensis*) with that of chimpanzees and our more recent relatives, *Homo erectus* and Neanderthals, and it was clear that we evolved the flexible joint around the same time that our ancestors took up walking and running.

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