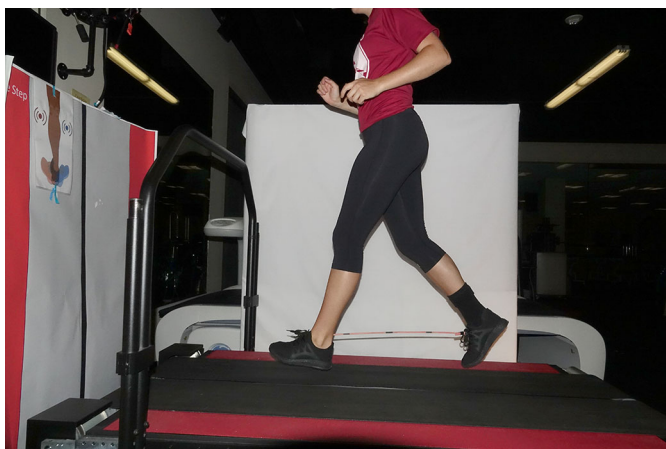


INSIDE JEB

Springy ankle tether saves runners' legs



An athlete running with a springy ankle tether on a treadmill. Photo credit: Cara Welker and Cole Simpson.

If you're not a natural runner, it takes a lot of effort to get out and pound the streets; and that's not just my personal opinion. 'Human running is inefficient', says mechanical engineer Elliot Hawkes from the University of California, Santa Barbara, USA. Cycling through San Francisco's Golden Gate Park during his postdoc at Stanford University, Hawkes noticed that runners wasted energy each time they stopped and started their swinging legs. Back at Stanford, Hawkes discussed the problem with mechanical engineer Cole Simpson and together they came up with a simple way of recycling some of the energy that is usually squandered. Why not tie the legs together with an elastic band that could store energy when stretched to pull the foot forward at the beginning of the next stride?

Intrigued by the suggestion, Stanford bioengineer Cara Welker built a computer simulation of an athlete running with a stretchy band linking their limbs, which suggested that human runners could benefit significantly from a stretchy

tether. 'At this point, I joined the team', recalls human gait energetics expert Jessica Selinger, currently at Queens University, Canada, who worked with Hawkes, Simpson and Welker to design experiments to test how the band would store energy to pull the foot forward. '[We] spent months prototyping the device', she says.

Eventually, the team came up with a length of rubber surgical tubing, 25% of the length of the runner's leg, linking their shoes together, which Simpson says was initially disconcerting. 'There's something tugging at your feet, but when you take it off, your legs feel heavy', he smiles. Once the team of 19 volunteer athletes was content running with the new springy tether, the Stanford researchers set them going on a treadmill at about 6 miles per hour (2.67 m s^{-1}) – the average running pace of 36 million users of the Strava social fitness network over 15 billion kilometres – with and without the rubber tube. The team also measured the amount of carbon dioxide exhaled by the runners to calculate how much

energy they were using, in addition to filming some of the runners and recording the activity of the muscles in their legs to figure out how the stretchy link affected their running.

Initially, the tube didn't seem to give the runners much of an advantage; however, by the end of the 2 day experiment, the tethered athletes were using 6.4% less energy than when running freely. 'We were very surprised to achieve savings this high. That percentage is nearly the entire cost typically associated with swinging the legs', says Selinger. The springy tether was saving the runners' legs by pulling them back into action faster at the end of a stride than when they were running unaided, shortening their stride length and increasing their stride rate by 8%, up to 85–95 strides min^{-1} .

But how much could a springy ankle tether improve the finishing time of an average marathon runner in practice? 'A runner, with a natural pace of 2.7 m s^{-1} and finishing time of 4 h 20 min, could expect a 6% improvement in economy with our device', says Hawkes, which could see competitors knock an impressive 15 min off their finish time. And when the scientists tested the springy adaptation on athletes running around the Stanford campus, the team was impressed that all of the runners completed a 4 mile circuit and one even increased his pace to run 5 min 40 s miles.

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Simpson, C. S., Welker, C. G., Uhlrich, S. D., Sketch, S. M., Jackson, R. W., Delp, S. L., Collins, S. H., Selinger, J. C. and Hawkes, E. W. (2019). Connecting the legs with a spring improves human running economy. *J. Exp. Biol.* **222**, jeb202895. doi:10.1242/jeb.202895

Kathryn Knight
kathryn.knight@biologists.com