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SWEAT SCIENCE

It’s Time to Rethink the Ideal Running Cadence

Real-world data shows elite ultrarunners average 180 steps per minute—and that means nothing

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On the surface, the findings from a new study—among the first to harvest biomechanical data from top runners during the heat of real-world competition using wearable technology—seem to support one of the most widely cited and hotly contested rules of running form. For decades, form gurus have argued that runners should aspire to take at least 180 steps per minute. And sure enough, data from 20 competitors at the International Association of Ultrarunning 100K World Championships found that their average cadence was 182.0 steps per minute. But the devil, as usual, is in the details.

The study was published in the Journal of Applied Physiology by Geoff Burns, a biomechanics Ph.D. student at the University of Michigan's Michigan Performance Research Laboratory, and his colleagues. Burns recruited 20 men and women, all of whom finished in the top 25 of the 2016 edition of the 100K championships, which took place in Los Alcazares, Spain. Burns himself was one of the subjects: he finished fifth overall, in a time of six hours, 38 minutes and 34 seconds, as part of the bronze-medal-winning U.S. team.

Cadence, which is simply the number of steps you take each minute, has been a hot topic in running form debates for years, dating back to an observation made by running coach Jack Daniels at the 1984 Olympics. Sitting in the stands and counting steps as the runners whizzed by, he noted that they all seemed to exceed 180—a threshold that came to be seen as almost a law of nature. Taking short, quick steps, the theory goes, optimizes your efficiency and minimizes your injury risk by reducing the impact on your knees and hips with each stride. It's also a relatively simple quantity to measure and change: it's much easier to tell someone to increase their cadence than to suggest they alter other biomechanical parameters like, say, their ground contact time or the angle of their lower leg when their foot hits the ground. But it's never been clear that emulating Olympic runners scooting along at well under five-minute mile pace makes sense for the rest of us.

The setup of the 2016 100K race was ideal for putting some of the prevailing cadence theories to the test. It consisted of ten laps of exactly 10K each, and was almost completely flat, with elevation ranging from 1 to 6 meters above sea level. Using the Garmin, Suunto, and Polar watches that the competitors were wearing anyway, Burns was able to collect cadence data from the entire race and then calculate averages for each lap. He could then figure out how cadence changed depending on speed, fatigue, and individual characteristics like height, weight, and running experience.

One of the big surprises was that fatigue didn't seem to matter. The runners maintained relatively constant cadences throughout the race, with any variations mostly explained by changes in speed. If a runner sped up, their cadence increased; if they slowed down, their cadence decreased. That part was fully expected based on previous research, and it's another reason why setting universal cadence goals make little sense: even Olympians have much slower cadence when they're jogging rather than racing. But for a given speed, each runner's cadence was essentially the same after 90K as it was after 5K.

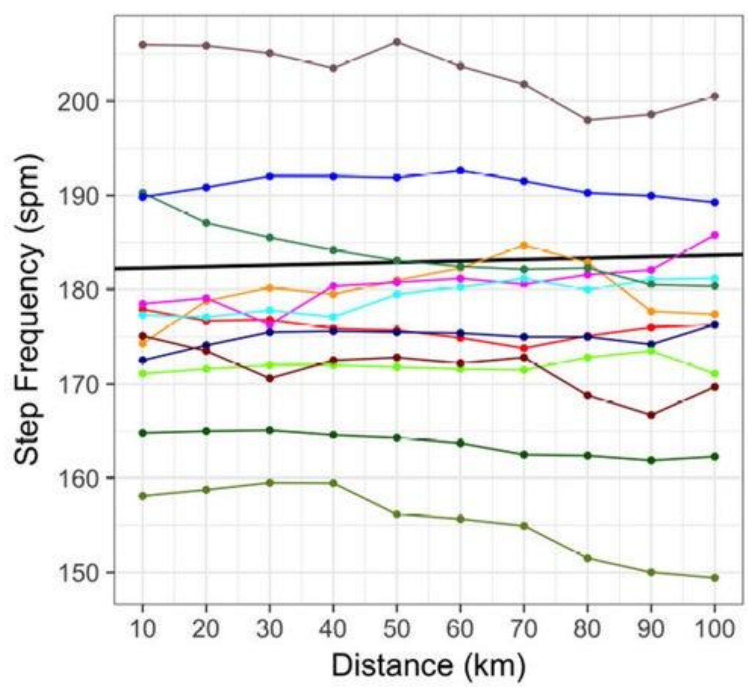
That's unexpected because a few previous studies have found that people tend to increase their cadence as they fatigue. Taking shorter steps, the thinking goes, may reduce the pounding of each stride when your muscles are tired, Burns explains. Think of the stereotypical "ultra shuffle." It may be that the relatively flat, easy 100K course minimized muscle damage; or it may be that world-class ultrarunners have built up (or are born with) greater fatigue resistance compared to the recreational runners tested in previous studies. Either way, it's a surprising new data point suggesting that cadence doesn't necessarily increase with fatigue after all.

Among the individual variables they measured—height, weight, age, and years of experience—only height had any significant influence on cadence. It makes sense that at any given pace taller people should have longer strides (and thus a lower cadence) than shorter people, though some advocates of a universal cadence of 180 steps per minute dispute that. In the new study, every additional inch of height was associated with a decrease of just over 3 steps per minute in cadence. That means someone who is 6 feet tall would typically take about 18 fewer steps per minute than someone who is 5'6". That's actually a bigger difference than you'd expect from biomechanical principles, which predict that stride length should be roughly proportional to the square root of leg length. But it confirms the general principle: tall people take longer steps.

A minor aside about the link between cadence and height: previous studies have produced mixed results on this, with some evidence suggesting that cadence and height are linked more strongly in elite runners than in recreational runners. The theory is that more experienced runners have had more time to “self-optimize” their strides, so they’re more likely to have converged on the most efficient possible cadence for their body. The very strong relationship between height and cadence in this paper might hint that world-class ultrarunners have logged enough miles to really dial in their most efficient stride.

The real crux of the paper, though, is in the actual values of cadence observed. As I mentioned at the top, the overall average cadence among all runners was 182.0. But Burns and his colleagues aren’t really interested in the average. When they originally submitted the paper, their key graphs showed the cadence measurements throughout the race for each individual runner. One of the peer reviewers asked them simplify the figure by simply plotting the pooled average values for each lap rather than each runner’s values—but Burns demurred: “My response was a more polite version of ‘No, no, no! That’s missing the point and propagating the wrong conclusions! Look at each individual!’”

So let’s do what Burns suggests. Here’s the individual data from the 12 men in the

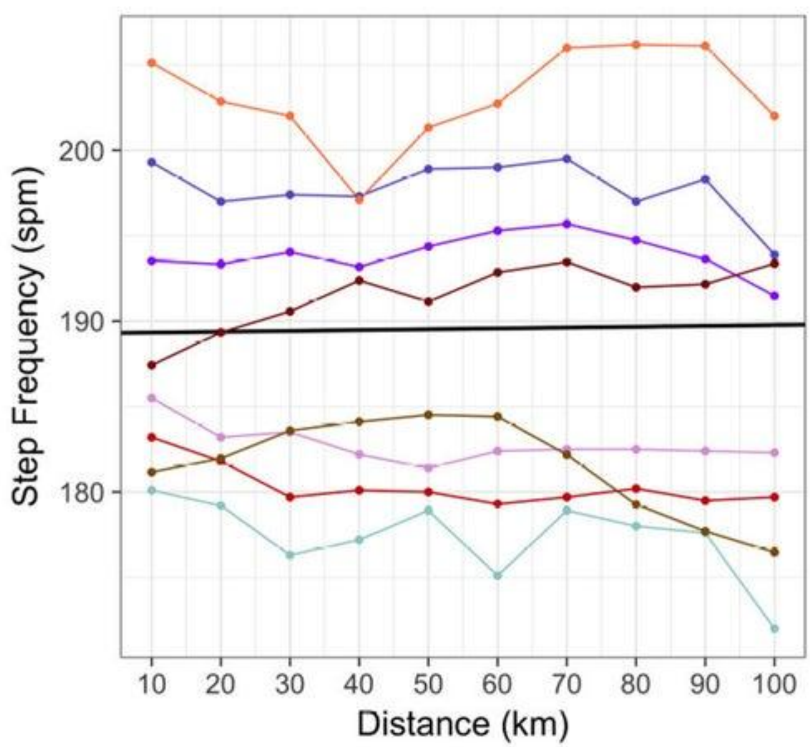


study, showing their average cadence for each of the ten laps in the race:

(Courtesy Journal of Applied Phys)

The big thing that jumps out is the huge variation between runners. There's one guy whose average was 155 and who never topped 160; another guy averaged 203. Those two runners actually finished the race, after nearly seven hours of running, within a few minutes of each other, Burns says. Whose cadence was more "correct?" Most of the runners certainly clustered in the 170 to 180 range, but the variability is enormous—and given that all these runners finished in the top 25 at the world championships, it argues against the idea that we should all aspire to identical cadence.

The women's individual data paints a similar picture, with generally higher values that correspond to their generally shorter heights. (After controlling for other factors like height and speed, there were no significant cadence differences between males and females.) Note that the lines are generally flat, meaning that cadence didn't change much from start to finish—but in the cases where cadence does change, that generally corresponds to changes in pace.



(Courtesy Journal of Applied Phys)

So is worrying about cadence a waste of time? I asked Burns, a serious runner who's studying cadence as part of his Ph.D., how he uses this kind of data in his training. "I don't actively pay attention to cadence in my training or racing," he explained, "but I use it like I use most other things that I measure (speed, heart rate, etc): post-hoc analysis." Over time, he's found that his cadence at a given pace tends to be a few beats lower when he's at his fittest, perhaps suggesting that he has a bit more power in his stride (enabling him to take longer but less frequent steps) at those times. But he doesn't consciously try to alter his cadence; instead, he might use the data as a hint about when he needs to hit the track or do some hills to rebuild that power.

As for the magical 180, my own take is that the idea has persisted because it's a good aspirational goal for many runners. Lots of runners overstride, crashing down on their heels and putting excessive force on their joints. Telling them to increase their cadence by, say, 5 percent results in shorter, smoother strides, and reduces loads on the knee and hip. But there's a very big difference between saying "Some runners might benefit from increasing their cadence" and "All runners, regardless of what speed they're running at, should take at least 180 steps per minute."

That acknowledgment of individual variability is probably the most important message to emerge from Burns's data, and should serve as a caution against trying to impose general rules on your running form. Burns's grand overall model tried to predict each runner's cadence based on every piece of data available—speed, height, weight, age, experience, and so on. Altogether, those factors were able to explain about 50 percent of the cadence variation between runners. The rest, in this study at least, was unmeasurable. "That was intellectually and romantically satisfying," Burns says. "We can explain half with science, but the other half is unique to you."
