

Chasing down a better way to run: Researchers making breakthroughs in learning how and why we run

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"I think people want to understand why they like running and why even average humans are so good at it, and why some people are so unbelievably good at it," said Daniel Lieberman, professor and chair of human evolutionary biology and principal investigator in the department's Skeletal Bio Lab. "There's a reason people love a marathon: They actually enjoy it. It's not a nasty chore. It's a celebration of the human body."

Credit: Jon Chase/Harvard Staff Photographer

Harvard Provost Alan Garber loves running - so much so that when he returned to his alma mater last year, he listed among the job's perks a chance to resume his exercise route along the Charles River.

"I love seeing Dunster House as I'm approaching the end of my run," said Garber, who'll soon be pounding the pavement with nearly 30,000 others in the Boston Marathon on April 16.

But until recently, Garber described himself as "recidivist runner." The cause wasn't a lack of enthusiasm or even of precious time, but an all-too-common phenomenon for regular runners: repeat injury. "I was at the point where injuries were making it questionable whether I'd be able to continue to run," he said.

Most people know about runner's high. But for most runners, injury is as much a part of the experience as euphoria. Studies vary widely, but it is estimated that between 30 and 80 percent of regular runners are injured in a given year. Shin splints, runner's knee, iliotibial band syndrome, plantar fasciitis: For many years, everyone from coaches to biologists to casual joggers has accepted such injuries almost as a necessary evil.

But a growing number of researchers, many of them at Harvard, are convinced it doesn't have to be that way. What's more, they say, we often don't need equipment to solve our many aches and pains. The human body, they argue, is built to run. Thanks to a growing body of scientific research, they're figuring out exactly how humans were meant to move.

These medical clinicians, biologists, and anthropologists are part of a cohort at Harvard, including several University-affiliated research centers, that may be unique in combining breadth and depth of research on the subject at a single university.

"There's an amazing group of people at Harvard working on helping people run better," said Daniel Lieberman, professor and chair of human evolutionary biology and principal investigator in the department's Skeletal Bio Lab.

Running is in our bones

Lieberman is at least partly responsible for that. As an advocate of barefoot running and co-author of several groundbreaking papers in the journal *Nature*, he has kept running in the scientific spotlight for the past several years. The first paper, written in 2004 with longtime collaborator Dennis Bramble at the University of Utah, marshaled the

fossil record's evidence for why we run.

The paper was only the second published study on the subject. The first came out in 1984. Running had simply been overlooked by most evolutionary biologists, who instead focused on why we developed the biomechanical tools for walking, our primary means of locomotion.

"We think of walking as the quintessential human gait, and it is," Lieberman said. But as he and Bramble pointed out, "the human body is also loaded with features that make us really exceptional runners. Our gifts and our ability to run are not just a byproduct of walking, but its own special skill that we have."

For instance, humans have a number of adaptations that help stabilize the head during running. As an example, Lieberman points out the nuchal ligament, a rubber band-like structure that emerges from a tiny raised ridge on the back of the human skull, that isn't present in our closest relatives, chimpanzees and gorillas.

A series of "springs" in our legs and feet, including our long Achilles tendons and the plantar arch along the underside of the foot, helps us to store and release energy efficiently when running. Our gluteus maximus muscle - more commonly known for giving the round shape to our rear ends - is distinctively enlarged in humans, helping to stabilize our trunks when running and keeping us from pitching forward.

Lieberman and Bramble hypothesized that many of these traits evolved 2 million years ago, when running would have been advantageous to early hunters who lacked sophisticated tools. An aptitude for endurance running would have allowed hunters to chase down and weaken their prey, driving them into hyperthermia. Humans would be less likely to overheat during long runs thanks to their larger number of sweat glands and relative lack of body hair.

The article touched a nerve. Lieberman received hundreds of emails, and the study was mentioned in nearly 1,000 news reports.

"I think people want to understand why they like running and why even average humans are so good at it, and why some people are so unbelievably good at it," Lieberman said. "There's a reason people love a marathon: They actually enjoy it. It's not a nasty chore. It's a celebration of the human body."

Barefoot, and back to basics

As more researchers embrace the idea of running as a natural human activity, there's been a shift away from developing bigger and better orthotics toward instilling better biomechanics. In other words, to figure out how to prevent running injuries, researchers and clinicians are taking the focus off of shoes, braces, and other man-made solutions and seeking answers in the body itself.

"It doesn't make sense that up to 79 percent of runners get injured in a given year, if we're doing something we're designed to do," said Irene Davis, director of the Harvard-affiliated Spaulding National Running Center (SNRC).

"We've gotten into a mindset that once a person needs a set of orthotics, they need them forever," said Davis, a physical therapist with a longtime research interest in running. "But when you take the foot - which is an amazing structure - and put that into a shoe with arch support, cushioning, etc., the foot becomes lazy and likely more prone to injury."

Davis, a visiting professor of physical medicine and rehabilitation at Harvard Medical School (HMS), came to Harvard a little over a year ago from the University of Delaware to start the SNRC, which will hold its grand opening for the public on April 12. The center combines a running injury clinic with a research laboratory, where Davis hopes to develop even better interventions to prevent musculoskeletal injuries in runners.

"I wanted to take my research to the next level," she said. She also rivals if not outpaces Lieberman in her enthusiasm for barefoot running. (Lieberman, whose 2010 Nature cover article on barefoot running received a flood of attention, calls Davis' hiring a coup for Harvard. And both have worked closely with journalist Christopher McDougall '85,

whose best-selling 2009 book "Born to Run" introduced barefoot running to a popular audience.)

"We came into the world barefoot," Davis said. And until the 1970s, she said, running shoes were much more minimal than we're used to today. "They had a surface that protected the bottom of your foot and something that kept it on," she said. "It's my contention that that's what shoes were originally designed for - not to take away the function of your foot."

Landing on our heels

The problem with shoes is they allow runners to strike the ground with their heels, rather than their mid- or forefoot.

"When you put a foot into a cushioned shoe, you land harder, and more on your heel," Davis said. "When you take your shoes off, you run differently." Three out of four shod runners land on their heels, according to Davis, while nearly every barefoot runner lands on the balls of his feet.

"When you heel strike, what happens, from a biochemical standpoint, is that you get this big, quick rise-to-peak in the force that your body experiences," she continued. Multiplied over the thousands of strides runners make, that repeated trauma can lead to a host of injuries.

Lieberman's Skeletal Bio Lab spent four years studying the Harvard track team for insights into how a runner's strike correlates with injury rates and published results online last month in [Medicine & Science in Sport & Exercise](#). (The paper's first author, Adam I. Daoud '09, was a research assistant in the lab and a member of the track team.) All of the runners in the study were shod, but 31 percent were natural forefoot strikers.

"We showed that members of the track team who habitually run with a forefoot strike have less than half the injury rate of the ones who rear-foot strike," Lieberman said.

Still, Lieberman is quick to point out that there's no one catchall solution, and adds that people who rear-foot strike shouldn't necessarily switch their

gait, especially if they are uninjured. Nor should a runner ever attempt to switch his gait overnight. Lieberman emphasized that there were plenty of forefoot strikers in the study who still suffered injuries, and there were some rear-foot strikers who did not.

"There are no simple answers, none," Lieberman said.

But there have been anecdotal success stories. Garber was one runner who benefited from a change in form rather than in shoe. When he returned to Harvard, he met Lieberman, and the two became running buddies. Lieberman pointed out that Garber was overstriding and leaning too far forward as he ran.

"I was also sure that I was landing on my mid-foot or forefoot, and he was convinced I was landing on my heel," Garber said. "Then he filmed me running and proved it."

Since Garber has started practicing drills to improve his form, he's been able to run with less pain - a trend he hopes will last through the upcoming marathon battle with Heartbreak Hill.

Davis believes that many runners with problems can be retrained. At the SNRC's clinic, she and her associates put them on treadmills in front of mirrors, allowing them to watch themselves move. When runners can see, for example, how their knees cave inward as they stride - "the egg-beater gait," in Davis' words - they can compensate more easily. Davis then gradually removes that visual reinforcement by putting a curtain in front of the mirror. "Eventually, they're doing it without any feedback at all," she said. Her team has followed up with former subjects for up to 12 months, showing that they continued their improved gait.

Giving real-time feedback

Researchers are able to study runners' gaits with high-tech, 3-D imaging on "the world's fanciest treadmill," as Lieberman calls it, which sits atop a force plate that can measure and record the forces acting on a runner's joints from all directions.

But that technology does little to help the average marathoner looking to correct her form. Area runners can turn to Pierre D'Hemecourt, an HMS lecturer on orthopedic surgery and director of primary care sports medicine at Children's Hospital Boston. D'Hemecourt oversees the Running Program at Children's, a multidisciplinary clinic modeled on the University of California at San Francisco's RunSafe approach.

The program, started two years ago, helps runners who want to improve their performance or prevent injuries. Patients meet with a four-person team that includes a physician, athletic trainer, dietitian, and podiatrist for an assessment. In addition, their running style is videotaped and played back to them. It's a 360-degree approach that few other cities can match, said D'Hemecourt, who's also co-medical director of the Boston Marathon.

D'Hemecourt pinpoints four major components of a runner's gait that could lead to injury. First, there's the heel strike. Then there's overstriding, or extending your foot beyond your hip. Women in the military, for example, reported a high rate of femoral neck stress fractures. As it turned out, they were lengthening their natural stride to keep up with men in daily marches.

Third is a slow cadence, an inefficient running pattern. A faster cadence minimizes the likelihood of overstriding, since the quicker steps push for a shorter stride. (D'Hemecourt recommends 170-180 steps per minute.) Fourth, many runners lean forward. "You should be landing with your hips, knees, and ankles bent a little bit so that you land under your center of gravity," he said.

Overall, the goal is to go easy on our bodies when we run, D'Hemecourt said. He recommends using a treadmill to "get a feel for that nice soft landing. If you can hear yourself landing heavily, then you're doing it wrong."

A community of runners

Researchers aren't the only running enthusiasts who've found a home at Harvard. In the past several years, the University's community of noncompetitive runners has grown by leaps and

bounds.

Running is the perfect activity to bring faculty, students, and staff together, said Craig Rodgers, a counselor at the Bureau of Study Counsel, who started the Harvard College Marathon Challenge (HCMC) in 2005. More than 470 people from around the University have joined the group's email listserv. Members use it to post information about races and events, to share tips, and to find last-minute running buddies.

"You don't need anything other than a pair of shoes, or not even a pair of shoes, if you want to go barefoot with us," Rodgers said. "It's something people can do easily on short notice. That fits very well with the Harvard culture and lifestyle, when our schedules allow it."

Harvard On The Move, a year-old University-wide initiative to promote physical activity, can attract as many as 40 or 50 people to its biweekly runs. (The Longwood Medical campus hosts its own twice-weekly jogs; neither group requires an RSVP.) More than 200 members of the Harvard community participated in the Cambridge City Walk/Run on April 1, raising more than \$3,000 for the Friends of Cambridge Athletics, the Andrea Harvey Memorial Fund, and Cambridge Special Olympics. Ryan Neely, a research assistant at the Center for Brain Science at Harvard, was the winner with a time of 26:53:2, which translates to a 5:23 mile pace.

And of course, many Harvardians will be running in the upcoming marathon. The five members of this year's HCMC marathon team, who are running to benefit the Phillips Brooks House Association, have raised more than \$18,000 of their \$25,600 goal.

"I don't think it's coincidental that marathons are charity events," Lieberman said. "It's deeply ingrained, I suspect, in the human experience."

A million years ago, he said, if we went running, we'd likely be hunting. When our ancestors got back to camp, they'd be greeted by their community, and would present and distribute their spoils. Perhaps not much has changed since then, Lieberman said.

"[Running](#) is about sharing," he said. "It's a community event, and it always has been."

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