



Editorial

Introduction: The past, present, and future of research on running barefoot and in minimal shoes

Barefoot running has been around for millions of years, and it is safe to presume that for most of that time, the practice occasioned little interest. Our ancestors ran barefoot because they had no shoes. When footwear was first invented during the last 40,000 years (no doubt at different times and in different places), shoes were by necessity minimal—essentially sandals and moccasins—designed to protect the sole of the foot but lacking any of the sophisticated features and materials present in modern running shoes such as elevated cushioned heels, arch supports, and toe springs. Most of these features were invented in the 1970s, and they quickly became more popular and sophisticated as running underwent a worldwide boom. Today, the vast majority of runners think it is normal to wear cushioned running shoes, and would never dream of running without them.

In the last few years, however, there has been a resurgence of interest in running either barefoot or in minimal shoes, igniting much passionate discussion and debate among runners, sports scientists, podiatrists, orthopedists, and others. Although a handful of studies had been published on barefoot running among habitually shod individuals asked to take off their shoes, interest in the topic was triggered by a 2004 publication in *Nature* (whose cover title was *Born to Run*), which argued that humans evolved to run millions of years ago, probably in order to hunt.¹ The article helped inspire the 2009 bestseller, also entitled *Born to Run*, which not only claimed that the famed Tarahumara ultrarunners from northern Mexico were phenomenal endurance runners in part because they ran only in minimal sandals, but also blamed many injuries on modern running shoes.² A few months later, a second paper in *Nature* presented the first biomechanical analysis of habitually barefoot runners, showing how they are able to run comfortably without generating an impact peak when the foot hits the ground by either forefoot or midfoot striking.³ As barefoot and minimally shod running gained rapid worldwide popularity, a vociferous public debate began. Is it safe? What

are the costs and benefits of wearing shoes? How should you run?

There remains much disagreement about barefoot running, but the debate has sparked lots of good research that ultimately should yield many benefits. We note that despite a lack of consensus on some key issues, extreme views with little grounding in science have tended to get the most attention in the popular media. Some advocates have argued that modern shoes cause injury, while others claim that barefoot running is a dangerous “fad”. Neither of these views is supported by scientific research, and many journalists and advertisers have further confused the issue by conflating actual barefoot running with running in minimal shoes, which are often oxymoronically termed “barefoot shoes”.

While dozens of papers have been published in the last few years on barefoot and minimal shoe running, we believe there is much to learn and resolve, so we are pleased to present the first edited issue devoted specifically to this topic. At the invitation of Walter Herzog, the issue was jointly edited by Irene Davis, Daniel Lieberman, and Benno Nigg. Because our goal was to solicit high quality, original, peer-reviewed research on the topic, we advertised the issue widely to researchers in the field via listservs and emails. We received 17 submissions, all of which went through rigorous peer-review, resulting in 10 accepted papers that present a wide variety of views and analyses. To briefly summarize the results:

Hein and Grau⁴ showed that habitually shod runners who typically rearfoot strike in cushioned shoes still tend to heel strike but with a slightly flatter foot placement when asked to run barefoot or in minimal shoes on a soft surface made of EVA, the same material used in a shoe’s heel.

Miller and colleagues⁵ presented a prospective randomized control study that tested how 12 weeks of running in minimal shoes altered foot shape and muscle cross-sectional area. They found that minimally shod runners developed significantly stiffer arches with relatively larger cross sections of several intrinsic foot muscles, indicating that the foot adapted to the greater demands required by such shoes.

Lieberman⁶ analyzed running kinematics of Tarahumara Native Americans in Mexico, showing that Tarahumara who wear only minimal shoes showed much variation in running form but were more likely to midfoot strike and forefoot strike than those who wear conventional shoes. This study also found

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that minimally shod Tarahumara had significantly stiffer arches than conventionally shod Tarahumara.

Pontzer and colleagues⁷ analyzed strike type variation among the Hadza hunter-gatherers of Tanzania, who were either barefoot or minimally shod. They found that Hadza men tend to midfoot strike, whereas women, children, and inexperienced runners are more likely to rearfoot strike.

Ahn and colleagues⁸ presented a detailed study of kinematics, EMG and kinetics among 40 runners asked to wear conventional shoes versus instrumented socks that on a treadmill. The majority of runners switched from a rearfoot strike when shod to a forefoot strike in socks by plantarflexing their ankles and activating the calf muscles earlier and for longer than when rearfoot striking.

Gruber and colleagues⁹ analyzed the frequency distribution of forces measured using accelerometers attached to the head and shank of habitual rearfoot and forefoot strike runners. Shock frequency content was significantly different in rearfoot versus forefoot strikers in the tibia but not the head, revealing differences in the pattern and degree of shock attenuation between the two styles of running.

Kasmer and colleagues¹⁰ compared EMG and kinematics of four experienced minimalist runners before and after completing two 50-km runs, one in minimal and one in conventional shoes. In both conditions, runners were more likely to rearfoot strike after the ultramarathon, with a greater degree of increased pressure under the heel in minimal shoes and increased activity of the anterior tibialis prior to foot contact.

Hryvniak and colleagues¹¹ survey of over 500 runners who switched to barefoot or minimal shoe running found that the vast majority of participants reported that the switch resulted in decreased injury or no serious harm.

Larson¹² analyzed foot strike patterns of a large sample of minimally shod and barefoot runners at a large outdoor race to test the effects of minimal shoes on strike type patterns. Among actual barefoot runners, 59% were forefoot strikers, 20% were midfoot strikers, and 21% were rearfoot strikers; but among minimally shod runners, 33% were forefoot strikers, 19% were midfoot strikers, and 48% were rearfoot strikers.

Samaan and colleagues¹³ tested the effects of gait retraining that incorporated real-time feedback on ground reaction force variables during barefoot and shod running. Their results showed that runners could immediately change their gait resulting in significant marked decreases in impact loading.

Good research always generates more questions than answers, and the research presented in this issue will be no exception. In our opinion, three broad topics merit the most attention as we go forward. First, to what extent and how do different kinds of forces (e.g., internal vs. external) affect the development of injuries? Second, how do variations in running form interact with different kinds of shoes to affect the development of injuries among individuals? Finally, how does

the body adapt to footwear in ways relevant to developing injuries? We hope that the excellent papers in this volume will help spur even more and better research on these and other important topics regarding barefoot and minimal shoe running.

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