The Disadvantages of Shod Running for Modern Humans

Casey Whipple

Writer's Comment: As someone who has on several occasions attempted to become a runner, only to be side-tracked by injuries, I found the idea of barefoot running to be both puzzling and intriguing. Casting aside the conventional wisdom of using high-tech foam blocks to cushion each footfall, proponents of this practice argue that humans evolved to be excellent long-distance runners even with their toes exposed to the elements. Needing a topic for the papers in UWP 102B, I decided to see what real, peer-reviewed research had to say about the practice of barefoot running. After I found some great, recent articles relevant to this practice, writing this paper was quite exciting, as it was both interesting and relevant to my own endeavors. I hope that my readers enjoy exploring this idea through my paper, and that future writing students find such inspiration in a topic as I did.

—Casey Whipple

Instructor's Comment: For this piece, Casey found ten articles that dealt with the evolution of running in humans and the effect of modern running shoes on runners, and he very ably pulled them together into a coherent review that supports the idea not only that humans have evolved long-distance running as part of their repertoire of strategies but also that the human body is designed for barefoot running. Most literature reviews are content to lay out what the most recent knowledge is in an area, but Casey's goes a step further and makes an argument. Even if the evidence for barefoot running is not conclusive, Casey demonstrates the logic of the idea, and his literature review shows the need for more research. In addition, the review is easy to read, even for those who may not quite be able to follow the more technical aspects of the presentation.

—Jared Haynes, University Writing Program

Introduction

Endurance running is purportedly an activity that humans were evolved to do. Today it is practiced in some form by a large portion of the populace: from casual joggers to famous marathoners. Millions of years of evolution have equipped us to perform this activity well, a fact that is readily apparent by glancing at our morphology. Achilles tendons, nuchal ligaments, and large gluteal muscles are features that contrast quite visibly with those of many of our extant arboreal-dwelling relatives (Bramble and Lieberman 2004). In spite of these advantages, runners continue to experience high rates of overuse injury related to distance running. A growing body of research is beginning to suggest that one of the fundamental design aspects of modern running shoes—the thick, cushioned sole—may be partly responsible for these injuries, and the use of more minimalistic shoes, or even going completely barefoot, possibly represents a superior alternative (Kerrigan *et al.* 2009). The superiority of these minimalistic options may be due to the specialization of the human leg, which has resulted from many thousands of years of evolution.

The Important Role of Running in Human Evolution

Recent research has added substantial evidence to the idea that *Homo sapiens*, like our ancestors before us, evolved to be excellent endurance runners—notably without the use of shoes. Leg length is one important aspect of our anatomy which supports this idea and in which we contrast quite visibly with our extant ape relatives. By measuring the energy expenditure and relative thigh and shank lengths of human subjects on treadmills, Steudal-Numbers, Weaver, and Wall-Scheffler (2007) were able to determine whether a certain ratio of upper to lower leg length was more favorable. These researchers found that a longer lower-limb most often results in greater efficiency while running and walking. Underscoring the importance of the length of the lower leg is a recent finding of an early *Homo* ancestor in Dmanisi, Georgia. This particular specimen consisted of the most complete lower-limb of an early *Homo* found yet. Even though the specimen displayed a mix of ancestral traits and derived traits, the lower leg had already evolved the length consistent with the ability for distance running (Lordkipanidze *et al.* 2007). Another recently studied aspect of human morphology that lends credence to the idea that running has been a primary driving force in human

evolution is the length of human toes. Humans have developed relatively short toes for an organism of their body mass. Rolian *et al.* (2009) argue that the energy savings of short toes affects running significantly more than walking, indicating that running likely played an important role in their evolution.

This idea that running was the main driving force behind the evolution of human bipedalism is not, however, without opponents. One key idea of this running-driven evolution is the supposed effectiveness of persistence hunting, or essentially running an animal down until it dies of, or is incredibly weakened by, exhaustion. Humans supposedly are able to accomplish this type of hunting through a unique aspect of their running gait—their energy costs increase linearly as their speed increases. Quadrapeds, on the other hand, do not enjoy a linear increase in energy costs as they increase speed and transition to different gaits. Instead, they experience a U-shaped curve in energy costs as they enter and exit each type of gait; this weakness can supposedly be exploited by the more flexible running style of humans. Recent research has shown that the human energy expenditure curve for running is in fact more similar to that of other terrestrial animals than previously thought, detracting from the idea that the favorable energetics of running and persistence hunting drove human bipedal evolution (Steudal-Numbers and Wall-Scheffler 2009). However, in support of this hunting strategy as an important factor in human evolution theory, other research contends that even though the energy costs of persistence hunting are high, its high success rate relative to other forms of hunting may outweigh these costs (Liebenberg 2007).

The Effects of Modern Running Shoes

While modern shoes can often make locomotion more comfortable in the short term, recent studies have shown that they present unnatural conditions for the foot and leg to adapt to, or do not necessarily encourage a stride similar to that used by *Homo* ancestors. It is possible that serious gait alterations may have negative consequences in the long term. One specific instance of how these changes in gait occur is in response to the varying levels of cushioning present in different shoes. Running is, in effect, a serial hopping from foot to foot. In order to absorb this impact while in a barefoot state, the legs act in a way not dissimilar to a spring. Bishop *et al.* (2006) have shown that the leg automatically adjusts the stiffness of this "spring" in response to the varying amounts of softness

present in different shoes, attempting to maintain a certain amount of energy efficiency. While a softer running shoe may feel more comfortable and forgiving, these shoes result in the leg stiffening to a greater degree in response to an impact relative to a shoe with less cushioning.

Shod running also affects running technique through how the feet strike the ground with each stride. Over 80% of runners who use modern running shoes take advantage of the large cushions present in the heels of these shoes and strike the ground heel-first. Experienced barefoot runners will, on the same surface, generally adopt a fore- or mid-foot foot strike. This difference in foot strike technique has strong implications for the impact forces felt by the leg. The dorsiflexion at the ankle decreases the effective mass of fore-foot strikers relative to those who are heel strikers (Lieberman *et al.* 2010). If humans are animals who have evolved to run for long distances, the results of this difference in technique are not surprising—the barefoot technique likely utilizes aspects of the lower leg in a fashion more similar to *Homo* ancestors. Lieberman *et al.* (2010) hope that future studies will directly study injury rates in barefoot running populations, as anecdotal evidence has suggested they may have lower injury rates.

The knees, hips, and feet also experience significantly different forces while one is wearing shoes relative to being barefoot. When one runs in typical modern running shoes, it has been shown that the knees and hips experience several significant increases in different types of torques. In particular, research has shown that typical running shoes cause the wearer to experience increased knee varus torque and hip internal rotation torque, which could increase the likelihood of developing osteoarthritis in the knee's medial compartment and the hip, respectively (Kerrigan *et al.* 2009). Morio *et al.* (2009) showed that for runners wearing sandals, the stiffness of the sole resulted in a restriction of foot movement, specifically reducing foot inversion and eversion, and reducing foot adduction and abduction. Additionally, the strap of the sandal around the forefoot was found to significantly restrict the ability of the forefoot to expand with each footfall, in comparison to being barefoot. While there is variation across types of shoes in both the sole stiffness and capacity for the forefoot to expand, Morio *et al.* suspect that these aspects of modern footwear may contribute to the development of foot deformities and stress fractures.

Conclusion

A growing body of both biomechanical and anthropological evidence supports a hypothesis that humans were evolved to run, and specifically, to run barefoot. Many skeletal features define us as runners; leg length in particular appears to have evolved early in the *Homo* lineage. The sum of this research paints a picture of a human that is highly adapted to a particular form of locomotion, a style of gait that is significantly different from that which is seen in wearers of thick-soled shoes. The thick sole, despite advances in modern materials science, seems to fundamentally encourage a gait that results in forces acting on parts of the human leg anatomy that may not necessarily be prepared to deal with them. If the human leg is as highly adapted to running barefoot as this body of research suggests, then future shoe designs should better encourage the running mechanics humans are equipped to handle.

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