CHAPTER **44**

CONCEPT OF MINIMALIST RUNNING BIOMECHANICS

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INTRODUCTION

The current popularity of running is largely attributable to resurging interest and the overall lower cost of participation. Running is a common athletic practice of recreation and competitive sports, and is associated with tens of thousands of office visits per year in the form of running injuries (1). Many of these injuries are primarily associated with either an acute mechanical insult or repetitive stress (2). It is, therefore, advantageous for runners to wear protective shoe-gear that is biomechanically supportive of function.

Barefoot and minimalist running trends, as well as the associated risks and benefits, have been previously discussed in the literature. This practice in running habits has undoubtedly led to an alteration in injury-associated office visits. As specialists of the foot and ankle, practitioners face newer challenges with these sporting habits of the patients we treat.

In modern practice, patients and running sports participants are likely to trust information and opinion from sources other than medical specialists of the foot and ankle. Podiatrists are not always regarded as "experts" in this arena. The purpose of this article is to provide an update on the biomechanical knowledge of running gait patterns in minimalists and shod runners alike, as well a survey of popular nonpeer-reviewed resources that the public values.

HUMAN RUNNING

Running is an activity of terrestrial animals, in that it allows for rapid locomotion on foot. The runner's gait is remarkably different from that of walking, in several measures. Although running speeds may be quite variable between jogging and sprinting, the key characteristic of a running gait is a lack of double support and the presence of a "float" segment, whereby no support is utilized. Upright running on two legs, is a unique characteristic of human ambulation (3).

Several studies have investigated the biomechanical differences in a variety of different running patterns (4). Recent discussion between these running patterns are associated with a heel strike versus forefoot/midfoot strike. Many of these measures focus by isolating the effects of running gait and foot strike patterns under a variety of shod and barefoot conditions (5).

MODERN RUNNING SHOES

It is thought that "natural" running is running without shoegear (6). The oldest evidence of human shoegear dates ~8,000 BCE, and it is therefore assumed that human evolution in running predates such appliances. Even with early shoegear, running is still believed to be a common activity by humans during that era. The emergence of running as a globally popular sport is something of recent phenomenon. In the last several decades, the market of retail running shoes has evolved dramatically. Running shoes originated as a specialized item for improved protection and comfort. As the design of modern running shoes has progressed, these models have become thicker in the heel portion of the sole. The belief is that greater shock absorption will facilitate a more comfortable stride with reducing stress to the runner's habitus.

In addition to comfort, shoe designers attempt to modify or improve biomechanical function in the runner, through manipulation. The concept of rearfoot function and pronatory dysfunction via overpronation or hyperpronation is largely considered a cause of suboptimal performance and even injury (7). In order to prevent such outcomes, shoe gear manufacturers market pronation control designs.

THE MINIMALIST RETORT

Minimalist running is based on the principle of "natural" evolution. It is believed that humans and ancestral species ran barefoot, thus shoes are an "unnatural" invention which antagonized the evolutionarily engineered human foot. Minimalist running enthusiasts believe the presence of this thicker padding, decreases proprioceptive feedback and promotes longer strides, which in turn induces a heel striking gait pattern. It is argued that a heel strike pattern is a component of a "jog" gait, which is a relatively new and unnatural style of ambulation to humans.

Minimalist running and barefoot running is a resurging practice in popular running culture. The concept behind minimalist shoe gear is one that attempts to provide a protected barefoot environment, thus promoting natural running gait patterns.

BIOMECHANICAL DISCUSSION

Running gait and walking gait are decidedly different mechanisms. Although the human foot is capable of both forms of propulsive ambulation, the means of which are not totally understood. Literary authors of lower extremity biomechanics do not entirely agree. Classic academia describes the foot functions of pronation and supination as an off/on weight-bearing repetition in the human gain cycle. Intrinsic foot muscles act to provide a stable foundation, which provide leverage to the longer extrinsic muscles in the leg to synergistically function for propulsion.

These dynamics of lower extremity ambulation are popularly described in several generalized models: forefoot to rearfoot coupling and twisted plate kinematics about the midtarsal joint. Locking and unlocking of this joint complex is permitted by subtalar joint pronation and supination. The mitered hinge model of the subtalar joint acts to convert torque between the functional foot and leg.

This model of human ambulatory biomechanics is widely accepted for walking gait dynamics, but is somewhat disputed by minimalist running enthusiasts. It is believed that a forefoot striking gait utilizes the architecture of the foot in a uniquely different manner (8). By this, a constant tension in the gastroc soleus muscle group act to stabilize the knee, ankle, and subtalar joint. This relieves torsional forces from the hip and knee, permitting a straightened alignment in the sagittal plane (9).These forces are believed to be deferred to the foot itself. By operating in a relatively plantarflexed position, the subtalar joint range of motion plays a role in facilitating shock absorption and subsequent resupination off contact. The heel is thus free to move during propulsion, whereby the conversion of torsional forces are performed by the acetabulum pedis. Similar to the way ballet dancers function en pointe, this position places the tarsal bones as a fulcrum, which in turn facilitates the extrinsic muscular attachments in the forefoot. This form is assumed to influence a return to a natural stride. Both a decrease in stride length and in increase in stride cadence are observed in forefoot runners. These characteristics are not exclusive to minimalist runners, and sound evidence is yet to be proven by in vivo studies.

Given the complex nature of running biomechanics, there exist several difficulties in providing substantial data (10). Long-term comparison studies of minimalist and shod runners are also nonexistent in literature. The true benefits and/or harm of such practices have not been fully appreciated, at the current time (11). Classic academic training and clinical experience have led many practitioners to caution against such methods of training. Despite this, many sporting enthusiasts and nonmedical resources play a more convincing role in swaying public opinion. An overview of biomechanical opinion has been provided, which is the basis for minimalist running beliefs.

REFERENCES

1. Van Gent RN, Siem D, van Middelkoop M, van Os AG, Bierma-Zeinstra SM, Koes BW. Incidence and determinants of lower extremity running injuries in long distance runners: a systematic review. Br J Sports Med 2007;41:469-80.
2. Hreljac A. Etiology, prevention, and early intervention of overuse injuries in runners: a biomechanical perspective. Phys Med Rehabil Clin N Am 2005;16:651-67.
3. Carrier ML. The energetic paradox of human running and hominid evolution. Current Anthropology 1984;25:483-95.
4. Lieberman DE, Venkadesan M, Werbel WA, et al. Foot strike patterns and collision forces in habitually barefoot versus shod runners. Nature 2006;463:531-5.
5. Bramble DM, Lieberman DE. Endurance running and the evolution of Homo. Nature 2004;432:345-52.
6. Hoffman L. Conclusions drawn from a comparative study of the feet of barefooted and shoe-wearing peoples. Am J Orthop Surg 1905;3:2.
7. Nigg BM. The role of impact forces and foot pronation: a new paradigm. Clin J Sport Med 2001;11:2-9.
8. Romanov RJ. Runners do not push off the ground but fall forwards via a gravitational torque. Sports Biomech 2007;6:434-52.
9. Kerrigan DC, Franz JR, Keenan GS, Dicharry J, Della Croce U, Wilder RP. The effect of running shoes on lower extremity joint torques. PM R 2009;1:1058-63.
10. Kong H. Anthropometric, gait and strength characteristics of Kenyan distance runners. J Sports Science Med 2008;7:499-504.
11. Jenkins DW, Cauthon DJ. Barefoot running claims and controversies: a review of the literature. J Am Podiatr Med Assoc 2007;1:231-46.