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Invited review

Is changing footstrike pattern beneficial to runners?

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Abstract

Some researchers, running instructors, and coaches have suggested that the "optimal" footstrike pattern to improve performance and reduce running injuries is to land using a mid- or forefoot strike. Thus, it has been recommended that runners who use a rearfoot strike would benefit by changing their footstrike although there is little scientific evidence for suggesting such a change. The rearfoot strike is clearly more prevalent. The major reasons often given for changing to a mid- or forefoot strike are (1) it is more economical; (2) there is a reduction in the impact peak and loading rate of the vertical component of the ground reaction force; and (3) there is a reduction in the risk of a running-related injuries. In this paper, we critique these 3 suggestions and provide alternate explanations that may provide contradictory evidence for altering one's footstrike pattern. We have concluded, based on examining the research literature, that changing to a mid- or forefoot strike does not improve running economy, does not eliminate an impact at the foot-ground contact, and does not reduce the risk of running-related injuries.
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1. Introduction

There are 3 types of footstrike patterns that human runners can employ. These are generally referred to as (1) rearfoot, (2) midfoot, and (3) forefoot. Footstrike patterns are categorized depending on the portion of the foot that initially contacts the running surface. For example, when using a rearfoot strike, a runner will contact the ground with the lateral aspect of the heel eventually toeing off as in the other footstrikes. Here, we use operational definitions for mid- and forefoot striking. A midfoot strike is one in which the runner initially contacts the ground across the metatarsal heads with the heel subsequently contacting the running surface while the forefoot strike is also one in which the initial contact is also on the metatarsal heads but the heel never touches the ground.

A study by Lieberman and colleagues[1] reported that individuals who have never worn shoes used a forefoot strike whereas those who are habitually shod used a rearfoot strike when running. This finding has been recently disputed by Hatala and associates[2] who reported that 72% of habitually barefoot African runners ran with a rearfoot strike although these data were collected in a different region of Africa than the previous study. However, Lieberman's findings led to the notion that humans may have evolved to be forefoot runners thus the forefoot pattern was the more "natural" footstrike compared to a rearfoot strike.[1] Lieberman's suggestions have led to several papers in the literature on barefoot versus forefoot running, many of which appear to promote a mid- or forefoot strike (e.g., Ahn et al.[3] and Paavolainen et al.[4]). Extending the notion that mid- or forefoot running is optimal for barefoot running is the suggestion that mid- or forefoot running is also optimal for shod running. Many running coaches have then suggested that changing a runner's footfall pattern from an "unnatural" rearfoot strike to a "more natural" forefoot strike, whether unshod or shod, may be a propitious way to improve performance and possibly reduce running-related injuries.[5–7]

There are many programs such as Pose running[8,9] or Chi running[10] that have influenced numerous running coaches to instruct runners to alter their footstrike to an mid- or forefoot strike. While some papers in the literature have suggested such a change to a mid- or forefoot strike,[3,4,11–14] to our knowledge, currently little evidence exists in the literature that conclusively demonstrates that runners would benefit from altering their footstrike in the long term.

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It is possible that switching from one footstrike pattern to another has become popular because of reports of isolated anecdotes rather than examining the idea that switching footstrike pattern would benefit all runners. Findings from a survey study indicate that 46% of those that switched from a rearfoot to a mid- or forefoot strike (n = 397/866) changed their footstrike because of previous injuries and this group reported experiencing a total of 500 injuries before they switched.[12] However, the authors did not report any data on the number of injuries that occurred in these participants after they changed their footstrike. No doubt there are some runners who benefitted from altering their habitual footstrike, but which runners and for what reasons are currently unknown. Studies have suggested that some individuals accrue some benefits by changing to a mid- or forefoot strike.[11–14] However, to extend this notion to all runners may not be a prudent or beneficial recommendation.

There are 3 major reasons that those who support altering one's footstrike give for changing to a mid- or forefoot strike from a rearfoot strike. These are (1) it is more economical; (2) there is a reduction in the impact peak and loading rate of the vertical component of the ground reaction force (VGRF); and (3) there is a reduction in the risk of a running-related injury. In this paper, we will critique these "reasons for change" and discuss alternate explanations that may provide contradictory evidence for altering one's footstrike to a mid- or forefoot strike. We focus on differences between shod rearfoot and shod mid- or forefoot strike running to isolate the differences between footstrike patterns without the influence of footwear.

2. Footfall pattern frequency and selection

The prevalence of the different footstrike patterns in the running population and how footstrike has been determined in the literature is a very important aspect of understanding footstrike behavior. There are at least 2 methods of determining a runner's footstrike. Cavanagh and Lafortune[15] suggested a method of determining footstrike pattern based on the location of the center of pressure pattern at initial ground contact termed the strike index. With a rearfoot strike, the foot initially contacts the ground in the posterior 1/3 of the length of the foot. In a forefoot strike, initial contact is on the anterior 1/3 of the foot generally in the area of the metatarsal heads. A midfoot strike is the most difficult to determine as the strike index suggests that initial contact is in the middle 1/3 of the foot. Recently, a study by Gruber et al.[16] suggested that, in addition to the strike index, the position of the ankle joint at foot contact (i.e., dorsiflexed for the rearfoot strike and plantar flexed for the mid- or forefoot strikes) and the presence (rearfoot runner) or absence (forefoot runner) of an impact peak in the component VGRF should be used together as indicators of a footstrike, rather than 1 metric alone as seen in many studies. However, in this paper, we will combine the mid- and forefoot strikes into a mid- or forefoot strike because the initial contact in both is on the metatarsal heads of the forefoot.

Interestingly, the epidemiologic data on footstrike demographics show that the rearfoot strike is one that is used by the greatest percentage of runners while the forefoot strike is used by a significantly lesser number of runners. Kerr et al.[17] found that 81% of runners at the 10 km and 20 km point of a marathon used a rearfoot strike while 19% used a midfoot strike. In an elite half-marathon, Hasegawa et al.[18] reported that 75% of runners used a rearfoot strike, 23% a midfoot strike, and 2% a forefoot strike. More recently, Larson et al.[19] concurred with the results of both the Kerr et al.[17] and Hasegawa et al.[18] studies. The prevalence of rearfoot runners has also been reported to be as high as 94% of 1991 runners in a competitive road race[20] and 95% of 514 runners tested in a laboratory setting.[21] Each of these studies reports a very low percentage of runners using a true forefoot strike. It has been argued that the high prevalence of the rearfoot strike is a result of the modern cushioned running shoe facilitating a rearfoot strike;[22] however, this speculation has been recently refuted.[23]

Which footfall pattern an individual selects may depend on a number of factors. In a forward dynamics simulation modeling study, it was reported that the rearfoot strike was optimal for the greatest number of goals of running, which include minimizing metabolic cost.[24] However, the model selected a more anterior footstrike (i.e., mid- or forefoot) to optimize for higher running speeds but at a greater metabolic cost. This result is supported by a human study for which increasing running speed resulted in 45% of runners switching to a more anterior footstrike.[25] Thus, it appears that the choice of footstrike may be task-specific. Running a long distance may require a rearfoot strike to minimize the metabolic cost of running while a more anterior footstrike may be necessary to run faster.

3. Changes in the economy of running

Several studies have observed that the top finishers of short, middle, and long distance events tended to use a mid- or forefoot strike.[17,18,21] Similar findings from earlier studies speculated that a mid- or forefoot strike increases the effective storage and release of elastic energy compared with a rearfoot strike and has led some to suggest that it is more economical (i.e., consume less submaximal oxygen for a given task) to run with either a mid- or forefoot pattern.[17,18,26–29] However, several studies, each with a small sample size and thus low statistical power, directly compared running economy between rear- and forefoot strike and reported no statistically significant differences in intra-subject oxygen consumption between these footstrike patterns.[29–31]

Ardigo and colleagues[30] reported no difference in oxygen uptake or internal mechanical work between a group of habitual rearfoot runners using both a rear- and forefoot strike pattern. These results were supported by later studies also showing no difference in running economy between rear- and forefoot strike patterns.[29,31] However, these studies were limited by low sample sizes and used only habitual rearfoot runners[31] or only habitual midfoot runners.[29] Recent studies have reported that there was little or no difference in the net mass normalized oxygen consumption or the net metabolic rate between mid- or forefoot runners versus rearfoot runners performing with their habitual footstrike pattern across submaximal running speeds (Fig. 1).[32,33]

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