Research Paper Review

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Barefoot Running: An Evaluation of Current Hypothesis, Future Research and Clinical Applications

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Tam N, Wilson JLA, Noakes TD & Tucker R

ABSTRACT

Barefoot running has become a popular research topic, driven by the increasing prescription of barefoot running as a means of reducing injury risk. Proponents of barefoot running cite evolutionary theories that long-distance running ability was crucial for human survival, and proof of the benefits of natural running. Subsequently, runners have been advised to run barefoot as a treatment mode for injuries, strength and conditioning. The body of literature examining the mechanical, structural, clinical and performance implications of barefoot running is still in its infancy. Recent research has found significant differences associated with barefoot running relative to shod running, and these differences have been associated with factors that are thought to contribute to injury and performance. Crucially, long-term prospective studies have yet to be conducted and the link between barefoot running and injury or performance remains tenuous and speculative. The injury prevention potential of barefoot running is further complicated by the complexity of injury aetiology, with no single factor having been identified as causative for the most common running injuries. The aim of the present review was to critically evaluate the theory and evidence for barefoot running, drawing on both collected evidence as well as literature that have been used to argue in favour of barefoot running. We describe the factors driving the prescription of barefoot running, examine which of these factors may have merit, what the collected evidence suggests about the suitability of barefoot running for its purported uses and describe the necessary future research to confirm or refute the barefoot running hypotheses.

ANALYSIS

Reviewed by Dr. Demetry Assimakopoulos DC, (Research Review Service)

Author's Affiliations:

UCT/MRC Research Unit for Exercise Science and Sports Medicine, Department of Human Biology, University of Cape Town, South Africa; Dynamics of Human Motion Laboratory, School of Biomedical Engineering, Dalhousie University, Halifax, Nova Scotia, Canada.

Background Information:

The concept of running barefoot has recently gained significant attention due to its supposed benefits for runners of all skill levels. These alleged benefits include reduced injury risk, greater running economy and better understanding and mastery of running biomechanics.

Previous publications have supported the theoretical basis for barefoot running, claiming that as a result of walking and running barefoot prehistorically, human beings have developed anatomical adaptations which minimize impact peaks, and increase proprioception and foot strength, thereby preventing injury. The claim is that these benefits can only be realized if barefoot running is performed as opposed to running in shoes (1).

In spite of this, there is a lack of concrete evidence both for and against barefoot running. The goal of this review was to evaluate the theoretical factors driving the increased discussion and study of barefoot running and then to conclude with an evidence-based recommendation for its use.

Summary:

Factors Driving the Promotion of Barefoot Running

Evolutionary Explanation & the Epidemiology of Injury:

The fact that human beings have the ability to run long distances might have been a major survival measure as the species evolved. Supporters argue that early humans did not have shoes, and that contemporary humans are maladapted to wearing shoes, in ways that might actually influence injury development. Many go as far as calling barefoot running the 'most natural' means of running. They claim that shoes limit foot proprioception, alter running form, weaken the intrinsic musculature of the feet and render them inflexible. These maladaptations purportedly prevent the lower limbs from adapting to external forces and loads, such as changing ground surfaces. While this might be a very attractive argument (that sells minimalist shoes, by the way!), the claim remains unproven by the current body of evidence.

On the contrary, evidence exits suggesting primitive humans might have worn footwear such as sandals or moccasins as early as 50000 years ago. However, in recent years, the increased participation in running as a form of exercise has led to the development of the modern running shoes, which are much different that the sandals and moccasins primitive humans may have worn.

The prevalence of running-related injury since its volcanic increase in popularity in the 1970's is staggering, ranging between 50-79% per year. The working hypothesis for this increase is that the body absorbs excessive forces from extreme movements during the gait cycle, exposing the body to increased stress, which subsequently raises injury risk (2, 3). A simple example of this is demonstrated by the association between stress fractures and higher ground reaction forces. This discovery led to the development of shoes featuring increased heel bevels, softer and thicker sole cushions and dual-density medial midsole support, in hopes of reducing the stress of running to a safe limit, thereby reducing the chances of injury. However, in spite of these technological developments, impact forces have been proven to only be part of, or completely unrelated to, the development of injury (4). Interestingly, the incidence of running related injury has remained largely unchanged in spite of technological advancement, with reviews concluding that no scientific evidence supports the prescription of shoes with elevated /cushioned heels and a pronation control system (5).

Biomechanical Justification & Foot Strike:

Recent reports have proposed that unshod runners feature a significant reduction in loading rate. This finding is significant, as the magnitude of loading rate has been correlated with tibial stress injuries. However, this approach is complicated by the conflicting evidence.

It has been suggested that a forefoot strike distributes the impact force across a greater surface area than just the heel, cushioning the impact from running. Additionally, forefoot striking has been associated with flatter foot placement at touchdown, greater plantar flexion and greater knee flexion angle on impact. The shift to a forefoot strike also changes the distribution of eccentric forces, with an increase in eccentric work at the ankle, leading to a decrease in the loading of the knee. Also, it has been proposed that the plantar fascia supports the medial longitudinal arch, acting as a shock absorber and an elastic spring during running (6, 7).

However, the strict classification of barefoot runners as forefoot strikers and shod runners as heel strikers is an oversimplification. Discrepancies in sample population and size have also complicated the body of literature as a whole. Additionally, most researchers and running enthusiasts are of the opinion that as one increases their running velocity, they will invariably transition to a forefoot strike. However, while forefoot striking is more common in faster runners, approximately 40% remain heel strikers. Suffice it to say, some variability exists between groups and generalizations cannot be made.

Recent evidence has shown that runners who preferably rear foot strike might incur a higher rate of repetitive injury when compared to runners who prefer a forefoot strike (8). This might be due to the purported decrease in impact peak in ground reaction forces during forefoot striking. While this is true, a subgroup of habitually shod runners who when put into an unshod condition maintain their heel strike motor pattern, leading to a sevenfold higher loading rate. The injury risk might then be increased when one is transitioning from shod to unshod, as it might transiently increase risk to runners prior to learning a new running pattern.

In spite of this information, more research on this topic needs to be performed; categorizing strike patterns into heel-, mid- and forefoot strike clusters might be reductionist, as striking has been shown to exist as a spectrum, and change as fatigue sets in as a race/marathon progresses. The intra-runner variability and inter-runner variability makes this topic difficult to research comprehensively. Therefore, a solid conclusion about whether barefoot running is good for ALL runners cannot be made at this point.

Region-Specific Considerations

Ankle and Foot:

- Habitually shod runners that make the transition to barefoot running might transiently increase the risk of stress fractures in the lower limb and foot.
- Stress fractures are most commonly located at the 2nd and 3rd metatarsals, and sometimes to the calcaneus due to direct load through the heel.
- Not all runners instinctively adopt a forefoot strike pattern upon initial exposure to barefoot running and might be at greater susceptibility to injury compared to a shod condition.
- Research has shown that when runners consciously adopt a forefoot landing pattern with the absence of a heel strike (POSE technique), while still wearing shoes, can decrease moments around the knee while increasing moments around the ankle, thereby protecting the knee from injury (theoretically).
- The POSE technique might however increase the risk of ankle, calf and Achilles tendon injury due to the ground contact sole angle, greater plantar torque and dorsiflexion torque, in addition to earlier and increased foot pronation; all of which have all been found to be causative

factors of Achilles tendinopathy in these cases.

- It might be that the increased plantar flexion on impact along with increased eccentric work on the ankle may increase the risk of Achilles tendinopathy in barefoot runners.
- Calf muscle group activity is greater in barefoot conditions, which may be indicative of increased strain on the calf, leading to an increased risk of Achilles tendinopathy. This increase in calf muscle activity might be beneficial in some way, as it might dampen and control the forces applied to the joints themselves, leading to a reduction in impact peak and a reduction of the mechanical stress during running.
- In the long run, habitual barefoot running may alter factors such as foot pronation, thus reducing injury risk – we need more research in this area.

Knee:

- Forefoot striking is associated with reduced eccentric loading of the knee and preparatory knee flexion prior to landing.
- It is suggested that runners suffering from patellofemoral pain adopt this running strategy.
- Forefoot running has been associated with a reduction in stride length and an increase in step frequency. These biomechanical factors may affect the loading rate and magnitude of loading on, not only the knee, but the hip and ankle as well.

Future Research that may Improve Practical Barefoot Running Recommendations

Skill Acquisition of Barefoot Running:

Further research must discover the process with which biomechanical adaptations occur with habitual training, and whether these adaptations occur in all learned runners. This will help both clinically and practically, to determine whether there is a subgroup of the population who cannot achieve the potentially favourable biomechanical changes, and whether they will be exposed to an increased risk of injury, especially early on. This is important, because habitually shod runners who transfer to an unshod condition face an 8.6% greater impact force than shod runners, along with an approximately 700% increase in the rate of loading, dramatically increasing their chances of injury.

It is reasonable to propose that a substantial learning component to barefoot running exists, as there is a compelling biomechanical difference between habitually barefoot vs shod runners. This begs the question of whether ALL runners can learn these biomechanical alterations in their gait. If these skills are learnable, then what is the timeframe? Since these questions remain, prescribing barefoot running as a clinical treatment might be premature. However, it does appear that changing an athlete's footstrike when injured or recovering from an injury may assist in alleviating or preventing further injury or other specific conditions. This still remains unclear.

Fatigue as an Indicator of Adaptation:

This topic is under-researched, and would serve to examine the effect fatigue has on running mechanics, muscle function and joint integrity of unshod runners. Specifically, understanding whether fatigue diminishes the body's ability to muscularly protect and dampen the stress through the joints by utilizing a barefoot technique is important. Does the body's ability to protect itself diminish with increased duration? Generally, localized muscular fatigue with running has been theorized to influence common lower extremity injuries. One study described foot strike patterns of runners at both the 10 and 32 km mark of a marathon. There was a 5.2% increase in rearfoot striking in the later phases of the race. It

needs to be proven whether this change is important and whether or not fatigue is a significant factor in this change in gait.

While barefoot running might create conditions that can protect the joints of the lower extremity, it is reasonable to presume that fatigue might be implicated in raising injury risk and needs to be researched further.

Performance indicated by metabolic and whole-body physiological factors:

Barefoot running has been associated with improved running economy. This has been assumed to be due to the lack of shoes, decreasing mass, shoe construction, and due to the effect of elastic compliance from the foot itself. It is important that studies on running economy take the absence of the weight of shoes into account in their analysis. It also should be determined whether running economy is affected as a result of training in the barefoot condition (without the weight of shoes), and if a difference exists while running shod or in a minimalist shoe.

Clinical studies of injury rehabilitation through barefoot running:

Some studies have found that using a forefoot strike intervention resolved symptoms of anterior compartment syndrome (9). This suggests that changing one's strike pattern might be used to treat common running injuries. Barefoot running might be able to induce these gait changes with minimal cuing, but this concept requires further research.

Clinical Application & Conclusions:

Clearly there is much to be learned about barefoot running! According to the current evidence, promotion of barefoot running is based on oversimplified, poorly understood research and anecdotal evidence. While the evolutionary hypothesis might be credible, it cannot justify barefoot running based on our current state of knowledge.

It has also been shown that running barefoot changes running kinematics and kinetics acutely and likely has an impact on the factors associated with injury. However, the lack of causal relationships, along with the high variability and complexity of injury (and running itself), leave researchers, clinicians and the public with more questions than answers, making this justification unconvincing at the moment.

Study Methods:

This article is a literature summary, not a meta-analysis or a systematic review which can infer cause and affect relationships. No statistical analysis was performed.

Study Strengths / Weaknesses:

This paper was well referenced and presented a balanced argument for and against barefoot running, with a concrete conclusion at the end. However, the authors did not outline their search summary, an important omission. Further, the conclusion at the end of the study is relatively biased towards publications written by the authors themselves. It is possible that a similar literature synthesis authored by different researchers could reach a different conclusion.

Additional References:

1. Lieberman DE. What we can learn about running from barefoot running. Exerc Sport Sci Rev 2012; 40: 63–72.

2. Oakley T, Pratt DJ. Skeletal transients during heel and toe strike running and the effectiveness of some materials in their attenuation. Clin Biomech 1988; 3: 159–65.

3. Nigg BM. The role of impact forces and foot pronation: a new paradigm. Clin J Sport Med 2001; 11: 2–9.

4. Richards CE, Magin PJ, Callister R. Is your prescription of distance running shoes evidence-based? Br J Sports Med 2009; 43: 159–62.

5. Divert C, Mornieux G, Baur H, et al. Mechanical comparison of barefoot and shod running. Int J Sports Med 2005; 26: 593–8.

6. De Wit B, De Clercq D, Aerts P. Biomechanical analysis of the stance phase during barefoot and shod running. J Biomech 2000; 33: 269–78.

7. Daoud AI, Geissler GJ, Wang F, et al. Foot strike and injury rates in endurance runners: a retrospective study. Med Sci Sports Exerc 2012; 44: 1325–34.

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