A Biomechanical Analysis of Barefoot Versus Shod Distance Running

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Reference


Clinical Question

In adults, what biomechanical differences exist between barefoot and shod running?

Data Sources

Studies were obtained from Ovid MEDLINE, Web of Knowledge, and Embase through January 2013. The search terms related to barefoot or shod running, muscle activity, impact forces, and electromyography (EMG). The authors used key terms that included impact peak OR ground reaction force OR vertical impact peak OR vertical active force OR propulsion peak OR collision force OR kinet* OR kinemat* OR motion OR biomechanic* OR muscle activ* OR electromyography OR EMG AND barefoot OR unshod OR shod OR shoe OR footwear OR strike pattern OR foot strike OR rearfoot OR forefoot OR midfoot AND run* OR jog*.

Data Extraction

Eighteen studies that met the inclusion criteria were included in the review. Twelve of the included studies investigated kinetics and 16 investigated kinematics. All 18 studies involved adult participants with previous distance running experience. The included studies compared barefoot running and at least one shod condition, some of which compared numerous shod conditions (e.g., Nike Free 3.0, Nike Inc., Beaverton, Oregon; Nike LunaRacer + 2, Nike Inc., Beaverton, Oregon; regular tennis shoe). Data extracted for meta-analysis by the authors included means and standard deviations for GRFs, impulses, joint moments, joint power, and joint angles. Standardized mean differences were calculated to estimate effect size (ES) for each variable, along with 95% confidence intervals.

Data Synthesis

All 18 studies were of low quality, scoring < 16 of 21 on the Downs and Black quality index. There was moderate evidence to support associations between barefoot running and lower GRF ($p = .76$) with a small pooled ES (-0.47; 95% CI -0.77 to -0.17), decreased ankle dorsiflexion ($p = .31$) with a large pooled ES (-1.78;
95% CI -2.39 to -1.18), greater knee flexion ($p = .22$) with a small pooled ES (0.49; 95% CI 0.12–0.87), and increased stride frequency (two studies examined Hz and three examined strides or steps per minute, which precluded data pooling). Strike pattern was related to loading rate. Almost 100% of shod runners exhibited a rearfoot strike pattern, whereas the majority of barefoot runners (approximately 75%) had a forefoot strike pattern.

**Conclusions**

The currently available research evidence relating to barefoot running is limited and judged to have relatively low quality. Biomechanical characteristics of barefoot running, such as decreased ankle dorsiflexion and increased knee flexion upon ground contact, may reduce overuse running injuries. Clinicians should be aware of differences in running mechanics that could play a role in development of a lower extremity overuse injury when an individual transitions from shod running to barefoot running. More research is needed to better understand the biomechanical effects of barefoot running.

**Commentary**

Barefoot running has become increasingly popular in response to its proposed benefits. Some believe that running in a more natural fashion decreases forces transmitted through the lower extremity, which may reduce risk for injuries such as iliotibial band syndrome, patellofemoral pain syndrome, and medial tibial stress syndrome. Some research has been conducted to compare the biomechanics, including kinetics (e.g., ground reaction forces) and kinematics (e.g., knee flexion angle), of barefoot and shod running. Claims have been made that barefoot running has the potential to decrease lower extremity injuries, but no high-quality evidence is currently available to support the claims. Clinicians are often questioned about latest trends in injury prevention by patients who are actively engaging in training fads or considering adoption of some new approach to training. Therefore, an understanding of the biomechanics of barefoot running is needed to advise patients.

The systematic review performed by Hall, Barton, Jones, and Morrissey demonstrated that the primary differences between barefoot and shod running relates to the respective foot strike patterns, which impose different stresses on the lower extremity. Shod runners typically exhibit a rearfoot strike pattern that is associated with a dorsiflexed ankle and extended knee at ground contact, which may cause greater stress on the patellofemoral and tibiofemoral joints. When contacting the ground in this manner, the vertical GRF is greater beneath the calcaneus. Barefoot runners typically exhibit a forefoot or midfoot strike pattern. A forefoot strike is characterized by the metatarsals landing before the heel, whereas a midfoot strike involves the heel and metatarsals contacting the ground at approximately the same time. These foot strike patterns are associated with a lower vertical GRF, due to landing with a more plantar flexed ankle and slightly flexed knee. Additionally, the ground impact force is dissipated over a larger area of the foot. A higher stride frequency for barefoot running may also be an important factor in reducing load on the lower extremity, which could reduce risk for injuries such as meniscal tear, stress fracture, and low back pain.

All of the studies included in the Hall et al. review had small sample sizes, which limits the strength of evidence for support of barefoot running as a means to reduce injury risk. Differences between barefoot and shod running for rate of loading, impulse, ankle eversion during stance phase, and knee coronal plane kinematics were not strong enough to establish a clear superiority of either condition for injury risk reduction. Therefore, the results of this systematic review should be interpreted with caution. Clinicians should carefully consider each patient’s unique characteristics to make a recommendation about the appropriateness of barefoot versus shod running. Factors such as gait pattern, injury history, and training habits (e.g., frequency, distance) should be considered. In addition, clinicians should be aware that transitioning to a forefoot strike pattern may lead to increased risk for metatarsalgia or a metatarsal stress fracture.

A gradual transition from shod running to barefoot running should also be emphasized. A progression that includes alternate days of shod running and barefoot running may allow the individual to adjust to the biomechanical differences. Alternatively, the progression might involve running shod for two days, and then running barefoot for one day, to allow time for tissues to adjust to different stresses. Once an acceptable level of comfort has been achieved, the runner could progress to alternating days of barefoot and shod running. In addition, we recommend beginning