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DOES WEARING SHOES IMPROVE KNEE JOINT STABILITY DURING RUNNING?

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SUMMARY

Running is a common recreational sport and recently barefoot running has received an increased focus. The aim of this study was to compare three dimensional joint kinematic changes among habitual shod runners during transition to barefoot running. Data was collected using body-worn sensors in an indoor stadium. Kinematic parameters estimated included three dimensional knee joint range of motion (ROM), acceleration impact at the tibia and temporal parameters like gait cycle time, flight time, impact propagation delay. The results revealed a significant (6.4%, $p<0.05$) reduction in flexion-extension range and increase (8.4%, $p<0.05$) in internal-external rotation range for knee joint from barefoot running. Vertical tibial acceleration impact reduced significantly (8%, $p<0.05$) and the breaking force increased (24%, $p<0.05$) during barefoot running. In conclusion it seems that barefoot runners could benefit from a reduction in vertical impact and increased breaking force; however, stability of knee joint might be compromised and the increased range of knee joint internal-external rotation may cause joint injury.

INTRODUCTION

Barefoot running has often been associated with a reduction in running related injuries [1]. Studies have shown that traditional shod runners actually suffer from more lower-extremity related injuries than runners who use minimalistic shoes [2]. Favorable changes in biomechanical parameters including reduction in impact force and joint movement have been linked to barefoot running [3-6]. Barefoot running may also reduce knee joint load as well as injuries based on the reduction in knee joint impact [7]. Most of the running related studies have focused on measuring ground reaction forces or joint torques with limitations to the sagittal plane [3,5,8]. Measurement protocols have also been limited to small number of steps in a laboratory or larger on an instrumental treadmill [4-5]. After reviewing current literature and studying the claims and controversies related to shod and barefoot running, it would be beneficial to collect data from several running steps in order to observe the three-dimensional joint kinematic changes at the knee joint during the two running including.

METHODS

Data was collected in an indoor stadium using wearable sensors (Biosensics, LLC, Cambridge, USA) attached to different body segments using elastic Velcro bands in 12 habitual shod runners. Two sensors were attached to each leg, one at the tibial tuberosity and one proximal to the patella. Additionally, one sensor was attached to the lower back. Each sensor incorporated a tri-axial accelerometer, gyroscope, and magnetometer collecting three-dimensional data. Participants were asked to run four continuous laps on a leveled track equaling to one trial of approximately 800 feet. Two trials were performed, one in shod condition where subjects wore their usual running shoes followed by barefoot running trial. Collected data was analyzed to determine the three-dimensional ROM of different joints and segments during each stance phase. Additionally, amplitude of shock received at the different segments was estimated.

RESULTS AND DISCUSSION

Twelve healthy habitual shod runners (6M,6F age:22.2±2.2, BMI (kg/m^2):21.4±2) with varying running experience were recruited from the University of Illinois. Repeated measures test was used to provide comparison between shod and barefoot running conditions (IMB® SPSS®). Alpha level of 0.05 was considered statistically significant.

Kinematic variables

During the transition from shod to barefoot running, the ROM for knee joint were altered significantly ($p<0.05$).

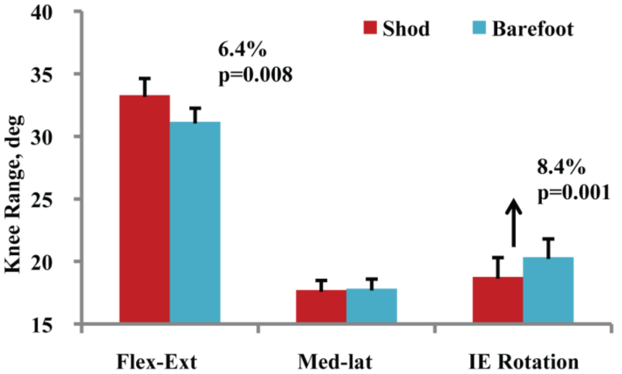

Figure 1: Changes in knee joint range of motion during shod to barefoot transition.

Flexion-extension range of the knee joint was reduced from 33.3±4.6deg (shod) to 31.2±3.7deg (barefoot) (p=0.008) and internal-external rotation range increased from 18.8±_5.3deg to 20.3±5.0deg (p=0.001) from shod to barefoot transition (Figure 1). Similar changes were observed for Tibia range of motion.

Impact characteristics
During barefoot running, the tibia vertical impact was reduced significantly (p=0.03, 8%) from 1.49±0.21g to 1.37±0.16g and a significant increase (p=0.01, 24%) in breaking force was observed from 0.83±0.21g to 1.03±0.27g (Figure 2). No significant (p=0.16) changes in medial-lateral acceleration were observed for the tibia.

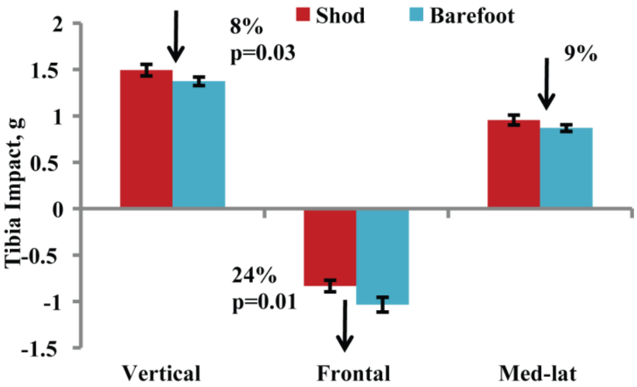

Figure 2: Tibial impact acceleration comparison between shod and barefoot running trials.

Temporal Parameters
Impact propagation from tibia to sacrum was delayed significantly (31.34±5.7ms to 37.92±7.6ms, p=0.006, 21%) during barefoot running, Figure 3.

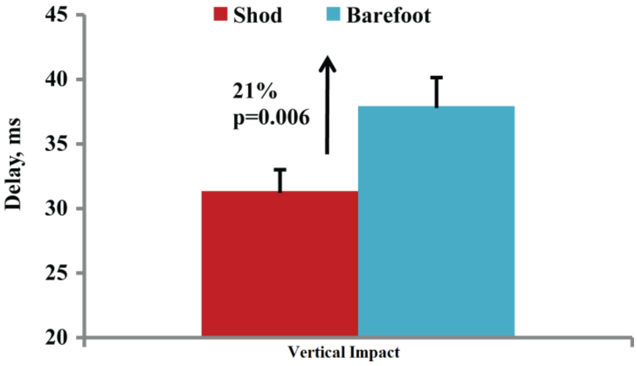

Figure 3: Comparison of impact propagation delay from tibia to sacrum between shod and barefoot running.

Other temporal parameters also showed significant reduction during barefoot running including gait cycle time and flight time. The values dropped from 0.73±0.03s to 0.70±0.02s (p<0.05, 3.8%) and 0.041±0.02s to 0.38±0.02s (p<0.05, 5.6%) for gait cycle time and flight time, respectively.

Our results show that tibial acceleration was significantly reduced in the vertical direction during barefoot running, in line with previous findings [4,5,9]. The significant increase in breaking force and reduced vertical acceleration impact may be associated to biomechanical changes during barefoot running leading to a more cautious strategy during foot placement on forefoot/midfoot strike. Although the medial-lateral tibial acceleration at heel strike was not significantly different between both running trials, a reduction trend (9%, p=0.16) similar to vertical impact was observed during barefoot running. The change can be the result of better plantar perception during barefoot running increasing the lateral stability of the ankle joint.

CONCLUSIONS

To our knowledge, this study is the first to explore three dimensional joint kinematic changes during the transition from shod to barefoot running using state-of-the-art inertial sensors. The results of this study report significant alterations in knee-joint range of motion specifically increase in knee internal-external rotation range. The increase in internal-external rotation demonstrates an unstable knee which can cause running injury [10], therefore should be taken into consideration when making the transition from shod to barefoot running.
Based on the findings of this research, it can be concluded that during the transition from shod to barefoot running, not only is the vertical impact reduced but also the breaking force is increased. However, due to increased range of knee joint internal-external rotation which increases risk of injury it is recommended that shod runners wanting to transition to barefoot running do it at a slow pace. Running barefoot may increase plantar sensation but in order to avoid a sudden change in foot-ground interface during barefoot running may be it is better to wear minimalistic shoes as they have shown similar changes in lower limb kinematics as barefoot running [3-4]. For a more comprehensive comparison of the two running conditions, future studies should measure kinematic changes in different running environments including track, street, dirt roads and grass.

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