Differences in Sagittal Plane Joint Angles between Shod and Barefoot Landing from a Drop Jump

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Background:

Shoes that restrict the natural movement of the foot have been shown to require the body to compensate for the limitation by introducing greater torques at the ankle; which, in turn, may contribute to an increase in physical strain on the musculoskeletal system, and have the potential to increase the risk of injury[1]. Furthermore, in a study by Sekizawa, shoes with thicker soles were correlated to decreased participant joint position sense, particularly into plantarflexion and inversion[2], an excess of which are common causes of ligamentous trauma to the lateral ankle. The greater knee flexion at the time of maximum ground reaction force is correlated to lower ground reaction forces overall[3] and landing in a position of more relative knee extension is shown to be an indicator of increased risk for ACL injury[4]. Minimalist footwear is associated with lower patellofemoral contact force compared to conventional footwear during drop jumps[5]. This however, comes at the cost of participant-reported comfort and performance during landings from vertical and horizontal jumps respectively[6]. The purpose of this experiment was to compare the effects of minimalist shoes and hiking boots on sagittal plane joint angles in the lower extremity and the subsequent impact on muscle activity, compared to barefoot, during a drop jump landing.

Methods:

Two healthy participants completed a series of drop jumps from a .81-meter box. Each subject participated in three trials of three test conditions: barefoot, shod in a lightweight Inov-8 Trail Talon 250 trail shoe, and shod in a heavyweight Merrell Moab hiking boot. Participants landed onto 2 Kistler force plates and sagittal plane kinematics and kinetics of the bilateral lower extremities were recorded by an 8-camera Vicon Nexus Motion Capture. Every trial at each joint of the subject's dominant side was averaged together, and the resultant graphs displayed joint angles and moments, respectively, by type of footwear.

Results:

The testing revealed an increase in flexion angles as the footwear transitioned from barefoot to sneaker to boot, with boots and sneakers forcing the subjects to land in more flexed lower extremity positions than when barefoot, as shown in Table 1. Subject A displayed drastically lower flexion angles in barefoot as compared to sneaker and boot. Subject B did not have such a large variation in flexion angles but did follow the same pattern. As for the moments, hip moments increased as the footwear transitioned from boot to barefoot, with barefoot displaying the greatest moment/torque at the hip (2747 ± 1216.3 Nmm/kg). In opposition, knee moments increased as the footwear transitioned from barefoot to boot, with boots displaying the greatest moment/torque at the knee (2143.3 ± 775.8 Nmm/kg). Meanwhile, results from the sneaker trials displayed the highest increase in ankle moments (1795.4 ± 544.5 Nmm/kg), when compared to barefoot (1700.1 ± 620.8 Nmm/kg), and especially boot (1662.8 ± 636.0 Nmm/kg).

Table 1

Average Angles ± Standard Deviations			
	Barefoot	**Sneaker**	**Boot**
Peak Hip Flexion	80.5 ± 10.5º	85.9 ± 4.7 º	85 ± 6.3 º
Peak Knee Flexion	99.2 ± 11.3 º	115.9 ± 4.5 º	113.6 ± 7.1 º
Peak Ankle Flexion	32.8 ± 5.0 º	36.2 ± 1.6 º	36.9 ± 4.3 º
Peak GRF	23.9 ± 5.4 º	22.0 ± 4.9 º	24.2 ± 4.0 º

Discussion:

The information gathered in this experiment is useful when considering what type of shoe our patients wear. Military and industrial workers who wear bulky boots will follow the pattern of higher flexion angles and lower hip and ankle flexion moments, with higher moments into knee flexion. Individuals, such as some athletes, who are barefoot or wear more minimalist shoes, may follow the pattern of lower flexion angles and higher hip moments. This information can be useful when assessing functional range of motion and strength for each individual.

This study is not without its limitations. First, this study only included two participants, neither of which were male. For more accurate information, a larger sample size would be needed. Second, this study did not consider the participants histories. Subject A has a history ankle injuries and Subject B has a history of joint hypermobility. Again, a larger sample size would be more effective in gathering accurate information. Lastly, there was no EMG study associated with this experiment to pinpoint exactly what muscles were working at what time. An EMG study would be a way to build upon the information gathered here.

References:

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