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THE EXAMINATION OF SHOCK WAVE ATTENUATION IN RUNNING SHOES

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Various sports footwear companies have produced different types of running shoes to "mimic" barefoot walking or running such as FiveFingers and Rush shoes. There is limited evidence suggesting these shoes are able to reduce vertical ground reaction forces while standing, walking or running. The purpose of this study was to examine the vertical ground reaction forces between the minimalist shoes and traditional well-cushioned shoes. All shoes underwent both static and dynamic performance testing on top of an AMTI force platform. The results indicated that the Vibram minimalist shoe provided the highest amount of vertical ground reaction forces during the dynamic testing but the lowest amount of vertical ground reaction forces during the static testing. The study provides a preliminary understanding of vertical ground reaction forces in minimalist running shoes.

KEY WORDS: force, forefoot, heel, minimalist, shock absorption.

INTRODUCTION: In the discipline of sports biomechanics research, sports footwear testing is one of the most popular and important areas because sports industry companies are able to design better footwear for comfort, protection, performance, support and shock absorption (Nebo, 2005). In running, dynamic shock waves are generated through repeated ground impacts, and running shoes with adequate shoe cushioning may attenuate the skeletal shock waves produced by such impacts (Nigg, 1995). Particularly for walkers, the static loading of vertical ground reaction forces is crucial because these forces are generated by standing for a prolonged period of time. It is recognized that running shoes are not always used strictly for running. Hence, in order to better understand the purpose of running shoes as well as their effectiveness, one must first be able to understand both dynamic and static shock absorption. When the cushioning properties of various types of footwear were tested for impact and shock absorption, Chiu & Shiang (2007) described that a shoe with a thinner thickness had less shock attenuation ability. In this study, insoles were advised to better attenuate the impact shock when compared to a barefoot condition. On the other hand, Foti & Hamill (1993) found that impact forces were not reduced with an increased amount of cushioning while running. The impact forces were significantly larger for well cushioned shoes as opposed to hard ones (Foti & Hamill, 1993). Recently, various sports footwear companies have produced different types of running shoes to "mimic" barefoot walking or running such as FiveFingers and Rush shoes with little cushioning. However, there is limited evidence suggesting these shoes can provide better shock absorption than traditional well-cushioned shoes, and also, the amount of shock absorption has yet been quantified. Therefore, the purpose of this study was to examine the shock absorption capability between the new trend of shoes that mimic barefoot walking and running and traditional well-cushioned shoes.

METHODS: One standard traditional cushioning shoe (Adidas Adizero) and two minimalist shoes (Nike Free Run and Vibram FiveFingers shoes) underwent both static and dynamic performance testing on top of an AMTI force platform in the Biomechanics Laboratory. The Nike and Vibram FiveFingers shoes were chosen because of their popularity and uniqueness. All shoes were for the right foot with the same size (US 8). The static testing consisted of placing 1 lb (0.45 kg), 3 lb (1.36 kg), and 5 lb (2.27 kg) inside the shoes for five seconds to ensure the steady state. The dynamic testing involved in dropping a 1 lb (0.5 kg) dumbbell inside a PVC pipe from a height of 2 feet (0.61 meters). Each shoe was divided into forefoot and heel regions, and both static and the dynamic tests were performed on both regions of the shoe. Three trials in each condition for both static and dynamic tests were conducted with the same researcher to ensure the reliability of the test. The peak vertical ground reaction

force (F_z) was recorded at 500 Hz, and the Butterworth filter function was applied. A one way repeated ANOVA test was conducted at $\alpha = 0.05$ between different shoes for both the static and dynamic testing, followed by a Bonferroni adjustment if a significant difference was found and the SPSS (v. 18) software was used for all statistical analyses.

RESULTS AND DISCUSSION: From the results, this study showed that Vibram FiveFingers minimalist shoe displayed the least amount of vertical ground reaction force on both heel and forefoot regions of the shoe in the static testing, Table 1 and Table 2. Adidas traditional shoe displayed the most amount of static force on both the heel and the forefoot, Table 1 and Table 2. An interesting observation during the static testing is that the Adidas shoe produced the highest vertical ground reaction force during all trials of force, as well as on both the heel and the forefoot testing of the shoe. It is hypothesized that the Adidas produced the highest vertical force as opposed to the Nike and Vibram's shoes due to its heavier mass.

Table 1
Static Testing on the Heel of the Shoe. Data are means (SD) in Newtons (N)

	1 lb. (0.45 kg)	3 lb. (1.36kg)	5 lb. (2.27 kg)
Adidas	8.5 (0.00)	17.4 (0.07)	26.3 (0.07)
Nike	7.0 (0.00)	15.5 (0.07)	25.3 (0.07)
Vibram	5.9 (0.07)	14.6 (0.07)	24.0 (0.00)

Table 2
Static Testing on the Forefoot of the Shoe. Data are means (SD) in Newtons (N).

	1 lb. (0.45 kg)	3 lb. (1.36kg)	5 lb. (2.27 kg)
Adidas	8.7 (0.07)	17.5 (0.07)	26.6 (0.07)
Nike	6.4 (0.07)	15.0 (0.07)	25.1 (0.07)
Vibram	5.9 (0.07)	14.6 (0.00)	24.0 (0.00)

This study showed that there was a vast difference between Vibram as compared to the other shoes. Vibram showed a substantial amount of vertical ground reaction force during the dynamic testing, Figure 1. Vibram produced 2,962 N of vertical ground reaction force during the dynamic testing on the heel as compared to Nike's 775 N and Adidas' 872 N. During the dynamic testing on the forefoot, Vibram produced 3,167 N of force as compared to Nike's 884 N and Adidas' 753 N of force. The Vibram shoe was not able to absorb as much force during the dynamic testing as they did during the static testing.

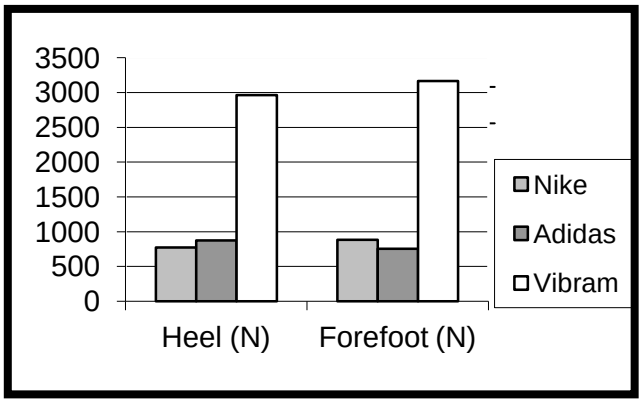

Figure 1: Dynamic testing on the heel and forefoot. Data are means (SD).

Significant differences were seen between Adidas and Vibram during all forms of testing except the dynamic heel testing. Significant differences were also seen between Adidas and Nike during the static heel 1 pound (0.45 kg) and 5 pound (2.27 kg) testing, and the static forefoot 1 pound (0.45 kg) testing. Nike and Vibram showed statistical differences during the

dynamic heel and forefoot testing. It is hypothesized that the Adidas and Vibram shoes had the most statistical differences because they were constructed differently. The Adidas shoe portrayed the most cushioning while the Vibram shoe was very minimalistic.
The authors recognize that the drop tests were controlled dynamic testing free from human inference. By controlling the dynamic testing, there was no human subject variability that interfered with the results. Hence, the dynamic loading results of this study provide a preliminary understanding of vertical ground reaction forces in response to different dynamic loads on various types of footwear.

CONCLUSION: The results from this study indicate that minimalist running shoes are able to reduce vertical ground reaction forces during both static and dynamic controlled testing. During the dynamic testing, Vibram produced the highest vertical ground reaction forces but produced the lowest vertical ground reaction forces during the static testing. Adidas produced the highest vertical ground reaction forces during the static testing. While still providing adequate cushioning, the Nike shoe is less aggressive than the Vibram shoe by producing a lower vertical ground reaction force during the dynamic testing while still providing minimalistic qualities. Nike also provided a median between the Adidas and Vibram shoes during the static testing in regards to the vertical ground reaction forces. The static and dynamic testing of these minimalist shoes provides the authors with a preliminary understanding of vertical ground reaction forces in running shoes. Future studies are warranted to examine the foot motion with these new trends of running shoes.

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