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Validation of windows for examining kinematics of the foot with respect to the shoe using a multi-segment foot model

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Introduction

Shoes designed for specific foot types are speculated to decrease running injuries by encouraging different foot kinematics. One method to test this hypothesis is to track reflective markers affixed to the foot via windows cut in the shoe. The window size should be small enough to maintain the shoe's structural integrity. Only one study had a detailed description of the method used to validate window sizes in the hindfoot [1]. The objective of this study was to validate window sizes for five different locations in the shoe: calcaneus, navicular, first metatarsal, fifth metatarsal and hallux using an optical tracking system.

Methods and procedures

One subject was tested under 3 different shoe conditions (motion control, stability and cushioning) with standard gait analysis using an 8-cameras system motion capture system (Eagle camera, EvaRT system, Motion Analysis Corporation, Santa Rosa, CA). For the first 10 trials, the shoe was intact with a heel and toe markers affixed to the shoe. For the next four conditions, windows of increasing size were cut into the shoe above the calcaneus, navicular, first metatarsal, fifth metatarsal and hallux bone. Triad marker clusters were affixed to the skin of the foot via the windows.

A neutral trial was collected in quiet standing and digitization of bony landmarks were collected for each condition [2]. The subject then walked at a self-selected pace over an 8 m runway.

The deformation of the shoe was assessed using the toe and heel markers on the shoe, and lateral malleolus marker. The foot was tracked as five individual segments [2]. The forefoot and hindfoot with respect to the midfoot (frontal plane) and the height/length ratio of the medial longitudinal arch were measured and compared for each window size [2].

Shoe deformation was assessed by mean differences between window sizes each compared to the intact shoe at the instant of heel raise. Foot kinematics differences were compared as mean differences between the first hole size and the following three hole sizes at heel raise. Sensitivity of the system was considered to be less than 3°. Any mean difference below 3° was considered insignificant.

Results

Both the shoe and the foot calculations demonstrated that a window size of less than 2.5 cm diameter was appropriate for all three shoes. Window sizes above this deviated from the original motion of the foot. Shoe motion generally remained constant. The forefoot graph is shown in Figure 1 as an example.

Discussion

Results show that the 2.5 cm holes were a valid window sizes in the three shoes. The first marker size was not cho-

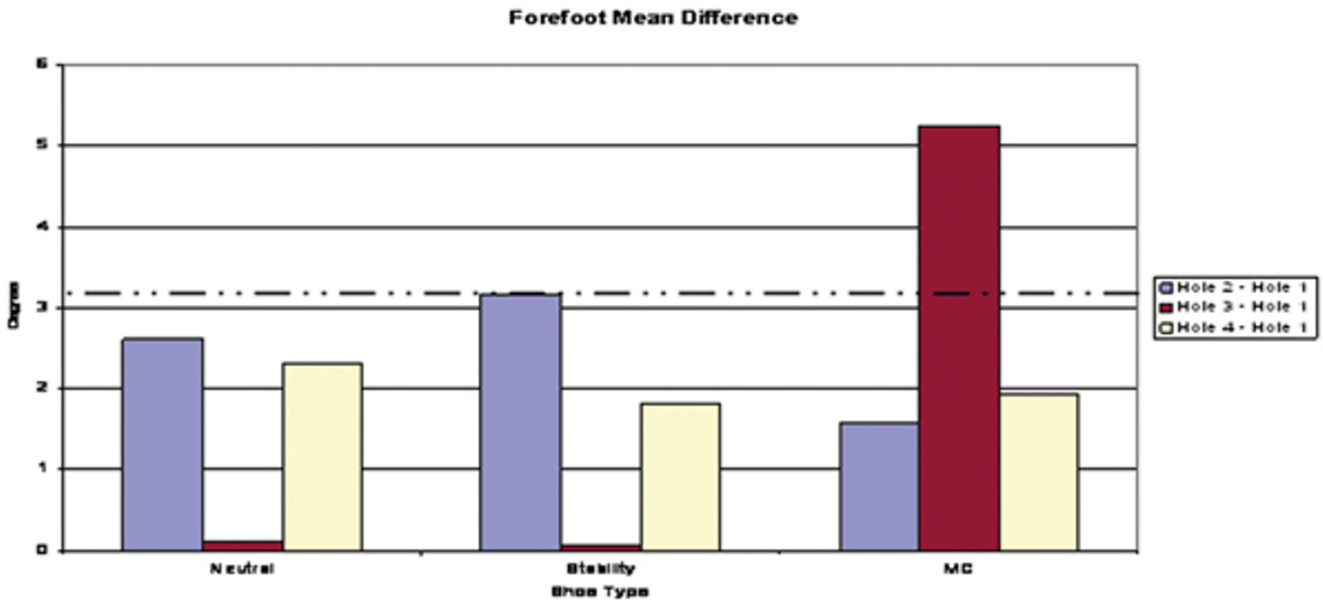

Figure 1
All mean differences for the 2.5 cm hole are below 3°.

sen since larger windows increased camera visibility of the markers on the foot and the decreased the possibility of marker-shoe contact.

The study was limited by the fact that only one subject was tested, using one shoe per condition. Future investigation of different shoes during different movements should be conducted since window size is speculated to depend on shoe type, shoe brand and activity.

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References

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