

MIDSOLE DESIGN EFFECTS ON HEEL PLANTAR PRESSURE DISTRIBUTION DURING SIMULATED WALKING LOADS

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INTRODUCTION

The heel pad of the foot plays an important role in protecting the underlying bones and has a structure that is optimized for load bearing [1]. High heel pressure during locomotion has been related to many foot problems such as heel spurs, plantar warts, and plantar ulcers [2]. Therefore, the design of shoe midsole and insole components geared towards heel pressure relief is important. Computational models of the foot and footwear have been successfully adopted to optimize footwear design. Using a 2D finite element (FE) model, insole parameters such as material thickness and heel shape conformity has been shown to reduce peak heel plantar pressure [3]. This study examines the influence of midsole design changes (in relation to calcaneal size) and material properties on peak heel pressure and heel pressure distribution using a 3D FE model.

METHODS

FE model geometry was developed by the reconstruction of 3D CT images of the left foot of a male subject. All foot tissues were idealized as linearly elastic, except the soft tissue and sole which were defined as hyperelastic and hyperfoam materials, respectively. Poron L24 was assigned as the insole material, and Nora was selected for the midsole. In order to identify the role of the midsole's area under the calcaneus (UCA), three sizes of the UCA were selected, 65%, 80%, and 95% of the width of the calcaneus (Figure 1). UCA material was chosen as Poron L24, Poron L32, and microcell Puff, which were considered as a soft, medium and hard midsole plug material. The upper surfaces of the soft tissues, distal part of tibia and fibula were fixed throughout the analysis period and contact has been assigned to the foot-sole interface. The loading condition was the average force reading during the heel loading phase of the subject barefoot walking across a pressure mat.

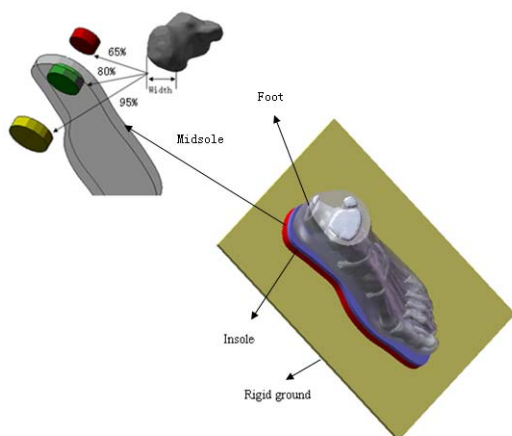


Figure 1: The illustration of the UCA inserted in the midsole.

RESULTS AND DISCUSSION

Measured heel pressure distribution resembled that obtained from the FE model (figure 2a) with peak values from the model and experiment being 279KPa and 245KPa, respectively. The FE model predicted peak pressure of the different UCA midsole materials and sizes and these can be seen in Figure 2b. The UCA modifications all reduced peak pressure relative to a homogeneous Nora midsole. For the softer UCA (Poron L32) with a size of 95% there was an 18% peak pressure reduction. The UCA diameter also changed the pressure distribution, such that the peak pressure was not located in the center of the heel. The largest center peak pressure reduction of 31% was found using Poron L24 with size 65% compared to Nora only midsole. These results showed that use of UCA midsole plug could effectively influence the plantar pressure distribution by selection of suitable materials and dimensions.

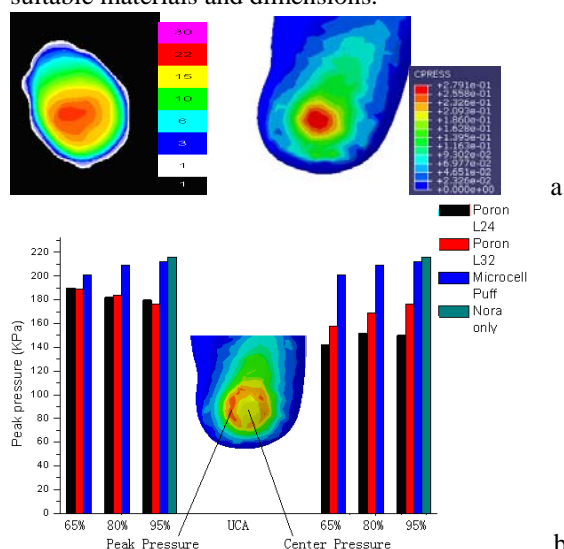


Figure 2: a) Barefoot model and peak pressure distribution. b) Peak pressures for different UCA simulations.

CONCLUSIONS

This study systematically investigated the effect of the UCA midsole material and design on plantar pressure distribution. The FE predictions showed that the use of the functional plug in UCA of the midsole is potentially an effective way to reduce to peak pressure at the center of the heel, which has been a common location of ulcer formation in people with diabetes [2]. Heel midsole material properties and dimensions have been evaluated by a parametric study and calcaneal size appears to be an effective indicator for design optimization.

REFERENCES

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3. Goske S., et al., *J Biomech.*, **39**, 2363-70, 2006.