THE RELATIONSHIP BETWEEN STATIC ARCH HEIGHT AND ARCH STIFFNESS

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INTRODUCTION

Foot type, and particularly arch height is an intrinsic injury risk factor which has received much attention within the literature (Cowan et al. 1993). However, the relationship between foot type and injury is somewhat unclear. In addition to arch height, arch stiffness may be important in trying to relate foot type to injury. It is commonly thought that high arches tend to be more rigid, and lower arches more flexible. Furthermore, it is suggested that more flexible feet with lower arches may serve as more effective natural shock absorbers than more rigid foot types. A higher incidence of shock related bony injuries has been reported in high arched runners (Williams et al. 2001). Zifchock et al. (2006) measured the foot structure of 145 individuals in both 10% and 50% of weight bearing, with relative arch deformation between conditions used as a means of assessing arch stiffness. Although a relationship between variables was observed, only 9% of the variance in arch stiffness could be explained by arch height (Zifchock et al. 2006). During shod running, vertical ground reaction forces can reach 2-3 times body weight. Assessing arch characteristics in loaded conditions closer to those seen during running may provide insight into dynamic arch stiffness and its potential relationship to injury. The aim of the present study was to assess the relationship between arch height and arch stiffness in 10% and 90% of weight bearing. It is suggested that calculating arch stiffness between these conditions may give a better indication of foot function in loaded conditions, such as gait.

METHOD

After ethics approval, 101 male participants (age 20.0±2.8, height 176±19 cm, mass 76.9±10.5 kg) gave informed consent to take part in the investigation. Measurements were taken on the right foot of participants in 10% and 90% of weight bearing, using a previously validated measurement system (Williams and McClay, 2000). A portable force plate was used to determine percentage weight bearing, with the 10% condition measured in a sitting and the 90% in a standing position. Dorsum height at 50% of foot length divided by truncated foot length was used as a measure of arch height index (AHI). Relative arch deformation between 10% and 90% of weight bearing was calculated using the equation described by Williams and McClay (2000). Relative arch deformation was normalised to body weight (BW) to give a measure of arch stiffness, with a lower arch stiffness score indicating a flexible arch structure, and a higher score indicating a more rigid arch. A one-tailed Pearson's correlation was used to examine the relationship between each AHI measure and arch stiffness. Significance was accepted at ($p<0.05$).

RESULTS

Based on normality analysis, arch stiffness data were found to be positively skewed. A log transform ($\log_{10}$) was applied to all data, resulting in normal distribution of all variables. The relationship between arch stiffness and AHI in 10% and 90% weight bearing can be seen in Figures 1 and 2 respectively. No significant relationship was seen between AHI in 10% of weight bearing and arch stiffness ($R^2=0.024, p=0.063$). A relationship was observed between AHI in 90% of weight bearing and arch stiffness, although it was a relatively weak one ($R^2=0.14, p=0.0001$). The observed trend suggests that a higher arch equates to a more rigid foot, and a lower arch a more flexible foot.
DISCUSSION

The findings of the present study suggest no relationship between AHI 10% and arch stiffness, and only a weak relationship between AHI 90% and arch stiffness. In support of the hypothesis regarding height and stiffness, a higher arch was suggestive of a more rigid foot, and a lower arch a more flexible foot. However, only 14% of the variance seen in arch stiffness can be explained by arch height. These findings do suggest a marginally higher association than the 9% variance previously reported (Zifchock et al. 2006). Such differences may be due to the population measured, or the use of AHI at 90% rather than 50% weight bearing. Although 90% AHI represented an increased degree of loading, it was still below the level that would be expected during running. Evidence from this study and the study by Zifchock and colleagues (2006) suggests static measures of arch height offer a limited indication of arch stiffness characteristics. Given the small amount of variance explained by arch height, other factors must be of importance in determining foot stiffness. Such factors might include foot mobility and the range of motion within the joints of the foot, particularly the midfoot. Significant rotations about the joints of the midfoot have been reported during walking (Lundgren et al. 2007). The degree to which bone and soft tissue structures permit motion between relative joints as they are loaded, is likely a crucial factor in determining arch stiffness. Future research should consider the three dimensional motions at the joints of the foot as it is loaded. Analysis of dynamic situations such as running should be a priority, in an attempt to establish links between foot stiffness and injury.

SUMMARY

A relationship between arch height and arch stiffness was only observed using AHI at 90% of weight bearing. Although this measure does provide some indication of arch stiffness, it is limited. The use of static measures may not reflect the dynamic function of the foot.

REFERENCES


