Influence of Foot Orthotics and Intrinsic Factors on Strain Measurements in the Fifth Metatarsal

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Category: Midfoot/Forefoot; Sports

Keywords: Base of Fifth Metatarsal Fractures; Basketball

Introduction/Purpose: Fractures of the fifth metatarsal occur in young, athletic populations and often result in sub-optimal clinical outcomes, even after surgical fixation. With such a high demand for decreased return to play in athletic populations, the development of intervention strategies which mitigate intrinsic and extrinsic risk factors of initial injury is important. Foot orthotics have been shown to decrease strain in the 2nd metatarsal. However, limited research has investigated the influence of intrinsic risk factors and the use of foot orthotics on fifth metatarsal strain. Therefore, the purpose of our study was to investigate the effect of foot orthotics and intrinsic risk factors on fifth metatarsal strain during cadaveric simulation.

Methods: Ten specimens were loaded to simulate the stance phase of normal gait using a validated 6-degree of freedom robot with tendon actuators. Strain gauges were placed at the metaphyseal - diaphyseal junction (Zone II), and the proximal diaphysis (Zone III) to measure principal strain. Specimens were tested in a sneaker-only control condition and ten orthotic conditions, which include combinations of a commercial orthotic insole, three plates, and two foam wedges (Figure 1A). The average peak strain from three simulations were recorded for each orthotic condition. Relevant intrinsic factors were recorded from reconstructions of axially loaded computed tomography scans. A two-way repeated measures ANOVA was conducted to determine the effect of orthotic conditions on fifth metatarsal strains, with significantly correlated intrinsic factors included as covariates. Tukey-Kramer post-hoc analysis with a Bonferroni correction was used to analyze differences between individual orthotic conditions and main effects of components.

Results: Metatarsus adductus angle, 4-5 intermetatarsal angle, and Meary’s angle (R2= 0.944; p<0.001) were included as covariates in analysis of Zone III strain. Significant (p<0.05) differences in Zone III strain were found for the both the main effect of a plate and individual orthotic conditions with statistical adjustment for previously stated intrinsic measurements. However, post-hoc testing revealed no significant differences between non-plate conditions and full plate conditions (p=0.23), lateral plate conditions (p=0.025), or lateral cut plate conditions (p=0.026). Additionally, the Full Plate with Lateral Wedge condition reduced strains by 285 µε relative to the sneaker condition, no significant differences (p = 0.07) were found in post-hoc analysis. No significant differences were found in Zone II with the models considered.

Conclusion: Zone III strains were shown to be significantly correlated with intrinsic factors in the current analysis. Plate conditions demonstrated a trend towards significant reduction of Zone III strain relative to the sneaker condition, despite failing to achieve statistical significance in conservative post-hoc analysis. However, these results may be clinically significant as the reduction of strain in plate conditions exceeded previously reported significant decreases in the 2nd metatarsal. Correlations found between intrinsic risk factors and strain in this study corroborate with previous studies. This indicates that the effectiveness of foot orthotics to reduce strain is strongly influenced by individual foot structure.
Figure 1: A) Components used to create the orthotic conditions; B) Zone II and Zone III strain in all orthotic conditions

Foot & Ankle Orthopaedics, 5(4)
DOI: 10.1177/247301420S00250
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