How Morphology and Mobility Shape Subtalar Joint Mechanics During Increased Loading

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Summary

This study explores how subtalar joint shape, size and mobility affect joint contact mechanics under additional mass. Using computed tomography and biplanar videoradiography, we quantified subtalar joint shape and estimated joint contact mechanics using joint contact centre location and orientation. While greater subtalar joint mobility was linked to larger deviations in contact centre location and orientation, these deviations remained small, suggesting joint contact mechanics are consistent under additional body mass.

Introduction

The subtalar joint plays a crucial role in adapting to the mechanical demands of bipedal locomotion. Its small articular surfaces experience high mechanical stress from large forces. Human adaptations, like a larger calcaneus[1] and more upright posture[2], may help manage these stresses, but variation in joint shape, size and mobility could influence loading patterns. Larger individuals adopt postural adjustments to reduce joint stress[3], yet how these strategies interact with subtalar joint mechanics under increased weight-bearing remains unclear. This study examines how joint shape, size and mobility affect subtalar joint contact mechanics under added mass, providing insight into how individuals adapt to increased loading.

Methods

Forty healthy adults (21F, 19M; 19-34 years) participated after Institutional Review Board approval and informed consent. Computed tomography scans of the right foot were acquired, and 3D bone meshes of the talus and calcaneus were created. Biplanar videoradiography captured three static loading trials: 0 BW, 1 BW and 1.5 BW, with real-time feedback ensuring consistent positioning. A statistical shape model of the subtalar joint was generated, and joint mobility was defined as the change in calcaneus position relative to the talus between the 1 BW and 1.5 BW conditions. Joint contact centre location and orientation were estimated using distance fields, a kinematic proxy for centre of pressure and joint reaction force direction. Stepwise regression assessed how joint shape, volume, and mobility predicted joint contact deviations under load.

Results and Discussion

Two participants were excluded due to missing data, resulting in 38 participants included in all analyses. Small deviations in joint contact centre location and orientation were observed under load, with an average shift of 1 mm in location and 1° in orientation (Figure 1). Larger amounts of subtalar inversion or eversion mobility (inversion-eversion range: 3.8° – 5.3°) resulted in larger deviations in contact mechanics. Subtalar PC3 (7.8%) was linked to deviation in mediolateral location, however to a lower extent than mobility (β-coefficient, mobility: 0.47, PC3: 0.38).

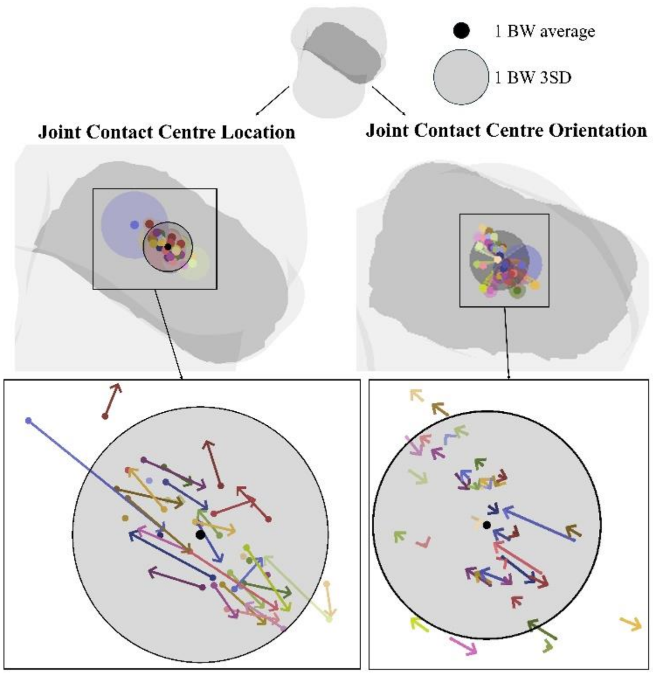

Figure 1: Deviation in contact mechanics under additional load.

Joint contact centre location and orientation remained relatively constant under increased load with no clear directional trend (Figure 1), implying these shifts may be influenced by joint orientation or articular surface shape over mechanical demands.

Conclusions

This study found that under added mass joint mechanics are primarily influenced by subtalar mobility along the inversion-eversion axis. While greater mobility predicted larger deviations, these shifts remained small, suggesting consistent joint contact mechanics despite variability in shape and mobility across participants. These results highlight the adaptability of the subtalar joint to increased loading.

References

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