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Assessing talonavicular joint rotations in three dimension

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Introduction

The union of the spherical talar head with the cupped shaped navicular shows the general characteristics of a ball-and-socket joint [1]. As such, the talonavicular joint should be expected to demonstrate three rotational degrees of freedom. Yet, conventional approaches to foot motion analysis provide little opportunity to assess motion of the intrinsic foot joints. A new approach, and perspective, is adopted that permits an appreciation of the talonavicular joint that is not restricted to the confines of marker dependence or the orthogonal reference frame. Data will be presented that shows talonavicular rotation about independent axes that possess orientations that are not orthogonal to any conventional reference frame.

Methods

Data are derived from the legs of 23 non-pathological embalmed cadavers. Legs were prepared by removing all soft tissue, so that only ligamentous structures remained to sustain limb integrity. Each specimen was cycled through three mutually orthogonal driving actions (Plantarflexion-Dorsiflexion [PD], Inversion-Eversion [IE], and Medial-Lateral Rotation [ML]) while monitoring the relative positions of the talus and navicular with an active-marker tracking system The Functional Alignment method [2] was used to derive joint axis orientations and motion patterns for three rotational degrees of freedom. These results are summarized using the axis triangle technique [3].

Results

Figure 1 shows consensus (average) axis triangle representations for the three driving motions. The position of each vertex (axis point) along with its distance from the reference frame origin denotes the orientation of the rotational axis and the movement that occurs about it. The sizes and shapes of the three different triangles indicate that the talonavicular joint responds differently to each driving action. None of the vertices of these axis triangles lies on the axes of the reference frame, which indicates that every

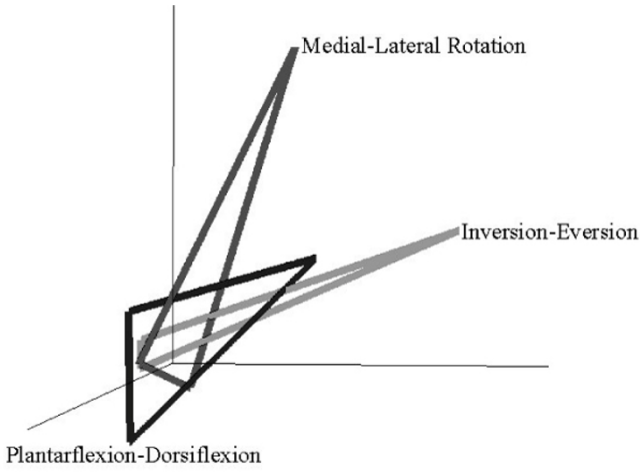

Figure 1
The consensus axis triangles associated with the three evaluated driving actions.

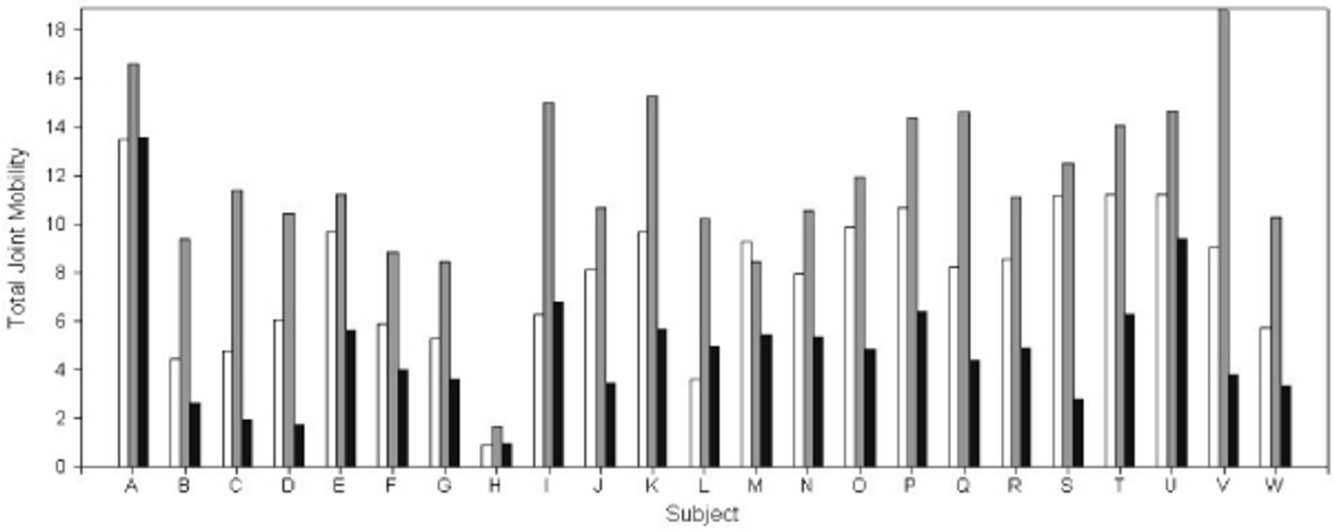

Figure 2
Expressions of total joint mobility based on the three driving actions in the 23 subjects. Bars are keyed: ML White; IE Gray; PD Black.

rotational axis of this joint has a highly oblique orientation.

Figure 2 compares the mobility-size assessment of total joint mobility observed in the three driving motions for each subject. Although the talonavicular joint is shown to be most mobile in response to the IE driving motion, in many instances the mobility-size values associated with the other driving motions are nearly as high. This suggests that the talonavicular movement is not restricted to, or even mostly associated with, a single action of the foot.

Conclusion

The talonavicular joint is a true three degree of rotational freedom joint. It responds in unique ways to different driving inputs. To identify and understand these differences, it is necessary to adopt a perspective that is not limited to movements aligned with an orthogonal reference frame.

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