Novel Marker Configuration for Tracking Talar Motion Using Motion Capture During Slow Running

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Summary

Motion capture for in vivo tracking of talar motion during gait often faces limitations due to difficulties in accurately determining the anatomical position of the talus. A new configuration for a triad of reflective markers has been proposed, hypothesizing alignment with results from biplane fluoroscopy studies. Kinematic data was collected and analyzed during slow running trials. Tibiotalar angles were compared to those reported for the transverse and frontal planes [5] and the sagittal plane [4]. Estimated subtalar angles were lower than those in [5] and [4] for sagittal and frontal plane motion, while transverse plane motion closely matched [5]. Overall, the estimated tibiotalar and subtalar angles approximated the patterns and values of [4] and [5]. Additional testing is needed to validate the new configuration's capabilities.

Introduction

Accurate measurements of talar motion using traditional motion capture techniques are often limited or lacking in the literature [3]. The anatomical position and size of the talus create challenges in identifying bony landmarks for the placement of individual or rigid body clusters of reflective markers. Alternatively, certain studies have published ankle kinematics through methodologies such as bone pins, biplane fluoroscopy, or magnetic resonance imaging, necessitating specialized equipment [1,2]. A modification to the standard triangular configuration of a triad marker has been proposed, involving a slightly curved, V-shaped plate with three reflective markers. This research aimed to assess the tracking capabilities of this new configuration in capturing talar motion during slow running compared to angles reported in published biplane fluoroscopy studies.

Methods

Fifty healthy adult subjects (25 males, 25 females; age 25.4 ± 7.9 years; height 172.5 ± 9.4 cm; weight 76.6 ± 18.6 kg) were recruited for this study. Triads were placed just above the lateral and medial malleolus of the right foot and on the calcaneus. A modified triad was placed just inferior of the lateral and medial malleolus. Ground reaction forces (AMTI, 1125 Hz) and 3D kinematics (12 camera Qualisys system, 225 Hz) were collected during seven trials of bare-foot slow running at a self-selected pace. Trials were trimmed to 10 frames before the first measurement of a ground reaction force and 10 frames following the last ground reaction force reading and later filtered using a low pass filter with a cutoff frequency of 10 Hz. Subtalar, tibiotalar, and rearfoot angles were derived based on the relative motion of their segment markers using helical angles. These angles were then compared to the values found by [5] and [4].

Results and Discussion

Tibiotalar dorsiflexion/plantar flexion angle pattern follows the curve of both [5] and [4] and is closer in values to [4] with maximum dorsiflexion angle approximately 9° at midstance. Inversion/eversion angles more closely followed [5], though maximum eversion occurred at 45% of stance instead of 60%, and 5° inversion at toe-off compared to 0°. Internal/external rotations matched reported values by [5] staying between 0 and 5° internal rotation, with maximum rotations occurring at the start and end of stance (Figure 1).

Dorsiflexion/plantar flexion and inversion/eversion angles at the subtalar were lower than [4] or [5]. Plantar flexion was seen at first contact and toe-off instead of dorsiflexion throughout the stance. Maximum inversion still occurred at first contact and toe-off. Internal/external rotation angles were within the range of both [4] and [5], and the curve following [5] more than [4] (Figure 1).

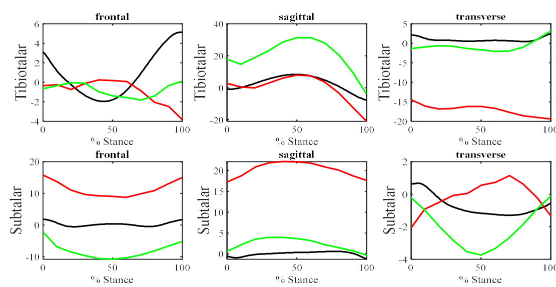

Figure 1: Subtalar and tibiotalar angles for 1. frontal, 2. sagittal and 3. transverse plane. [4] in red and [5] in green.

Apart from inversion/eversion tibiotalar angles, other tibiotalar and subtalar angles were within reported ranges in the literature. There was some disagreement between the markers. This may be due to skin motion associated with motion capture or triad fit. The magnitude of the reported angles may differ due to differences in the method used to calculate the angles.

Conclusions

Slow-running trials with the new markers yielded angles within the range of the literature values. Further testing is needed to fully validate the markers and to test the impact of different sizes and curvatures on reported angles.

References

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