EFFECT OF MARKER PLACEMENT METHODS ON CALCANEAL ROTATIONS

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INTRODUCTION

Most full-body models used in gait analysis view the foot as a single rigid segment and ignore the complex sub-segment motions in the foot. Newer motion capture technology and smaller markers have allowed more comprehensive foot models to be created. Several groups have reported detailed models to determine the kinematics of various foot segments (e.g., [1, 2]). Some deformities may hinder the placement or obstruct the view of markers placed on the sides of the calcaneus. This paper will compare a common method to a more robust marker placement method, which removes the side calcaneal markers and uses only the calcaneal tuberosity for the segment's primary definition.

STATEMENT OF CLINICAL SIGNIFICANCE

Detailed foot models can provide an important tool for studying outcomes of foot surgeries and for pre-operative planning, much like the full body gait models commonly used today for lower limb procedures. An improved kinematic model will enhance our understanding of foot biomechanics and subsequently help to improve surgical outcomes.

METHODOLOGY

The left feet of 23 adult subjects walking at self-selected speeds were analyzed with an eight-camera Vicon 612 system recording at 120 Hz. The cameras were located around the perimeter of a 30 ft. by 40 ft. room. Kinematics were determined with a custom Vicon BodyBuilder model. Joint rotation means and standard deviations for both methods were calculated and paired t-tests were performed on the min/max peak joint rotations. Both marker sets were placed on the feet at the same time to reduce marker placement error. This first method is a common calcaneal marker method (CC) where markers were placed on the most medial projection of the sustentaculum tali, the lateral apex of the peroneal tuberacle, and the upper ridge of the calcaneal tuberosity. The second method used is referred to here as the paired calcaneal marker method (PC). Markers were placed superiorly and inferiorly on the calcaneal tuberosity.

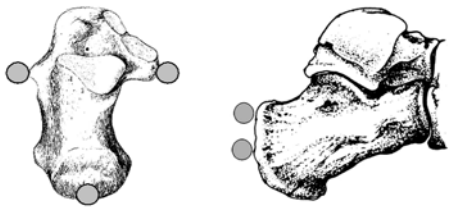

Figure 1. Marker placement for the CC method (left – superior view) and the PC method (right – sagittal view)

RESULTS

There were no significant differences in maximum or minimum values between the two marker methods along any axis of rotation (see Fig. 2). The paired t-test of the peak values was performed and showed no significant difference. In Inversion/Eversion the PC method has approximately 10 degrees of static offset from the CC method. Both methods have a similar pattern, but the PC method has a 140% greater range of motion. Dorsiflexion/Plantarflexion rotations of the two methods are closely aligned with no significant difference in the min/max peak values. The Internal/External rotation of both methods followed the same pattern. There is a slight static offset between the two methods of about 3 degrees, but there is no statistical difference between the two methods.

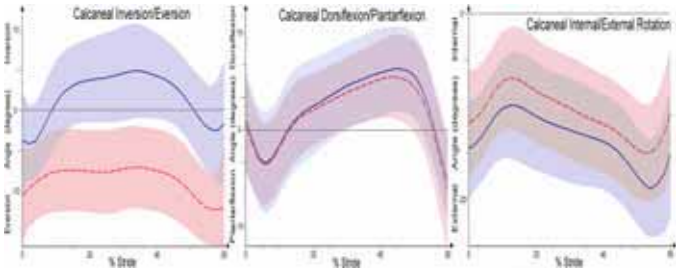

Figure 2. Rotations for the calcaneus with respect to the tibia during the stance phase of gait. The PC method is the solid blue line, the CC method is the dashed red

DISCUSSION

The lack of statistical significance between the two methods and the good shape agreement in all three planes of rotation indicates that the two methods can be used interchangeably when looking at these particular planes of motion. The offset between the PC and CC methods in the Inversion/Eversion and Internal/External rotation is due to the difference in location of the calcaneal center and talonavicular joint, which are used to define the segmental orientations. The larger range of motion of the PC method in Inversion/Eversion is comparable to the ranges reported by a calcaneal tuberosity defined calcaneus[3]. The differences in the range are most likely the result of soft tissue movement influencing one method more than the other. Further testing can determine the accuracy of each of the methods.

REFERENCES

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