A MULTI-SEGMENT FOOT MODEL BASED ON IN-VIVO AND IN-VITRO STEREOPHOTOGRAMMETRIC STUDIES AND CLINICAL THEORIES OF DYNAMIC FOOT FUNCTION: WALKING GAIT RELIABILITY

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INTRODUCTION

Studies investigating walking gait have traditionally either modeled the foot as a single rigid segment, or as a rearfoot segment. While these studies have improved the understanding of foot function during gait, they assume the joints distal to the calcaneus do not contribute significantly to foot function. Recent, in-vitro [1] and invasive in-vivo [2] studies, however, suggest that significant motion does occur in the joints distal to the calcaneus during gait. Several surface based multi-segment foot models have recently been developed [3,4] and applied in a number of clinical and injury related investigations. These studies have further advanced the understanding of the effect of injury and disease on foot function. Absent from the majority of the foot models have been definitions of medial and lateral midfoot and forefoot segments. A recent invasive in-vivo multi-segment foot study [5], however, reported relatively independent motion in the medial and lateral forefoot segments. Although the study suggested that the medial and lateral midfoot may function as a relatively rigid segment in healthy individuals, the coupling may not be rigid in persons with abnormal foot structure or in clinical populations.

The purpose of the current study, therefore, was to investigate the reliability of a six-segment foot model that includes medial and lateral forefoot and midfoot segments during walking gait.

METHODS

Three healthy participants (2 f, 1 m; age: 20.3 ± 1.5 yrs; mass: 86.9 ± 38.8 kg; height: 177.0 ± 14.9 cm) were with typical foot posture were recruited. Typical foot posture was determined using a digital photographic measurement method and previously collected descriptive data [6]. Specifically, typical foot posture was defined as navicular indices (navicular height/truncated foot length) that were within ± 1 SD of the mean indices from the descriptive data.

The foot model defined 6 functional articulations (rearfoot complex, calcaneonavicular complex, calcaneocuboid joint, medial forefoot, lateral forefoot, 1st metatarsophalangeal complex) from 6 foot segment and a leg segment (Figure 1). Three-dimensional (3D) positions of groups of 6.4 mm reflective markers (technical clusters) located on the leg and foot segments were captured using a 10 camera Motion Analysis Eagle motion capture system sampling at 120 Hz.

Gait analysis consisted of completion 7 successful walking trials at a speed ranging between 1.3 and 1.4 m/s. Prior to the gait analysis trials, an anatomical calibration procedure was performed to identify the positions of additional anatomical reference landmarks and to define local coordinate systems within each segment.

A custom written program (Matlab) was used to filter the data, reconstruct the 3D
position of each segment using the calibrated anatomical system technique with a single value decomposition optimization procedure, and compute joint angles between adjacent segments (Figure 1).

The coefficient of multiple correlation was used to determine the reliability of the model using 5 of the walking trials. Correlation coefficients ≥ 0.70 were considered to be very repeatable.

RESULTS AND DISCUSSION

Walking gait kinematics were very repeatable in all three motion planes for the rearfoot complex, calcaneocuboid, medial forefoot, and 1<sup>st</sup> MTP functional articulations (Table 1). For the calcaneonavicular complex, walking gait kinematics were very repeatable in the sagittal and transverse planes and moderately repeatable in the frontal plane (Table 1). Finally, for the lateral forefoot the gait kinematics very repeatable in the transverse plane and moderately repeatable in the sagittal and frontal planes (Table 1).

The study suggests the six segment foot model is very reliable during walking gait.

REFERENCES


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<tr>
<th>Coefficients of multiple correlations for the six functional articulations</th>
<th>Sagittal</th>
<th>Frontal</th>
<th>Transverse</th>
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<td>Rearfoot complex</td>
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