INTRODUCTION

Electromagnetic motion tracking systems measure absolute position and orientation of individual sensors with respect to a magnetic field source. Relative angular motion between two body segments can then be computed from their absolute orientations. Two advantages of electromagnetic tracking, with respect to optoelectronic tracking are: (i) line of sight to sensors is not needed, and (ii) only a single sensor is needed to quantify segment orientation.

This study sought to evaluate feasibility of obtaining clinically relevant, mid-foot/shank relative motion, during stance phase, via electromagnetic tracking. It was conceived that reliable, electromagnetic, foot/shank motion data could be used to detect individual responses to orthotic intervention. It was noted that relative motions between the actual foot (rather than the shoe) and shank would be needed to properly assess response to orthotic intervention.

METHODOLOGY

Foot and shank motions were measured, for 10 healthy young volunteers, with an electromagnetic motion tracking system. Sensors were placed on each right foot dorsum and anterior tibial surface. A standard work shoe was then donned with the tongue folded forward over the toe region, so as not to contact the foot sensor. Laces were secured at the top and bottom eyelets. In this manner, the shoe was reasonably well secured, while the foot sensor was isolated from contacting the shoe. Subjects were permitted time to acclimate to the experimental environment.

A static alignment trial was performed with foot and shank in a neutral standing position such that their local coordinate systems (LCSs) were approximately parallel to each other, and to the global coordinate system (GCS). For this position rotation matrices that aligned the LCSs were determined. These rotation matrices were then applied for each sampling interval. Five trials were collected for each of two conditions. In one condition no orthotic insoles were used. In the other, orthotic insoles, which have been marketed as being able to modify ankle kinematics, were inserted in the shoes. These insoles were liquid gel-filled, with the gel being a thick viscoelastic silicone type.

For each sampling interval, the shank LCS was rotated into the foot LCS using an Euler angle sequence (sagittal axis – frontal axis – transverse axis) to obtain relative foot/shank motions. For each trial these motions were plotted versus percentage of stance phase.

RESULTS

Relative sagittal and frontal foot/shank angular motions for the no insole and gel-filled insole conditions are shown, in figures 1 and 2, for two individual subjects. All subject trials, as well as the ones shown, demonstrated noticeable consistency within each condition. For the subject in Figure 1, it was noted that sagittal plane motions were similar for both conditions, while use of the
gel-filled insole appeared to shift frontal plane motion toward a more neutral posture during stance. The subject represented in figure 2, however, showed no discernable frontal plane effects with the insole, but demonstrated a tendency toward greater dorsiflexion throughout stance, that was more pronounced during early stance.

Discussion

Successful optoelectronic measurement of three-dimensional relative foot/shank motion has been previously reported; however, the need for line of sight necessitated a barefoot condition (Kidder et al. 1996). Moreover, the need for line of sight to several foot and tibial markers restricted measurement to be primarily below knee level.

Results of the present study have demonstrated that electromagnetic motion tracking can be successfully applied to relative foot/shank motion measurement for a shod condition. In this manner, an individual’s kinematic response to an orthosis can be evaluated clinically in much the same manner as individual plantar pressure response to an orthosis can be assessed with shoe based plantar pressure measurement systems.

Electromagnetic tracking could enable clinicians to assess relative foot/shank motion effects of orthotic interventions, while shoes are worn, when such effects may be too subtle to be discerned via optoelectronic tracking of markers outside of the shoe.

REFERENCE