INTRODUCTION

While kinematic and kinetic differences between shod and barefoot running have been heavily investigated [1], one area which has not been examined is how the trajectory of the center of pressure (COP) changes between these two conditions. Since the COP trajectory has been shown to be a valid tool for assessing foot function and injury risk [2, 3] understanding how it changes from shod to barefoot running could help clarify the relative injury risks associated with each condition. The COP characteristics most often examined include the anterior-posterior (AP) and medial-lateral (ML) excursions and velocities, as well as the relative locations of the COP at specific instants during stance. To date, one underutilized characteristic is the variability in the above parameters. Reduced variability in the positioning of the COP may concentrate loading under specific anatomic structures, which over time may play a role in the development of repetitive stress injuries, though this has not been reported in the literature.

Therefore, the purposes of this study were to quantify changes in the position of the COP relative to the foot during stance, examine changes the AP and ML excursions of the COP, quantify changes in the variability of the COP trajectory from shod to barefoot conditions in a group of habitually shod recreational, runners.

METHODS

Ten habitually shod, recreational runners (mean age 32.4 ± 4.1 years) currently running at least 20 miles per week were assessed. Subjects ran continuous laps around a 25 meter track in the laboratory under both shod and barefoot conditions. Whole body motion data were collected at 200 Hz using an 8 camera motion capture system (Motion Analysis Corp.) Ground reaction forces were recorded at 1000 Hz by three force plates (AMTI) located in series along the 5 meter capture region. Subjects ran at a self selected speed approximating their normal training run pace.

The COP trajectory was calculated for all trials with a clean force plate strike. At each instant the COP location was referenced to the anatomic coordinate system of the foot. The orientation of this coordinate system was established when the foot was flat on the ground with the AP axis aligning with the long axis of the foot and the superior-inferior axis being perpendicular to the floor. The foot ML axis was orthogonal to the other two, and pointed laterally for both the left and right feet. Since the origin for both feet was set at the heel marker, the COP positions were subsequently described relative to this point.

Average AP and ML position of the COP relative to the heel marker at each instant, for each foot, was calculated along with standard deviations in both the AP and ML directions, in increments of 10% stance (Figure 1). The AP and ML positions and standard deviations were compared between shod and barefoot running at foot strike, 60% stance, and toe off using 2x3 repeated measures ANOVAs. AP and ML excursions from foot contact to toe off were compared between shod and barefoot running using paired t tests. Each foot was analyzed separately.

RESULTS AND DISCUSSION

The COP was located significantly more medially at all time points in the barefoot condition compared to the shod condition (Figures 2 & 3). In the AP direction, the COP was located more anterior at foot
contact in the barefoot condition compared to the shod condition. However, there was not a difference in the AP location at 60% stance or toe off between conditions (Figure 3).

Figure 1. Representative plots of the COP trajectory (from a left foot) and its variability (standard deviation of the average COP location in the AP and ML directions, respectively). 1 of one subject are shown.

Figure 2. Changes in the COP ML positioning relative to the heel marker. * indicates significant differences between conditions (p < .05).

Variability in the location of the COP showed significant main effects for percent stance, but no main effects for shod and barefoot conditions, in both the AP and ML directions. Both directions showed higher variability at initial foot contact and at toe off and smaller variability through midstance.

The COP excursions showed significant differences between shod and barefoot conditions for only the AP direction, not the ML direction (Table 1).

Table 1. Changes in COP AP and ML excursions. * indicates significant differences (p < .05).

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<tr>
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<th>Shod</th>
<th>Barefoot</th>
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<tr>
<td>COP AP excursion (cm)</td>
<td>21.75 (± 2.81)</td>
<td>10.38* (± 5.73)</td>
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<tr>
<td>COP ML excursion (cm)</td>
<td>2.78 (± 1.96)</td>
<td>2.81 (± 1.56)</td>
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CONCLUSIONS

Compared to shod running, the trajectory of the COP during barefoot running is marked by a more medial location under the foot throughout stance, a more anterior position at initial contact, and reduced AP excursion. That there are no differences in variability of the COP trajectory or ML excursions suggests, apart from the initial contact position, the dynamics of foot roll over are similar between shod and barefoot running. However, the few COP differences which were observed in this study are similar to COP characteristics which have previously been shown to be related to injury [3, 4]. Therefore future studies should examine how or if these changes may be related to injury risk during barefoot running.

REFERENCES