UTILIZED TRACTION AND LOWER EXTREMITY RESULTANT JOINT MOMENTS DURING CURVE RUNNING

Geng Luo and Darren Stefanyshyn
Human Performance Laboratory, University of Calgary, Canada
Email: gluo@kin.ucalgary.ca; Web: www.ucalgary.ca/hpl

INTRODUCTION
Footwear traction is commonly subdivided into translational and rotational components; from an injury prevention perspective rotational traction has received particular emphasis. An early epidemiological study by Torg et al. [1] suggested a correlation between lower extremity injury incidence and peak rotational traction. This result was later supported in a prospective study by Lambson et al. [2]. However in these studies translational traction was not quantified and hence its influence remained unknown. Resultant joint moment has been associated with tissue stress [3]. Recent investigations on footwear traction and lower extremity injury mechanisms found increased resultant joint moments in shoes with both higher rotational and translational traction [4, 5]. However, the contribution of each traction component to the changes in joint loading requires further investigation.

In the aforementioned studies, only mechanically assessed traction was used to establish the relationship with either injury incidence or joint loading. While mechanical testing provides a repeatable boundary measurement, it does not necessarily represent the traction utilized throughout a manoeuvre. The utilized translational traction is defined as the ratio of the horizontal divided by the vertical ground reaction force; the utilized rotational traction is defined as the free moment generated about the centre of pressure in the plane parallel to the contact surface. Together they represent the major part of the external loading condition to the lower extremity, and thus play an important role in determining the joint loading. It was proposed that an investigation in the utilized traction might help gain insight into the contribution of each traction component to the changes in joint loading.

Therefore, the purpose of this study was to examine how utilized translational and rotational traction are related to ankle and knee resultant joint moments.

METHODS
The experiment was conducted over a uniform laboratory surface in two footwear traction conditions (Low & High). Mechanical measurements were performed first. The testing shoes were fitted onto a prosthetic foot that was in 20° plantar-flexion, then vertically loaded (600 N) on top of a force plate. They were then dragged across and rotated on the force plate. Force data were collected (2400 Hz) in order to determine the translational traction, defined as the peak static coefficient of friction at the instance sliding motion was initiated, and the rotational traction, defined as the peak static free moment at the instance rotation was initiated. Average values from 14 trials were calculated for each traction component in each shoe condition.

Twenty-eight injury-free athletes were recruited. They performed maximum-effort curve running on a circle of 2.3 m radius. Sufficient practice was given and all the athletes were able to reach their top speed when entering the collection volume. Seven trials per traction condition were collected and the condition order was randomized. Sufficient rest periods were ensured to minimize the effects of fatigue. Reflective markers were placed on the right leg of the athletes and eight high-speed cameras were used to collect the kinematic data at 240 Hz. Force applied by the athletes’ right foot to the ground was collected using a force plate (2400 Hz). The peak translational and rotational utilized traction was determined. Transverse-plane ankle and knee resultant joint moments were calculated using inverse dynamics. In order to determine the contribution of each traction component to joint loading, the utilized traction at the instances when resultant joint moments reached the peak values were compared across conditions.

Prior to any calculation, a low-pass fourth-order Butterworth filter was applied, at a cut-off frequency of 100 Hz for the force data and 20 Hz for the kinematic data. Paired t-tests were used to detect statistical differences at the α-level of 0.05.

RESULTS AND DISCUSSION
The mechanical traction properties, both translational and rotational, differed significantly between the two shoe conditions (Table 1).

During the movement trials, the High condition showed significantly larger peak utilized traction for both the translational and rotational components (Table 1).

Table 1: Mechanically assessed and peak utilized traction. Inequality symbols were used in cases statistically significant differences were detected (p<0.05).

<table>
<thead>
<tr>
<th></th>
<th>Rotational Traction [Nm]</th>
<th>Translational Traction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Mechanical Measurement</td>
<td>6.2 ± 0.6</td>
<td>&lt; 19.0 ± 1.2</td>
</tr>
<tr>
<td>Peak Utilized Traction</td>
<td>10.7 ± 4.3</td>
<td>&lt; 16.1 ± 5.6</td>
</tr>
</tbody>
</table>
For the transverse plane resultant joint moments, the High condition showed significantly larger peak ankle abduction (36.9%) and knee external rotation (50.3%) moments. On average, the peak ankle abduction moments occurred at the 53.5% of stance and the peak knee external rotation moments occurred at the 46.5% of stance across conditions. At these instances, the High condition showed significantly larger utilized translational traction (25.8 % when the peak ankle abduction moments occurred; 32.4% when the peak knee external rotation moments occurred) and no difference in the utilized rotational traction (Figure 1 & 2).

**CONCLUSIONS**

Typically translational traction was associated with performance and rotational traction was related to injury. A number of footwear design efforts have been made to reduce the rotational while maintaining the translational traction [6]. Results from the current study suggested that further consideration should be given in terms of the role translational traction may play on lower extremity injuries.

**ACKNOWLEDGEMENTS**

Li Ning Company Limited

**REFERENCES**