INTRODUCTION

Impact shock during running can be measured by quantifying ground reaction forces and transient accelerations at the tibia during heel-strike. Increases in impact shock magnitude and frequency have been linked to an increased likelihood of degenerative diseases, stress fractures and other overuse injuries (Guanche and Sikka, 2005). It has also been observed that vertical impact force is greater during downhill running compared to level running (Mercer, et al., 2003), and such increases imply increased likelihood of injury during downhill running (Gottschall and Kram, 2005). Lateral asymmetry has been reported to be smaller for left-limb preferred (LP) individuals than right-limb preferred (RP) individuals because of adaptations to right-limb oriented lifestyles (Purvees, et al., 1994).

The purpose of this study was two-fold: to explore if a relationship exists between lower-limb symmetry and tibial impact shock (TIS) while running downhill and to examine the tendency of limb preference to affect lower-limb symmetry. It was hypothesized that asymmetry would be greater at steeper declines (larger differentiation of TIS) and that LP would exhibit greater symmetry.

METHODS

Six subjects were recruited for this initial study (24±1.9 years, 164.9±7.4 cm, 61.35±6.9 kg). All subjects were female, heel-strike runners with no current injuries. Lower limb preference was observed by kicking a ball. Of the six subjects, one was determined to be LP and the remaining five RP.

Subjects were asked to run on a negative grade capable treadmill (Trackmaster, Newton, KS). After a familiarization period, subjects were asked to perform a self-determined warm-up on the treadmill. Following warm-up, subjects then self-selected their running speed for each of four grades (level running, -3% grade, -6% grade, and -9% grade).

Lightweight (1.7 gram) piezoelectric accelerometers (PCB Piezotronics, Depew, NY) were attached bilaterally to the antero-medial tibia. Subjects then performed four-minute phases at each of four grades. The order of grades was determined using a Latin-square technique. Four TIS samples were taken for each grade at a frequency of 1000 Hz. One sample was defined as five heel-strikes of each foot. Raw accelerometry data were filtered using a 4th order low-pass Butterworth filter (cut-off frequency = 50 Hz).

A symmetry index (SI) was calculated for each of four samples at each grade.
for each subject using the following equation:

\[ SI = \frac{(XR - XL)}{0.5(XR + XL)} \times 100\% \]

where XR and XL are the TIS of the right and left tibias, respectively (Herzog, et al., 1989). Mean SI were used to determine if asymmetry increased with decreasing grade.

A 2-factor ANOVA of side (right/left limb) with repeated measures of grade was performed for RP data (\( \alpha = 0.05 \)).

RESULTS AND DISCUSSION

Averaged TIS magnitudes for RP and LP are shown in Figure 1 and Table 1. TIS of RP subjects increased with decline in a linear fashion (p < 0.001). Of the data collected, there were no trends in SI regardless of grade. There appeared to be a trend relating the difference between left and right impact shock for RP subjects, however these measures were not significant (p=0.074). The small sample size combined with the high variability of subjects’ SI is a primary limitation of this initial study. With increased subject recruitment, it is expected that the trends will show significance.

SUMMARY

The findings of this study support Mercer et al.’s data that impact kinetics increase with downhill grade (2003). The trend relating the change between left and right TIS is promising, and future research with larger subject recruitment is expected to reveal statistical significance. Future research will also include examination of laterality and its influence on TIS.

REFERENCES


Table 1: Mean tibial impact shock values for right and left limbs of RP subjects. (Mean ± SD)

<table>
<thead>
<tr>
<th>Tibial impact shock (G)</th>
<th>Side</th>
<th>0% grade</th>
<th>-3% grade</th>
<th>-6% grade</th>
<th>-9% grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right limb</td>
<td>3.706 ± 1.08</td>
<td>3.856 ± 1.57</td>
<td>4.159 ± 1.63</td>
<td>4.507 ± 1.88</td>
<td></td>
</tr>
<tr>
<td>Left limb</td>
<td>3.245 ± 0.83</td>
<td>3.370 ± 1.07</td>
<td>3.602 ± 0.93</td>
<td>3.819 ± 0.91</td>
<td></td>
</tr>
<tr>
<td>Run speed (m/s)</td>
<td>--</td>
<td>2.272 ± 0.34</td>
<td>2.295 ± 0.36</td>
<td>2.354 ± 0.33</td>
<td>2.377 ± 0.33</td>
</tr>
</tbody>
</table>

Figure 1: a. Averaged TIS for five RP subjects. b. TIS for both limbs of one LP subject.