LONGITUDINAL CHARACTERISTICS OF PLANTAR PRESSURE MEASUREMENTS OF A RUNNING SHOE

Songning Zhang, Michael Wortley, Kurt Clowers, and Charles Kohstall

Biomechanics/Sports Medicine Laboratory, The University of Tennessee, Knoxville, TN, USA
E-mail: szhang@utk.edu

INTRODUCTION

Fifteen to thirty percent of the North American population are active runners (Reinschmidt and Nigg, 2000). However, 37 – 56% of runners are injured every year (Nigg, 2001). The overall running injury rate is approximately between 25 to 75% (James, et al., 1978). Most footwear studies have concentrated on running shoes, one of the most popular recreational sports. Very few longitudinal studies of running shoes are available in the biomechanics literature (Cook, et al., 1985). Therefore, the purpose of the study was to examine longitudinal changes of plantar pressure and ground reaction force (GRF) measurements of a running shoe.

METHODS

Twenty healthy recreational male runners with no impairments to their lower extremities at the inception of the study participated in the study and nine of them completed the study.

Subjects ran in a pair of running shoes (Boston, adidas) for 400 miles and participated in five biomechanical test sessions: at 0 (beginning), 50, 100, 200, and 400 (end) miles during the study. Each subject performed five level running trials at 4.0 m/s during each testing session with simultaneous recording of sagittal and rear view kinematics (120 Hz, JVC 1980), ground reaction forces (1200 Hz, AMTI), and plantar pressure (120 Hz, Fscan). In the first test session (0 mile), each subject was asked to run in the testing shoes for 10 min on an outside track and then fill out a questionnaire immediately afterwards about the perception of comfort, fit, cushion, and stability of the running shoe. The subject was asked to fill out a weekly survey form during the study. Material properties of selected shoes were also tested using an Instron before and after the 400 miles run.

The plantar surface of the foot was divided up into six regions for data processing. The sensor area was divided into four rectangular regions based on longitudinal length: the heel region (the most posterior 30%), the midfoot region (the next 25% anterior to the heel), the ball region (the next 29% anterior to the midfoot), and the toe (the most anterior 16%). The heel and ball regions were further evenly divided into medial and lateral regions.

A one-way repeated measures analysis of variance (ANOVA) and post-hoc comparisons were performed on selected GRF and plantar pressure variables (p < 0.05).

RESULTS AND DISCUSSION

The subjects took an average of 17.9 weeks to complete the 400 miles. The ANOVA and post hoc comparisons showed no significant changes for the peak vertical GRF (Fmax), and maximum breaking (MaxBrk) and propulsive force (MaxProp) over the study period (Table 1). The plantar pressure data (Table 2) indicated that there was a significant increase from 0 to 200
miles, from 0 to 400 miles, and from 50 to 400 miles for the peak plantar pressure of the entire foot (PP). For the peak pressure of the toe region (Ptoe), an increase from 50 to 400 miles was significant. For the peak ball pressure (Pball), increases from 0 to 100, 200 and 400 miles were also significant. In addition, a significant increase from 0 to 400 miles was found for the peak heel (Pheel) and medial heel plantar pressure (Pmedheel). Finally, an increase from 0 to 100 miles was observed for the peak lateral heel pressure (Platheel).

Table 1. Selected GRF variables (mean ± SD).

<table>
<thead>
<tr>
<th>Cond</th>
<th>Fmax</th>
<th>MaxBrk</th>
<th>MaxProp</th>
</tr>
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<tbody>
<tr>
<td>0 miles</td>
<td>2.65 ± 0.23</td>
<td>-0.44 ± 0.08</td>
<td>0.34 ± 0.05</td>
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<tr>
<td>50 miles</td>
<td>2.67 ± 0.29</td>
<td>-0.45 ± 0.07</td>
<td>0.35 ± 0.05</td>
</tr>
<tr>
<td>100 miles</td>
<td>2.62 ± 0.27</td>
<td>-0.46 ± 0.11</td>
<td>0.34 ± 0.04</td>
</tr>
<tr>
<td>200 miles</td>
<td>2.69 ± 0.27</td>
<td>-0.45 ± 0.08</td>
<td>0.34 ± 0.06</td>
</tr>
<tr>
<td>400 miles</td>
<td>2.66 ± 0.30</td>
<td>-0.49 ± 0.09</td>
<td>0.32 ± 0.07</td>
</tr>
</tbody>
</table>

GRF unit is in N/kg. a – significantly different from 0 mile, b – significantly different from 50 mile, c – significantly different from 100 mile, d – significantly different from 200 mile.

Even though the GRF related variables showed no significant changes (Table 1), the plantar pressure data exhibited significant changes over the entire 400 miles of running. The peak plantar pressure of the entire foot, ball and heel regions at the 400 miles all demonstrated significant increases over the 0-mile condition (Table 2). These represent 64, 44 and 27% of increases in the peak plantar pressure for the whole foot, ball and heel regions respectively. Increases in the plantar pressure of these regions measured at some of the intermediate miles were also observed compared to the onset of the study, however, no statistical significances were found. These plantar pressure findings were supported by the results of the Instron testing. The rearfoot functional stiffness increased 39% and 11% over the reference shoes (new) for sizes of 12/12.5 and 9/9.5 respectively; the decreases in the rearfoot maximum deformation were 26% and 11% for the same two sizes. These results suggested that there was graduate deterioration in the cushioning capacity of the shoes over the run and are different from the results of the previous study (Cook, et al., 1985).

**SUMMARY**

We have documented a long-term profile of GRF and plantar pressure over a 400-mile run through this study. The results suggested a graduate breakdown in the cushion capacity of the running shoes from 50 – 400 miles.

**REFERENCES**


**ACKNOWLEDGEMENTS**

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