Plantar Pressure Differences Between Treadmill and Overground Running

Milad Zarei, Stephen P. Canton, MaCalus V. Hogan, William J. Anderst

Biodynamics Lab, Department of Orthopaedic Surgery, University of Pittsburgh, Pittsburgh, PA, USA
Biodynamics Lab website: bdl.pitt.edu

Introduction

Background

- Impact forces and plantar pressure distribution during running can help identify risk factors for injury and evaluate athletes for return to sport after injury.
- Previous studies suggest plantar pressure is reduced under the toes[2] or under the heel and toes[1] during treadmill running versus overground running.
- A limitation of those studies was that the analysis included very few foot strikes per surface (2 and 5)[1,2].

Aim

- Compare plantar pressure during overground and treadmill running.

Hypothesis

- Plantar pressure during treadmill running would be lower in the heel and toe regions in comparison to overground running.

Methods

Data Collection

- 20 healthy participants (10 M, 10 F, age: 30.7±6.3 years, Weight: 157.5±25.7 lbs., BMI: 24.1±3.1 kg/m^2), provided informed written consent prior to participating in this IRB-approved study.
- All participants ran over a 6.9 m runway 4 times in the lab. They also ran on an instrumented treadmill 8 times at their average overground running speed.
- Reflective markers were placed on the body to determine the speed of overground running (average speed of 2.2±0.5 m/s) using a conventional motion capture system (Vicon).
- A Pedar insole pressure system (Novel) was used to collect bilateral plantar pressure for all trials at 100 Hz with 99 sensors per insole.
- All participants wore the same type of running shoes (Nike Zoom) for the test.

Data Processing

- The insole was divided into 9 regions for analysis[2] (Figure 1).
- The Peak Pressure (PP), defined as the peak of the average pressure within each region, and the Pressure-Time Integral (PTI), which reflects the overall loading within each region, were calculated for each subject.
- The PP and PTI were normalized to body weight, and then averaged over all steps within each participant in the overground and treadmill running trials separately.

Data Analysis

- Paired t-tests with the Bonferroni-Holm correction for multiple comparisons were performed to identify differences in the PP and PTI during overground and treadmill running within each of the 9 regions with significance set at $p<0.05$.

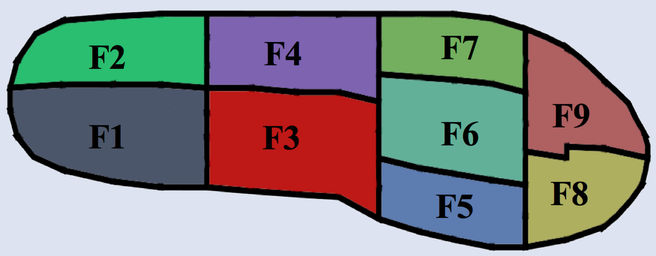

Figure 1: *The foot was divided into 9 regions: medial heel (F1), lateral heel (F2), medial midfoot (F3), lateral midfoot (F4), medial forefoot (F5), central forefoot (F6), lateral forefoot (F7), greater toe (F8), and lesser toes (F9).*

Results

- A total of 264 steps (average foot strikes: 13.2±3.3) for overground and 999 steps (average foot strikes: 49.9±10) for treadmill running were analyzed.
- The PP during treadmill running was lower in the medial heel ($p<0.001$) and lateral heel ($p<0.001$) in comparison to overground running (Figure 2).
- In contrast, the PP during treadmill running was higher in the medial midfoot ($p<0.001$), the medial forefoot ($p<0.001$), and in the central forefoot ($p<0.001$) in comparison to overground running.

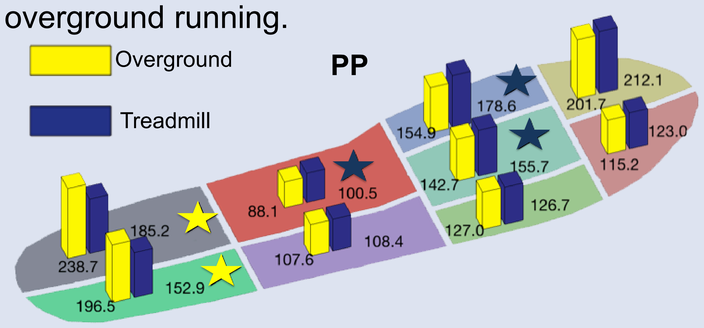

Figure 2: *The average peak pressure (unit of kPa/N) during overground and treadmill running.*

- The PTI during treadmill running was less in the medial heel ($p<0.001$) and lateral heel ($p<0.001$) in comparison to overground running (Figure 3).
- The PTI during treadmill running was greater in the medial midfoot ($p=0.001$), and in the medial forefoot ($p=0.017$) in comparison to overground running (Figure 3).

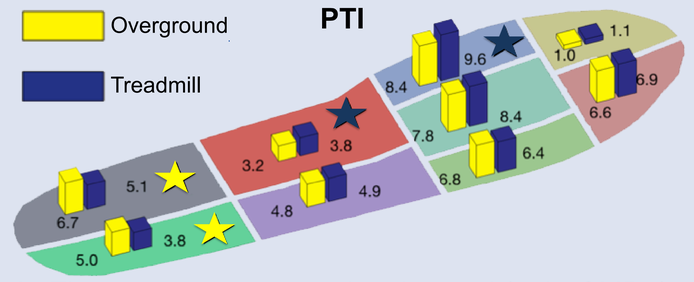

Figure 3: *The average pressure-time integral (unit of MPa*sec/N) during overground and treadmill running.*

Discussion

Main Finding

- **Plantar pressure during treadmill running was shifted from the heel to the midfoot and forefoot in comparison to overground running.**
- Small sample sizes may have prevented previous studies from observing the increased medial midfoot and forefoot loading during treadmill running.
- **Limitations:** The small sample size precluded analysis based upon running speed, foot type, and foot strike pattern.
- **Strengths:** Consistent shoe type and a high number of foot strikes.

Clinical Significance

- **Altered foot loading patterns may lead to subtle changes in joint loading (forces and moments) during treadmill running. These loading differences should be considered when prescribing treadmill running for rehabilitation or when evaluating running performance.**

References and Acknowledgements

1. Garcia-Perez et al., *Gait & Posture*, 2013. 2. Hong et al., *J Sci Med Sport, 2012.*
3. Riley et al., *Med Sci Sports Exerc*, 2008.

This work was supported by NIH grant number 2R44HD066831.

National Institute of Arthritis and Musculoskeletal and Skin Diseases