Effects of Running Shoe Type and Speed on Rearfoot Eversion Excursion in Elite Runners

Evan R. Sirls[1], Logan W. Gaudette[1], Michelle M. Bruneau[1], Alan V. Lussner[1], Adam S. Tenforde[1]
[1] Spaulding Rehabilitation Hospital, Spaulding National Running Center, Department of Physical Medicine and Rehabilitation, Harvard Medical School, Boston, MA 02138, USA
Email: atenforde@mgh.harvard.edu

Summary

This study examined the effects of footwear on rearfoot eversion excursion in elite runners across three running speeds. Two types of technologically advanced running shoes (TARS) – responsive foam shoes (Foam) and responsive foam shoes with a carbon plate (CFP) – were compared to traditional neutral running shoes (Neutral). No differences were observed across footwear and running conditions. These results do not support TARS alters rearfoot eversion excursion in elite runners.

Introduction

TARS have enhanced running performance by improving running economy [1]. However, these changes may alter biomechanics and contribute to risk for injury [2].

Biomechanical variables such as rearfoot eversion excursion have been associated with bone stress injuries (BSI) including the tarsal navicular [3,4]. While TARS have been tied to increased eversion excursion and cases of navicular BSI in competitive runners, further research is needed [2,5].

To our knowledge, no studies have compared multiple footwear types in elite distance runners across different running efforts. The purpose of this study was to evaluate how footwear and speeds affect rearfoot eversion excursion, offering insight into how this biomechanical variable may influence injury risk using TARS.

Methods

Runners were eligible to participate if they were: a.) over 18 y/o b.) healthy with no spine or lower extremity (LE) injury for at least three months / no spine or LE surgery within the past year, and c.) qualified for Olympic trials, national championships, or competed at a collegiate level or higher. Participants ran in three randomized three shoe conditions (CFP, Foam, Neutral). 42 retroreflective markers were placed on the pelvis, thigh, shank and foot.

After a 5-minute accommodation, participants ran for 5 minutes on an instrumented treadmill (AMTI, Watertown, MA) at self-selected easy, tempo, and 10k race paces. Kinematics were collected using 3-D motion capture (250 Hz, Vicon, Oxford, UK) and processed in MATLAB (MathWorks, Inc, Natick, MA). Ground reaction force data and marker trajectories were filtered with a 4th order, Butterworth low-pass filter (50-Hz and 8 Hz cutoffs). Stance was determined via a 50-N threshold of the vertical ground reaction force. Rearfoot excursion was determined using Visual3D (HAS-Motion, Kingston, ON) and a model-based approach. It was measured and calculated as the range from initial contact inversion to peak eversion of the rearfoot relative to the tibia at midstance. Statistical analyses were performed using RStudio (version 4.4.0). Participant characteristics were reported descriptively. To determine within-subject and between group differences, two-factor repeated measures ANOVA was performed.

Results and Discussion

We enrolled 9 participants (3 female, 6 male). Mean age was 24.8 ± 2.2 years-old, BMI was 21.5 ± 1.9 kg/m2, and weekly volume was 60.56 ± 14.7 miles. Self-selected easy pace was 3.6 ± 0.4 m/s, tempo pace was 4.8 ± 0.3 m/s and race pace was 5.3 ± 0.17 m/s.

Excursion angles for each speed and shoe condition are in Table 1. No interaction effect was detected ($p = 0.437$). Although rearfoot excursion values were similar to those from previous research, we found no significant main effects of shoe type ($p = 0.164$) or speed ($p = 0.933$) across conditions (Table 2) [3,5]. The largest effect size was noted to be by shoe type.

Conclusions

Rearfoot eversion excursion was similar across shoe types and running speeds. These results do not support TARS alters rearfoot eversion excursion in elite runners compared to other common forms of footwear.

References

[1] Hoogkamer W, et al. (2019). *Sports Med*, **49**(1): 133-143.
[2] Tenforde A, et al. (2023). *Sports Med*, **53**(8): 1499-1505.
[3] Becker J, James S, et al. (2018). *Orthop J Sports Med*, **6**(4): 2325967118767363.
[4] Milner CE, et al. (2010). *J Orthop Sports Phys Ther*, **40**(2): 59-66.
[5] Hannigan JJ, et al.(2024).*Footwear Sci.*,**16**(2):115-121.

Table 1: Mean rearfoot eversion excursion angle with each condition.

Speed	CFP	Neutral	Foam
	Excursion (°)	Excursion (°)	Excursion (°)
Easy	16.38 ± 3.8	15.74 ± 3.5	17.21 ± 4.2
Tempo	15.94 ± 4.4	16.03 ± 4.3	17.03 ± 4.2
Race	16.05 ± 4.1	15.98 ± 3.6	17.02 ± 4.1

Table 2: Two-way ANOVA examining the effects of shoe type, speed type, and their interaction on rearfoot excursion.

	P-Value	Effect Size
Shoe	0.164	0.018
Speed Type	0.933	0.0002
Shoe × Speed	0.437	0.0012