The Influence of Modified Footstrike Patterns on Vertical Acceleration of the Sacrum During Running

Ephrem B. Mekonnen[1], Moksha Dilip[2], Sean K.T. Gaiesky[1], Christopher Napier[1]
[1]SFU Run Lab, Department of Biomedical Physiology & Kinesiology, Simon Fraser University, Vancouver, Canada
[2]WearTech Labs, Simon Fraser University, Vancouver, Canada
Email: emekonne@sfu.ca

Summary

This study examined the effects of modified footstrike patterns on peak vertical accelerations at the sacrum while running at varying speeds. Runners with a habitual rearfoot strike exhibited higher peak vertical accelerations than runners with a habitual non-rearfoot strike, regardless of the footstrike pattern employed. These findings suggest that other lower extremity biomechanics (e.g., step length, knee flexion angle) may play a greater role in determining peak vertical accelerations at the sacrum than footstrike pattern.

Introduction

Some experts claim that a non-rearfoot strike (non-RFS) running pattern reduces impact loading and injury risk, but studies have not confirmed its superiority over a rearfoot strike (RFS) pattern or established a clear link between impact loads and injury risk [1]. Understanding how footstrike modification affects impact loading may provide insight into how runners adapt to changes in technique, whether impact forces are primarily influenced by footstrike or other factors, and how these forces could inform future research investigating their relationship to injury risk. However, little is known about how footstrike modification influences accelerations of the center of mass (COM). An inertial measurement unit (IMU) mounted over the sacrum is a valid proxy for the COM [2] and vertical accelerations measured at the sacrum may be a useful tool to quantify whole-body impact forces outside of a lab [3]. This study examined the effect of modified footstrike patterns on sacral vertical accelerations in habitual RFS and non-RFS runners.

Methods

Eighteen healthy recreational runners (age: 35.61 ± 8.33 years; BMI 23.57 ± 3.21 kg/m^2, 8 habitual NRFS, 10 habitual RFS strike, 10 females, 8 males) completed a 5-minute warm-up followed by 30-second running trials on an instrumented treadmill at varying speeds (3.0 m/s, 3.5 m/s, 4.0 m/s, 4.5 m/s,) using habitual and modified footstrike patterns in standardized shoes (Saucony Endorphin Speed v3, Saucony, Waltham,, USA). We determined footstrike pattern during warm-up based on foot strike angle, with midfoot strikes grouped with forefoot strikers as non-RFS [4]. We measured vertical accelerations using IMUs embedded in a pocket in participants' running half-tights at the level of S2. We processed raw acceleration data using a 4th-order Butterworth filter with a low-pass frequency of 15 Hz, averaging data across both limbs using the middle 30 steps of each limb per trial. We used a repeated-measures ANOVA to compare peak vertical accelerations between habitual RFS and habitual NRFS runners across all speeds and footstrike conditions with post hoc analyses for significant main effects and interactions.

Results and Discussion

When running with their habitual footstrike pattern, habitual RFS runners exhibited significantly higher peak vertical accelerations than habitual non-RFS runners across all speeds (Figure 1). Interestingly, when participants ran with modified footstrike patterns, the habitual RFS runners still exhibited significantly higher peak vertical accelerations compared to habitual NRFS, despite running with a NRFS pattern. Overall, the trend was that RFS runners exhibited higher peak accelerations when adopting a modified footstrike.

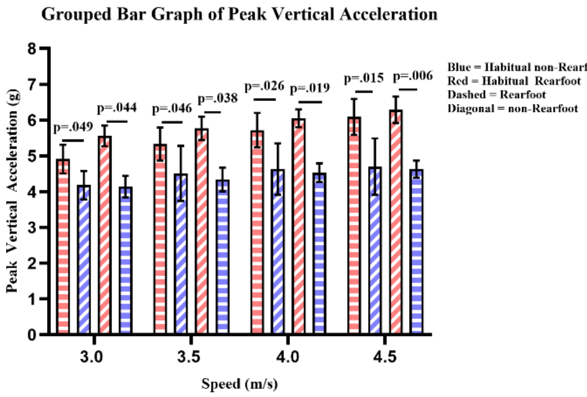

Figure 1: Comparison of Peak Vertical Acceleration by Footstrike and Speed. Blue diagonal = habitual non-rearfoot strike; Red dashed = habitual rearfoot strike; Blue dashed = habitual non-rearfoot strike running with modified footstrike (RFS); Red diagonal = habitual rearfoot strike running with modified footstrike (non-RFS).

Conclusions

Habitual RFS runners exhibited higher peak vertical accelerations even when adopting a non-RFS pattern, contrary to the expectation that a non-RFS pattern would reduce impact forces. This may be influenced by other factors common in RFS runners, such as longer step length and reduced knee flexion at initial contact, which can increase impact forces [5]. These findings highlight the importance of considering other stride characteristics, such as step length and knee flexion angle, when implementing gait retraining interventions to reduce peak vertical accelerations. Future research should assess whether these differences in acceleration persist after habituation and investigate other strategies to reduce vertical acceleration of the COM.

References

[1] Hamill J and Gruber AH (2017). *J Sport Health Sci,* **6(2)**, 146–153.
[2] Napier C et al (2020). *J Biomech* **108**: 109886
[3] Alcantara RS et al. (2021). *PeerJ*, **9**: e11199.
[4] Altman AR and Davis IS (2012). *Gait Posture*, **35(2)**, 298–300
[5] Blagrove RC. (2021) *The science and practice of middle and long distance running*; Routledge.