

Center of Mass Vertical Excursion is Effected by Running Shoe Type

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Summary

This study examined the effects of footwear on vertical center of mass (vCOM) excursion and step rate in elite runners across three running speeds. Three different types of footwear were examined. A main group effect of shoe type on vCOM excursion was observed. Lower vCOM excursion was observed in Foam shoes compared to both Neutral and carbon fiber plate (CFP) shoes. The findings highlight the need for further investigations into the effect of footwear on biomechanical variables and running related injury risk.

Introduction

Vertical center of mass (vCOM) excursion and step rate have been associated with bone stress injuries (BSIs) in high-level collegiate runners[1],[2]. Previous literature suggests a 5-10% increase in step rate results in a reduction in vertical COM displacement [2].

Recent advancements in footwear technology include the addition of a carbon fiber plate (CFP) to a foam insole, referred to as “super shoes.” One case series identified an association between CFP shoes and BSIs of the navicular bone [3]. However, limited research has compared CFP shoes to other forms of footwear commonly used by runners [4]. The purpose of this study was to evaluate if differences in step rate and vCOM are observed in CFP shoes compared to lightweight foam (Foam) or neutral running shoes (Neutral).

Methods

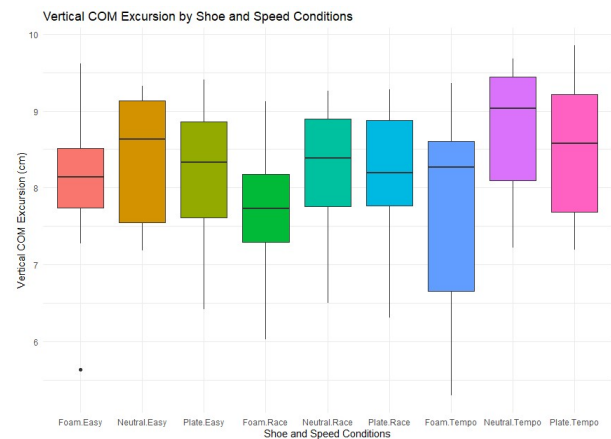
Runners were eligible to participate if they were: a.) over 18 years-old, b.) healthy with no spine or lower extremity injury for at least three months and no spine or lower extremity surgery within the past year, and c.) qualified for their respective country’s Olympic trials or national championships or competed at a collegiate level or higher.

Anatomical and tracking retroreflective markers were placed on the segments of participants’ pelvis, thigh, shank and foot. Following a 5-minute accommodation period, participants ran for 3 minutes on an instrumented treadmill (AMTI, Watertown, MA) at a self-selected speed for each of the following speed conditions: easy pace, tempo pace, and 10k race pace. Full body kinematics were collected using 3-D motion capture (250 Hz, Vicon, Oxford, UK). Biomechanical data were processed via a custom-written MATLAB code (MathWorks, Inc, Natick, MA). Ground reaction force data and marker trajectories were filtered with a 4th order, Butterworth low-pass filter with respective 50-Hz and 8-Hz cutoffs. Stance was determined via a 50-N threshold of the vertical ground reaction force. The center of mass was determined using Visual3D (HAS-Motion, Kingston, ON)

and a model-based approach. Vertical excursion of the center of mass was then determined as the difference between the maxima of center of mass position during the flight phase and its minima at mid-stance.

Statistical analyses were performed using R studio. Participant characteristics were reported descriptively. To determine within-subject and between group differences, a two-factor repeated measures ANOVA was performed for step rate and vCOM excursion in three footwear conditions at three different speeds.

Figure 1: vCOM excursion by shoe and speed condition.



Results and Discussion

Nine runners participated (3 female, 6 male) of mean age 24.8 ± 2.2 year-old, BMI 21.5 ± 1.9 kg/m², and weekly volume 60.56 ± 14.7 miles. Self-selected easy pace was 3.6 ± 0.4 m/s, tempo pace was 4.8 ± 0.3 and race pace was 5.3 ± 0.17 m/s.

No interaction effect was observed. Main group effects were observed for vCOM excursion by shoe type ($p = 0.03$), but not by speed ($p = 0.10$). vCOM excursion was lower in the Foam group compared to the Neutral ($p = 0.015$) and CFP group ($p = 0.048$). No group effects were detected for step rate.

Conclusions

Our results suggest footwear may modify vCOM, a variable associated with bone stress injuries in runners.

References

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