The Influence of Carbon Fiber Plate Running Shoes on Peak Knee Flexion and Knee Extensor Moment in Elite Distance Runners

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Summary

The knee is the most common location of injury in runners. There is currently limited research on biomechanical risk factors for knee injuries associated with carbon fiber plate shoes, referred to as "super shoes." This study investigated the relationship between peak knee flexion and knee extensor moment across three different footwear types in elite distance runners. There were no significant differences in peak knee flexion between footwear conditions. However, peak knee extensor moment was lower in carbon fiber plate shoes compared to both neutral and light weight foam shoes. These findings may inform future work evaluating influence of footwear on biomechanical risk factors for knee injuries.

Introduction

Running shoes containing a carbon fiber plate (CFP), also known as "super shoes", have exponentially increased in popularity over the past five years, especially as racing shoes for elite runners. While limited research has associated CFP shoes with foot injuries [1], it is unclear how this footwear may influence biomechanics of the knee. Peak knee flexion and peak knee extensor moment have been associated with patellofemoral pain in runners [2,3]. However, the association between these variables with CFP shoes has not been explored in an elite population of distance runners. The purpose of our study was to compare peak knee flexion and knee extensor moment in different shoe types across varying speeds in elite distance runners.

Methods

Participants were eligible 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 ran competitively in college.

We placed 42 reflective markers on anatomical landmarks on the trunk, spine, pelvis, thigh, shank, and feet. Participants ran for 5-minutes on an instrumented treadmill (AMTI, Watertown, MA) at a self-selected speed in three different shoes (neutral, foam, CFP) for three different speed conditions (easy pace, tempo pace, 10k race pace). Kinematic data were collected at 250 Hz using 3-D motion capture (Vicon, Oxford, UK). Knee moments were calculated using Visual3D (Kingston, Ontario). A custom-written MATLAB code (MathWorks, Inc, Natick, MA) was used to process biomechanical data. 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. All statistical analyses were performed using RStudio (version 4.4.0). Participant characteristics were reported descriptively. A two-factor repeated measures ANOVA (shoe condition x speed) for each of the knee biomechanical variables of interest were performed. Post hoc comparisons were used to determine group differences in the presence of a significant ANOVA ($p<0.05$).

Results and Discussion

Nine elite distance runners (3 females, 6 males; mean age 24.8 ± 2.2 year-old; BMI 21.5 ± 1.9 km2; weekly volume 60.56 ± 14.7 miles per week) were included in the study. No significant interactions were observed for peak knee flexion or knee extensor moment (all $p>0.05$). For peak knee flexion, there were no significant main group effects by shoe type ($p=0.09$) or by speed ($p=0.73$). Significant group effects were observed for knee extensor moment by shoe type ($p<0.05$) and by speed ($p<0.01$) (Figure 1). Peak knee extensor moment was lower in the CFP group compared to the Foam group ($p=0.0071$) and the Neutral group ($p=0.0010$).

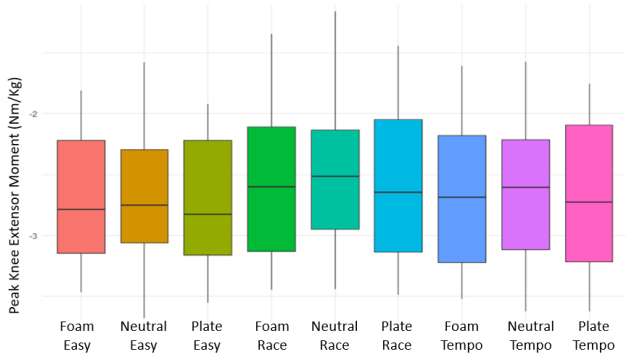

Figure 1: Peak Knee Extensor Moment by Shoe and Speed Condition

Conclusions

While no differences were observed in peak knee angle by shoe type, the main group effects by both shoe type and speed for knee extensor moment suggests that knee mechanics may be influenced by footwear. These findings may inform future work evaluating influence of footwear on biomechanical risk factors for knee injuries.

References

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