BIOMECHANICAL COMPARISON OF PRESSURE * TIME ACROSS DIFFERENT FOOTWEAR CONDITIONS DURING WALKING AT VARYING SPEEDS

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Summary

This study compared the overground pressure distributions of carbon fiber plates (CFPs) shoes, CFP inserts, and no-plate shoes at different walking speeds. Significant effects of Shoe and Speed were observed for Pressure*Time, Peak Pressure, Peak Time, and Area in heel, arch, forefoot. CFPS demonstrated the shortest peak time and reduced localized pressure, indicating they may reduce foot load and improve walking efficiency. CFP insert exhibited similar benefits, particularly in lowering peak pressure. These observations highlight the potential benefits of CFP shoes and inserts.

Introduction

Embedding CFPs in running shoes can improve performance by limiting MTP bending and saving energy [1,2]. However, there has not been research on replacing the insole with a CFP in a running shoe that does not originally have a CFP. This study explores the overground pressure distributions of CFP shoe (CFPS), CFP insert (CFPI), and no CFP (CFPN) shoes at different walking speeds.

Methods

Five adults were recruited for this study (age: 23.2±0.8, years; body mass: 67.0±4.5 kg; height: 169.8 ±4.0 cm). Participants walked on a 16-foot GAITRite walkway (Version 4.8.8; CIR Systems Inc., Sparta, NJ, USA) at three different velocities. Data was collected at 200 Hz. The dependent variables include Pressure*Time (The sectional integrated pressure over time), Peak pressure, Peak time, and Area of the heel, arch, and forefoot. Two-way (Shoe×Speed) ANOVA with repeated measures was used to examine the difference between shoe conditions and speed. Alpha=0.05.

Results and Discussion

In the arch region, main effects of Shoe were found for P*T ($F(2,78)=256.2$, $p<0.001$, $\eta^2=0.87$) and Area ($F(2,78)=375.13$, $p<0.001$, $\eta^2=0.91$), while Speed affected P*T ($F(2,78)=3.68$, $p=0.03$, $\eta^2=0.09$) and Area ($F(2,78)=4.09$, $p=0.021$, $\eta^2=0.10$). A Shoe×Speed interaction was observed for Peak Time ($F(4,20)=6.13$, $p=0.002$, $\eta^2=0.55$) and Peak Pressure ($F(4,156)=3.18$, $p=0.015$, $\eta^2=0.08$). In the heel region, Shoe affected on P*T ($F(2,78)=11.17$, $p<0.001$, $\eta^2=0.22$) and Peak Pressure ($F(2,78)=84.68$, $p<0.001$, $\eta^2=0.68$), while Speed influenced Peak Time ($F(2,76)=95.38$, $p<0.001$, $\eta^2=0.72$). A Shoe×Speed interaction was found for Area ($F(4,156)=4.13$, $p=0.003$, $\eta^2=0.10$). In the forefoot region, significant main effects of Shoe were observed for P*T ($F(2,78)=8.46$, $p<0.001$, $\eta^2=0.18$). Peak Time ($F(2,78)=15.79$, $p<0.001$, $\eta^2=0.29$), Area ($F(2,78)=20.32$, $p<0.001$, $\eta^2=0.34$), and Peak Pressure ($F(2,78)=11.40$, $p<0.001$, $\eta^2=0.23$). Speed influenced Peak Time ($F(2,78)=327.37$, $p<0.001$, $\eta^2=0.89$) and Peak Pressure ($F(2,78)=4.14$, $p=0.019$, $\eta^2=0.10$). Regardless of speed, CFPS had the shortest mean Peak Time (slow: CFP Shoe: 0.57s<CFP Insert: 0.61s<No Plate: 0.62s; fast: CFPS: 0.40s<CFPI: 0.42s<CFPN: 0.43s). Additionally, CFPN exhibited the highest mean relative Peak Pressure (slow: CFPN: 10.37>CFPS: 9.72>CFPI: 9.10; fast: CFPN: 10.30>CFPS: 9.94>CFPI: 8.84).

Previous studies placed the CFP below the insole, between the midsole, and just above the outsole, respectively. The two conditions below the insole and between the midsole correspond to the CFPS or CFPI in this study, and the same condition in terms of peak pressure was obtained [3]. Another study tested two specific running speeds with two shoe conditions, where a stiff plate was added either in a high location (under the insole) or a low location (between the midsole and outsole). The results show that the high location significantly decreased propulsive ground reaction forces [4].

Conclusions

CFPS significantly shorten peak time and reduce localized pressure across different walking speeds, potentially alleviating foot load compared to non-CFPS. CFP inserts exhibited a comparable trend, particularly in reducing peak pressure. These findings support the potential of CFPS in enhancing performance and reducing fatigue risk.

References

[1] Nielsen A et al. (2022) *Int. J. Sports Med*, **43**: 804-810.
[2] Shorten MR. (2024) *Footwear Sci*, **16**: 149-162.
[3] Song Y et al. (2023) *J. Biomech*, **15**: 1-7.
[4] Flores N et al. (2019) *Sports Biomech*, **18**: 1-16