Effects of Carbon-plated Running Shoes on Running Smoothness in Novice Runners

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Summary

This study investigated the effects of carbon-plated running shoes on running smoothness during the stance phase in novice runners. The results revealed no significant differences in running smoothness, as measured by jerk-cost, across the two shoe conditions.

Introduction

Carbon-plated running shoes provide a mechanical advantage by enhancing energy return and stiffness, thus improving running efficiency. However, the impact of these shoes on running smoothness remains unclear. The 'minimum jerk' theory suggests that the maximum smoothness of simple movements is achieved when jerk (the first derivative of acceleration) is minimized [1]. Jerk-cost (JC) is calculated as the time integral of the squared jerk, with higher JC values indicating reduced smoothness, especially in more complex motions [2]. This study examined the effects of carbon-plated running shoes on running smoothness, as measured by JC, in novice runners.

Methods

Fourteen healthy male novice runners participated in this study (height: 174.57±2.98 cm; mass: 74.36±8.54 kg). Two shoe prototypes were tested, differing only in longitudinal bending stiffness (LBS) level: low LBS (LLBS, 10.89 Nm/rad, without carbon-fiber plate) and high LBS (HLBS, 32.95 Nm/rad, with a carbon-fiber plate). Kinematic data were collected at 200 Hz using a 3D motion capture system (Mars 4H, Nokov), and ground reaction force data were collected at 1000 Hz using a Kistler force platform. JC was calculated in the horizontal (JC_x), vertical (JC_y), and sagittal (JC_z) directions for the endpoint of the heel marker using Visual 3D, along with a resultant component (JC_r). Participants performed three trials per shoe condition at 15 km/h, ensuring full right-foot placement on the platform. Paired sample t-tests were performed to assess differences in the mean values of JC_r between groups during the stance phase. A significance level of $\alpha = 0.05$ was applied for all comparisons.

Results and Discussion

As shown in Figure 1, the jerk trends in the sagittal, horizontal, and vertical directions, as well as the JCr, were assessed during the stance phase. The average JCr during the stance phase revealed no significant difference between the HLBS and LLBS shoes ($p = 0.106$). The numerical trend slightly favored the LLBS shoes for a smoother movement pattern, but this difference was not statistically significant.

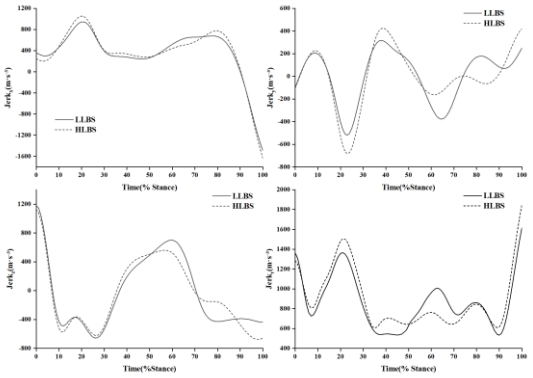

Figure 1: Average curves of the horizontal (x), vertical (y), sagittal (z), and resultant(r) jerk during the stance phase for each shoe condition.

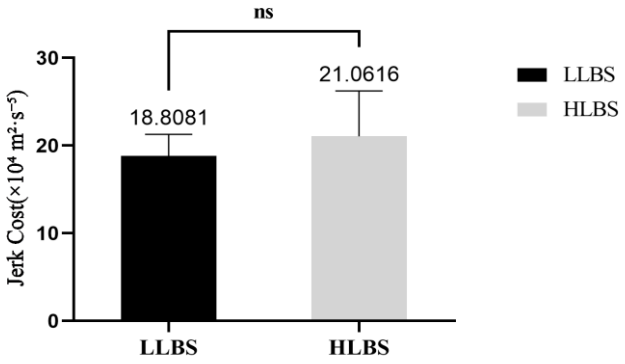

Figure 2: Mean values of resultant jerk-cost (JC_r) during the stance phase for each shoe conditions

Conclusions

This study found no significant difference in running smoothness, as measured by JC, between shoes with HLBS and LLBS in novice runners. Despite the trend indicating slightly smoother running in LLBS shoes, the differences were not statistically significant. These findings suggest that carbon-fiber plates may have a limited effect on running smoothness in novice runners. Further research, utilizing larger sample sizes and examining the entire gait cycle, is necessary to gain a more comprehensive understanding of this relationship.

References

[1] A. Hreljac (2000). *Gait & posture*, **11**: 199-206.
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