The Effects of Different Shoe Stack Heights on Running Style During Running at Different Speeds

Cagla Kettner, Bernd J. Stetter, Thorsten Stein
Institute of Sports and Sports Science, Karlsruhe Institute of Technology, Karlsruhe, Germany
Email: cagla.kettner@kit.edu

Summary

Stack height of running shoes has been highly discussed especially since World Athletics restricted it to 40 mm. Various studies reported that increased stack height may increase performance but the underlying biomechanical effects have not yet been well understood. This study aimed to investigate the influences of different stack heights (27, 35 and 50 mm) on running style during level running at different speeds. The results indicated that the 50 mm stack height resulted in longer ground contacts relative to the stride time compared to 27 mm. Vertical center of mass oscillation increased with increasing stack. The higher stacks (≥ 35 mm) led to longer steps at 15 km/h. Stack height effects on joint angles were observed only in the ankle. The findings showed that stack height variations affect running style.

Introduction

Shoes may influence running performance. The effects of stack heights have been highly discussed, especially since Word Athletics restricted it to 40 mm. Associated biomechanical effects are still not well understood [1]. Running style is important for running performance [2] and can be influenced by many factors such as shoes [3] and running speed [2]. To date, no study focused on the effects of higher stack heights (≥35 mm) on running style.

This study aimed to investigate the effects of different stack heights on running style at different speeds. It was hypothesized that higher stacks (≥35 mm) lead to changes in running style (H1) and this effect is more pronounced at a higher speed (H2).

Methods

Seventeen healthy male experienced runners participated. After a familiarization to treadmill (h/p/cosmos) and warm-up, the running protocol was repeated for three running shoes differing mainly in heel stack height (H: 50 mm, M: 35 mm, L: 27 mm, parallelized order). The running protocol consisted of two runs each lasting 90 s (first at 10 km/h than 15 km/h). There was a 2-min break between speed conditions and 5-min between shoe conditions. Kinematics were collected by a 3D motion capturing system (Vicon, Oxford, UK, 200 Hz). Full body inverse kinematics were calculated using OpenSim Hamner running model. Duty factor (DF) and step frequency normalized to leg length (SF_{norm}) were calculated based on the dual-axis framework for running style [4]. Additionally, the vertical oscillation of center of mass (COM_{osc}) during stance as well as the frontal and sagittal angle time series of the ankle, knee and hip normalized to stance time were calculated. The differences between the shoe (H, M & L) and speed (10 & 15 km/h) conditions were analyzed with rmANOVAs for DF, SF_{norm} and COM_{osc}. Statistical parametric mapping (SPM) rmANOVAs were used for the joint angle comparisons. Bonferroni-Holm corrected t-tests were performed in *post-hoc*. The significance level was set to $\alpha = 0.05$.

Results and Discussion

Stack height affected DF ($p = 0.018$) and COM_{osc} ($p = 0.013$) independent of the speed, whereas stack height effects on SF_{norm} were speed dependent ($p = 0.001$). *Post-hoc* tests revealed that H led to higher DF compared to L ($p = 0.021$). The higher the stack, the higher was the COM_{osc} (H-M: $p = 0.035$, H-L: $p = 0.012$, M-L: $p = 0.030$). SF_{norm} was lower for higher stacks (H-L: $p = 0.046$ & M-L: $p = 0.012$) at 15 km/h. Significant stack height effects were identified for the sagittal and frontal ankle angles but not for the knee and hip. M led to the highest inversion (Fig. 1).

The results indicated that H compared to L shifted the running style to the direction of a "stick" style which associates with longer contacts relative to total stride (i.e. higher DF) [4]. At 15 km/h, the higher stacks (H & M) shifted the running style to a "push" style which relates to longer steps [4]. With increasing stack, the COM_{osc} increased which could be linked to a decreased running economy [2]. However, running economy was not directly measured (e.g., VO_2).

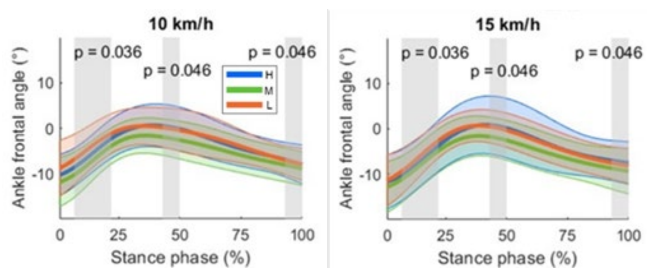

Figure 1: Ankle frontal angle as mean ± standard deviation. Positive and negative angles indicate an eversion and inversion, respectively. Shaded areas show significant shoe effects.

Conclusions

Stack height variations modulated the running style. The highest stack led to longer ground contacts relative to the stride time compared to the lowest stack. With increasing stack, the COM_{osc} increased. Higher stacks resulted in longer steps at 15 km/h. Joint angle differences were observed only in the ankle joint.

References

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