Biomechanical adaptations of runners who hit the wall in full marathon.

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SUMMARY

This study investigated the biomechanical characteristics of runners who experienced "Hitting the Wall" (HTW) during marathons, where 30-40% of participants encounter a notable slowdown in pace. A comparison of biomechanical parameters measured after 30 km in the race and those during training sessions showed higher cadence, shorter stride lengths and vertical displacements during races. Notably, runners who hit the wall demonstrated increased vertical stiffness in later stages of the race, contrasting with those who maintained their pace. These biomechanical changes suggest that exhaustion during HTW forces runners to increase cadence while reducing stride length and vertical displacement, indicating a compensatory mechanism in response to fatigue.

INTRODUCTION

Many runners participate in full marathons, but 30-40% of them experience a significant slowdown in pace during the later stage of the race, commonly referred to as “Hitting the Wall” (HTW) [1]. While some studies have reported biomechanical changes during the races [2,3], the differences in pace may complicate the understanding of these changes. The purpose of this study was to compare the biomechanical characteristics observed during training sessions with those observed during HTW.

METHODS

The dataset included 144 recreational runners, of whom 88 maintained a constant pace throughout the race, while 56 experienced HTW, as defined by their pace profiles after 25 km in a full marathon compared to those from 5 to 20 km. Data were collected using a commercially available inertial measurement unit (IMU) (CMT-20S-AR; CASIO Computer Co.), which was securely clipped to the back of the runner’s shorts. Cadence [steps/m], stride length [/height], vertical displacement [/height], vertical stiffness [kN/m/kg], and contact time [ms] were calculated every 1 km using a validated algorithm. In addition to race data, information from daily training sessions prior to the races was also collected.

Linear mixed models (LMMs) were fit for each parameter measured by the IMU. The LMMs included a dummy variable for after 30 km in the race and training sessions, with running speed [km/h] included as a covariate. For each parameter, the 80% and 95% credible intervals (CIs) of the posterior distributions of the fixed effects for the dummy variable were used to determine whether the parameters observed in the race were different from those observed in the training sessions, and whether the changes in runners who experienced HTW were different from those of runners who maintained their pace (Kept).

RESULTS AND DISCUSSION

In Figure 1, thick and thin line segments represent the 80% and 95% CIs for each fixed effect of the dummy variable, respectively. The circles indicate the mean of each posterior distribution. For both groups, higher cadence, shorter stride length, and shorter vertical displacement were observed in the races ($p < 0.01$). In contrast, runners who hit the wall exhibited higher vertical stiffness ($p < 0.05$) in the latter stages of the races, whereas runners who maintained their pace showed an opposite trend ($p < 0.05$).

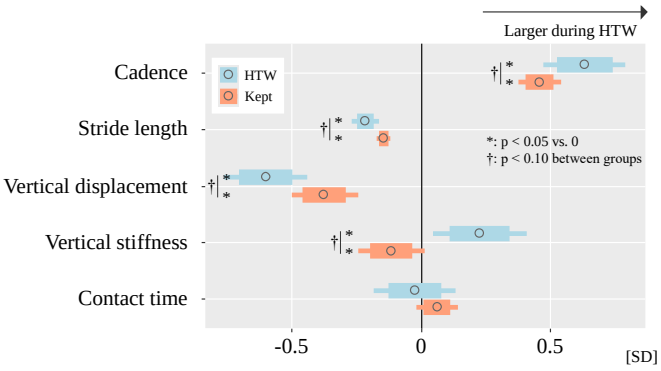

Figure 1: Credible intervals for each fixed effect of the dummy variable.

Aside from comparisons with training sessions, runners who hit the wall exhibited trends of higher cadence (80% CI; [0.53 0.74] for HTW and [0.40 0.51] for Kept), shorter stride length (80% CI; [-0.25 -0.18] for HTW and [-0.16 -0.13] for Kept), and shorter vertical displacement (80% CI; [-0.70 -0.50] for HTW and [-0.46 -0.29] for Kept). These differences appear to stem from the exhaustion experienced during HTW, as runners who experienced HTW were unable to sustain their stride length and may have compensated by increasing their cadence to continue running with less effort per step.

CONCLUSIONS

The findings suggest that the characteristics of hitting the wall are evident in variations in vertical stiffness. Increased vertical stiffness, coupled with shorter vertical displacement, reduced stride length, and higher cadence, may signify the condition of fatigued legs.

REFERENCES

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