The Relationship Between Spatiotemporal Parameters and Performance Scores in Middle- and Long-Distance Runners

Yojiro Kamano[1], Kou Ogawa[1], Ayato Kato[1], Hidetaka Okada[1]
[1]The University of Electro-Communications, Graduate School of Informatics and Engineering, Tokyo, Japan
Email: hidetaka@e-one.uec.ac.jp

Summary

The relationship between spatiotemporal parameters and the performance scores of middle- and long-distance runners with various running abilities was examined using treadmill running at various speeds. Higher-performance runners tended to have a greater forward flight distance per stance phase, indicating a greater ability for the stretch-shortening cycle.

Introduction

Spatiotemporal running parameters vary with changes in speed and performance levels. Higher performance levels are associated with a lower stance phase ratio (duty factor [DF]) within each cycle [1]. Although the Reactive Strength Index (RSI) [2] is used to assess jump performance, it is not commonly used to evaluate plyometric performance during running. During running, generating a forward distance rather than a vertical distance within a short stance phase is critical. This study aimed to calculate spatiotemporal parameters across various speeds in middle- and long-distance runners with different performance levels and examine the relationships between them and performance levels at multiple running speeds.

Methods

Fourteen male middle- and long-distance runners (age: 21.1 ± 1.9 years; height: 171.6 ± 7.4 cm; weight: 61.3 ± 6.4 kg) from a university track and field team participated in this study. Performance levels were evaluated using a WA Scoring Table (WA score). The participants performed treadmill running experiments at six speeds (180, 210, 240, 270, 300, and 330 m/min). Data were captured using a markerless motion capture system (THEIA3D, Theia Markerless Inc.; sampling rate: 200 Hz). The analyses were conducted using THEIA3D, Visual3D (HAS-Motion Inc.), and MATLAB (MathWorks Inc.). A running cycle was divided into six phases (BR, PR, AO, F1, F2, and PO). Spatiotemporal parameters were calculated, including the duration (s) and ratio of each phase in a running cycle (BRt, BRr, PRt, PRr, AOt, AOr, F1t, F1r, F2t, F2r, POt, POr), the duration (s) and ratio of stance and flight phases (STt, STr, FLt, FLr), stride length (SL), stride frequency (SF), stride ratio (SL/SF), flight distance, and stance distance. Indicators representing the vertical and forward distances during the flight phase, normalized by STt and STr, were also computed: flight vertical distance / STt (RSI_v), flight vertical distance / STr (VD/STr), flight forward distance / STt (RSI_f), and flight forward distance / STr (FD/STr). All variables were averaged over ten cycles in each trial. The relationships between the spatiotemporal parameters at each speed and the WA scores were analyzed using Pearson's correlation coefficient ($p < 0.05$).

Results and Discussion

Significant correlations with the WA scores were observed for FLt, AOt (time of phase from toe-off to the point when the fifth metatarsal head was located furthest back from the CG), flight distance, and FD/STr across all speeds (all positively correlated).

Figure 1 shows the relationships between WA scores and RSI_v, VD/STr, RSI_f, and FD/STr at running speeds of 180 and 330 m/min for each participant. At 180 m/min, moderate positive correlations (r: 0.5–0.7) were observed for all four variables, while at 330 m/min, a significant moderate positive correlation was found only for FD/STr. These results suggest that higher-performing runners exhibit a greater forward flight distance per stance phase.

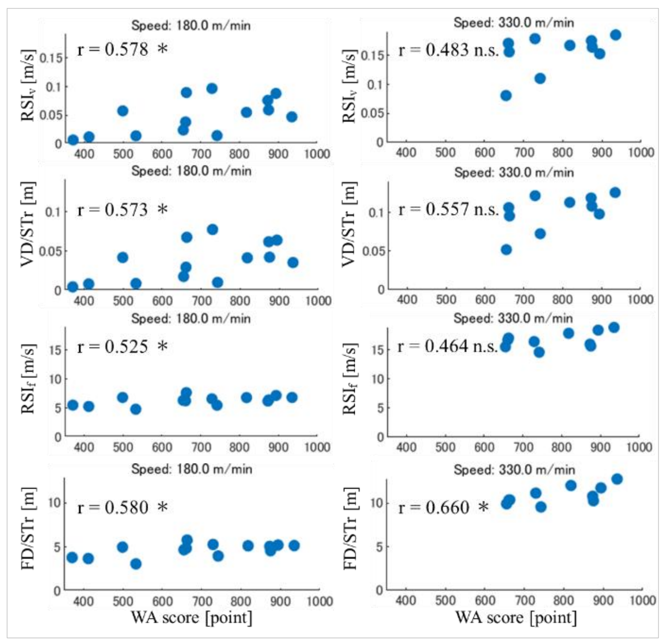

Figure 1: Relationships between WA score and RSI_v, VD/STr, RSI_f, and FD/STr (* p<0.05).

Conclusions

Spatiotemporal parameters related to the performance level and running speed were identified. High-performing runners tended to have a greater forward flight distance per stance phase, indicating a greater ability for the stretch-shortening cycle.

References

[1] Van Oeveren et al.(2024). *Sports Biomech*, **23**: 516-554.
[2] Barker LA et al.(2018). *J Strength Cond Res*, **32**: 248-254.