Running style difference on joint work distribution across running speeds

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Summary

Runners are classified into stride type, who increases speed primarily by extending step length, and cadence type, who increase both step length and step frequency. Biomechanical data from 10 stride type and 10 cadence type runners at running speeds of 3.5, 4.5 and 5.5 m/s were collected to determine if the joint work generation patterns differ between the stride and cadence types. The total negative and positive work of the three lower extremity joints increased with running speed in both types. However, the stride type exhibited greater total positive work than the cadence type with a higher proportion of positive work at the ankle joint, while the cadence type showed greater negative work at the hip joint at higher running speeds.

Introduction

Although running speed is calculated as the product of step length and step frequency, there are two strategies for changing running speed: those that increase step length (stride type) and those that increase both step length and step frequency (cadence type) [1]. Previous studies have examined the relationship between changes in running speed and changes in the work of the three lower extremity joints [2]. However, the effects of changes in running speed on the joint work and the proportional work distribution of these joints between the two types of runners remain unclear. Therefore, the purpose of this study was to investigate the differences in joint work and the proportional work distribution of the three lower extremity joints between stride type and cadence type runners.

Methods

Twenty healthy adults (10 stride type and 10 cadence type) were recruited for this study. Kinematic and kinetic data were collected using a motion capture system and force plates while participants ran over a 50-m runway. Data were selected for running speeds of 3.5, 4.5 and 5.5 m/s. Step length was defined as the distance between consecutive contralateral foot strikes. Step frequency was determined as the reciprocal of the duration of a single step cycle. Joint power was calculated by multiplying joint moments by joint angular velocity, and negative and positive joint works were determined as the integral of the negative or positive joint power during the stance phase. The proportion of joint work during the stance phase was calculated by dividing negative or positive work by total negative or positive work of the three lower limb joints during stance phase. A two-way analysis of variance (ANOVA) was conducted to examine the effects of runner type and running speed condition on the proportional work distribution of the three lower limb joints. When a significant main effect or interaction was detected, a post-hoc test was performed. The significance level was set at $P < 0.05$.

Results and Discussion

Total negative and positive joint works were significantly greater at a running speed of 5.5 m/s compared to 3.5 m/s (negative work: $F = 6.66$, $P < 0.05$; positive work: $F = 4.67$, $P < 0.05$). Stride type runners exhibited significantly greater total positive work compared to cadence type runners ($F = 11.56$, $P < 0.05$), as well as a higher positive work at the ankle joint ($F = 18.6$, $P < 0.05$) and a higher the proportion of positive work at the ankle joint ($F = 5.73$, $P < 0.05$). In cadence type runners, both negative work at the hip joint and its relative the proportion were significantly greater at running speed of 5.5 m/s than at 3.5 m/s ($F = 4.05$, $P < 0.05$). These findings suggest that stride type runners generate a greater the proportion of joint work through ankle plantarflexion, whereas cadence type runners achieve higher running speeds by increasing joint work through hip flexion.

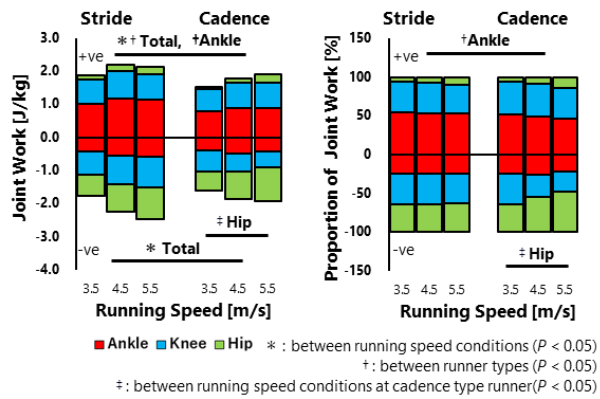

Figure 1: Amount of joint work and proportion of joint work.

Conclusions

Stride type runners generated a greater the proportion of joint work through ankle plantarflexion, whereas cadence type runners relied more on hip flexion to achieve higher running speeds. Total work increased with running speed, with stride type runners exhibiting greater positive work and cadence type runners showing increased negative work at the hip joint at higher speeds. These findings highlight the distinct biomechanical strategies used by each runner type in response to changes in running speed.

References

[1] Sakaguchi et al. (2023). *Int Society of Biomechanics*.
[2] Willer, J. et al (2024). *Scand J Med Sci Sports*, *34*(8), e14690.