Shared Kinematic Profiles but Divergent Running Consistency: Differences Between Habitual and Acutely Adopted Non-Rearfoot Strike Patterns via Sample Entropy

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Summary

This study investigated the running stability and consistency of habitual rearfoot strike (RFS) runners acutely transitioning to a non-rearfoot strike (non-RFS) pattern, compared to habitual non-RFS runners by using sample entropy. Lower limb kinematic data from 14 habitual non-RFS and 15 habitual RFS runners were collected. The results revealed that RFS runners adopting a non-RFS pattern had a similar kinematic profile with non-RFS runners but exhibited lower movement stability and consistency, as evidenced by greater SampEn values at the knee joint movement.

Introduction

The topic of foot strike pattern has been widely discussed. Over 80% of distance runners are habitual rearfoot strike (RFS) runners, and many are encouraged to adopt a habitual non-rearfoot strike (non-RFS) pattern to potentially reduce injury risk or enhance performance. Previous studies suggested that habitual RFS runners can mimic the mechanics of habitual non-RFS runners with minimal practice, showing few significant differences in most variables [1,2].

However, from a motor learning perspective, skilled non-RFS runners are expected to exhibit higher movement consistency and stability than RFS when adopting a non-RFS pattern. Sample entropy (SampEn), a measure of movement regularity, is often used to assess stability and consistency. This study aims to investigates these differences between habitual and acutely adopted non-RFS runners.

Methods

Fourteen habitual male recreational non-RFS and fifteen habitual male recreational RFS runners attempting non-RFS transition were recruited. Participants ran at 9 km/h on an instrumented treadmill (Bertec, USA) with a non-RFS pattern. Lower limb kinematics were captured via motion capture system (Vicon T40, UK) at 200 Hz for 30 seconds.

Foot strike angle (FSA), sagittal-plane maximum angles and ROM of the hip, knee, and ankle, were analyzed from 15 gait cycles of the right leg. Sample entropy (SampEn) was computed from joint angle time series (15-second duration) using the formula:

$$\text{SampEn}(m, r, N) = -\ln\left(\frac{A}{B}\right) \qquad (1)$$

where N is the number of data points, A and B represent counts of similar vectors for dimensions m+1 and m falling within a relative tolerance limit ($r \cdot$ sd), respectively. SampEn was calculated with m = 2 and r = 0.1, 0.2, and 0.3. Independent t-tests (α = 0.05) with Holm-Bonferroni correction compared two groups.

Results and Discussion

All participants demonstrated the non-RFS pattern during the test (FSA < 8.0°). There was no significant difference in maximum angle and ROM of three joints between RFS and non-RFS group (Figure 1). However, knee joint angle SampEn of RFS group was significantly greater than non-RFS in all tolerance limit r condition (Figure 2, $p < 0.01$).

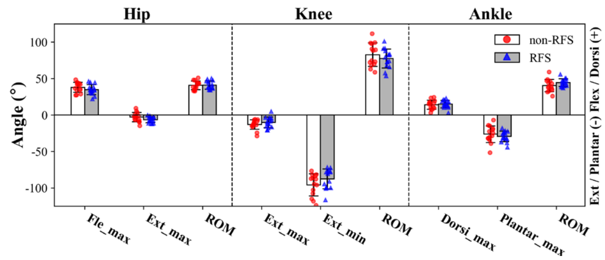

Figure 1: Maximum angle and ROM of lower limb joints in two groups adopting non-RFS.

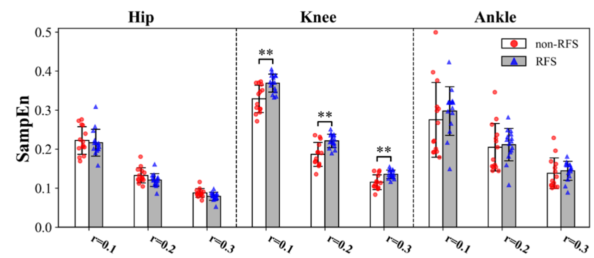

Figure 2: SampEn of lower limb joints in two groups adopting non-RFS. **: $p < 0.01$

Habitual RFS group are tend to have less probability that similar patterns of behavior at knee joint than habitual non-RFS group when acutely transit to non-RFS pattern.

Conclusions

Although habitual RFS can replicate the kinematic profiles of non-RFS with minimal practice, they exhibited reduced movement stability and consistency in knee joint. This indicated the necessity of gait retraining when habitual RFS runners transition to a habitual non-RFS pattern.

Acknowledgments

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References

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