Changes in hip and knee coordination variability in female recreational runners following a half marathon

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Summary

This study investigates fatigue and recovery effects on coordination variability (CV) in fifteen female recreational runners following a half marathon. Kinematic and kinetic data were collected pre-, immediately post-, one-day and two-days post-race. CV of hip and knee joint coupling was analyzed in the sagittal and frontal planes. Results showed significant CV changes during stance phase starting one day post-race. These findings suggest that CV may indicate neuromuscular adaptation to running-induced fatigue during recovery.

Introduction

With the rising popularity of half marathons, understanding fatigue-induced biomechanical adaptations and injury mechanisms is increasingly important. Coupling Angles and corresponding CV offer a holistic approach to movement analysis by examining the interplay between joints and segments rather than analyzing them in isolation [1]. Research indicates that CV may either decrease [2] or increase [3] following fatiguing tasks as a compensatory strategy. The purpose of this study was to investigate if fatigue influences CV in prolonged running. It was hypothesized that CV will change immediately post-half marathon compared to baseline and gradually return to baseline in the following two days.

Methods

Fifteen female recreational runners completed a half-marathon on a laboratory-instrumented treadmill, aiming to complete as quickly as possible. Kinematic and kinetic data were recorded during a separate running task at 10 km/h at four time points: pre (baseline), immediately post (within five minutes), one day post, and two days post half marathon. Data acquisition lasted 20 seconds using an eight-camera Oqus system (200 Hz; Qualisys, Sweden) and an instrumented treadmill (2000 Hz; H/p cosmos, Germany). Hip and knee joint coupling angles and corresponding CV were analyzed in the sagittal and frontal plane following Needham et al. [3]. The stance phase was identified via vertical ground reaction force and segmented into four stance phase intervals (SPI): initial stance and loading response (SPI1), midstance (SPI2), terminal stance (SPI3), and pre-swing (SPI4).

Repeated measures ANOVA with post-hoc Bonferroni correction were conducted within each SPI to analyze differences in CV across conditions (pre, post, day 1 post, and day 2 post). Statistical significance was set at $p < 0.05$.

Results and Discussion

No significant differences were found in sagittal plane CV during SPI1, SPI3 or SPI4 (all $p > 0.05$). However, SPI2 revealed a significant main effect ($F(3,42) = 3.73$, $p = 0.037$), with CV decreasing on day 1 post-marathon compared to baseline ($p = 0.008$). In the frontal plane, significant effects were found in SPI1 ($F(3,42) = 3.12$, $p = 0.036$), and SPI3 ($F(3,42) = 6.78$, $p < 0.001$). Post-hoc tests showed significant differences in SPI1 between day 1 and day 2 ($p = 0.039$) and in SPI3 between immediately post and both day 1 ($p = 0.030$) and day 2 ($p = 0.001$), indicating post-fatigue alterations. No significant changes were observed in the frontal plane during SPI2 and SPI4 (all $p > 0.05$).

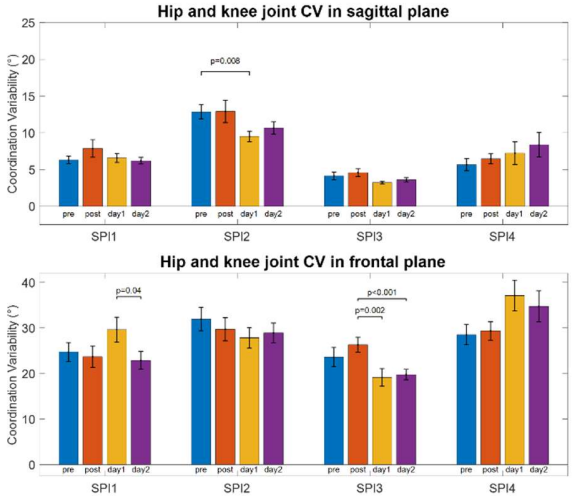

Figure 1: Mean hip and knee joint CV in sagittal and frontal plane.

These findings suggest post-fatigue alterations in CV during midstance in the sagittal plane, as well as during initial stance and loading response, and terminal stance in the frontal plane, starting one day post-half marathon. Thus, the hypothesis was partly accepted, as CV did change post-race but did not consistently follow a gradual return to baseline across all conditions. In the sagittal plane, CV significantly decreases during midstance one day post-fatigue compared to pre-half marathon, recovering to baseline within two days. The observed decrease in CV on days one and two compared to immediately post-run during SPI3, along with the increase in CV from day one to day two during SPI1, suggests a slightly delayed neuromuscular adaptation to fatigue. Therefore, CV in hip and knee coupling angles may serve as an early indicator of compromised movement control during the recovery phase within two days post half marathon.

Conclusions

The observed changes in CV in hip and knee joint coupling following running-induced fatigue emphasize the importance of studying CV to enhance recovery strategies to refine training protocols and reduce injury risk in running.

References

[1] Needham R et al. (2014). *J Biomech,* **47**(5):1020–1026.
[2] Smith JA et al. (2021). *Gait Posture*, **84**:1–7.
[3] Chen TLW et al. (2020). *J Sport Health Sci,* **11**(1):67.