The sagittal plane adaptations of hip and knee joints during a half-marathon

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Summary

This study aimed to investigate how cumulative mileage in a half-marathon affects lower extremity biomechanics in recreational runners. As running mileage increased, the hip and knee joints showed distinct adaptations in sagittal plane, with an increased hip extension moment ($p < 0.05$) and increased knee flexion angle at 10 km ($p < 0.001$) and 15 km ($p = 0.023$). These findings indicate complex adaptations in lower extremity kinematics and kinetics during long distance running. These insights could inform training strategies to reduce injury risk and enhance performance.

Introduction

Participation in marathons has grown significantly over the past decade, with global race data showing a 49% rise in participation from 2008 to 2018 [1]. In running, most of the body's movements occur in the sagittal plane. This is reflected by the relatively high force amplitudes in the vertical and the horizontal direction compared to the medio-lateral direction. Fatigue from prolonged running often leads to altered movement patterns in lower extremity, which can influence running gait, potentially affecting both performance and injury risk [2]. Understanding how the accumulation of mileage during a half marathon impacts joint kinematics, and kinetics is crucial for identifying mechanisms of injury in the lower extremities.

Methods

Thirty-seven recreational runners were recruited. Reflective markers were placed on specific bony landmarks, covering seven anatomical segments: the pelvis, bilateral thighs, shanks, and feet. Kinematic and kinetic data were synchronously collected with an eight-camera system and instrumented treadmill at 10 km/h for 20 s at five intervals: at 0 km, 5 km, 10 km, 15 km, and 20 km. A lower extremity model in Visual 3D was used to calculate peak knee and hip angles, peak knee and hip moments. A one-way repeated measures analysis of variance with Bonferroni correction for multiple comparisons was used to identify statistical differences across time points. The significance level was set at $p < 0.05$.

Results and Discussion

The peak hip extension moment increased significantly at 10 km ($p = 0.001$), 15 km ($p = 0.001$), and 20 km ($p < 0.001$) compared to the start, while the peak hip flexion angle showed no significant changes (Fig. 1). Regarding the adaptations of knee joint, no significant changes were observed in peak knee extension moment. the peak knee flexion angle increased significantly at 10 km ($p < 0.001$) and 15 km ($p = 0.023$) (Fig. 1).

The increased hip extension moment aligns with a greater reliance on hip muscles to propel the body forward as leg muscles fatigue, possibly compensating to maintain speed [3]. Additionally, the increased knee flexion angle at 10 km and 15 km indicates a greater reliance on knee flexion for impact absorption, which may increase stress on the patellofemoral joint. Previous research has shown that heightened knee flexion during running can raise stress on the patellofemoral joint, potentially increasing the risk of patellofemoral pain [4].

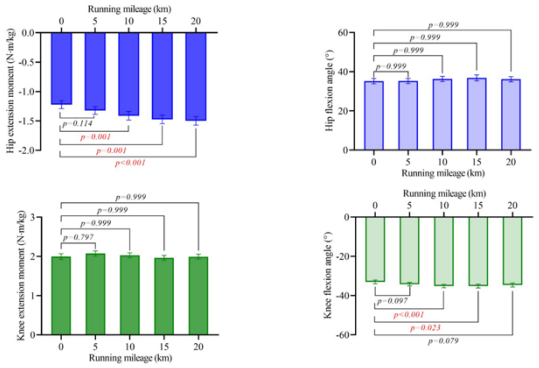

Figure 1: Biomechanical changes during a half-marathon.

Conclusions

This study identified distinct fatigue-induced sagittal plane adaptations in hip and knee joints. In the future, studies could clarify whether these adaptations are interrelated or represent compensatory mechanisms aimed at maintaining lower limb stability during fatiguing running.

References

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