Effects of Running Distance on Lower Limb Muscle Co-Contraction During a Simulated Half-Marathon

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Summary

This study investigated the lower limb muscle co-contraction patterns in forty amateur marathon runners during a treadmill-based half-marathon. Surface electromyography data (sEMG) were collected over the 21-km run, and the co-contraction index (CCI) for six muscle pairs was calculated. A significant effect of distance on CCI was observed only in the rectus femoris (RF) and biceps femoris (BF) muscle pair. Linear regression analysis revealed a decreasing trend in RF-BF CCI as the distance increased. These findings suggest that continuously monitoring RF-BF muscle co-contraction during long-distance running may be beneficial, and targeted strength training for these muscles could enhance performance and reduce injury risk.

Introduction

Muscle co-contraction is crucial in long-distance running, such as marathons, by enhancing joint stability and reducing injury risk [1]. While increased co-contraction contributes to greater joint stability, it also elevates the metabolic cost of running due to higher muscle activation and may increase injury risk by altering joint loading patterns [1]. Previous studies have examined the effects of fatigue, running speed, and foot strike patterns on muscle co-contraction during running. However, the co-contraction patterns of key agonist-antagonist muscle pairs throughout an entire marathon remain underexplored. Therefore, this study aims to investigate lower-limb muscle co-contraction using sEMG data collected during a treadmill-based simulated marathon. The findings may inform training strategies to improve running economy and reduce injury risk in marathon runners.

Methods

Forty amateur marathon runners (age: 25.0 ± 4.0 years, height: 174.4 ± 5.1 cm, weight: 65.8 ± 7.0 kg) participated in this study. sEMG data were recorded from rectus femoris (RF), vastus medialis (VM), vastus lateralis (VL), tibialis anterior (TA), gastrocnemius medialis (GM), and gastrocnemius lateralis (GL) during a treadmill-based simulated half-marathon. At each kilometer, one minute of sEMG data was collected while participants ran at a steady speed of approximately 15 km/h. Raw sEMG signals were segmented into gait cycles, band-pass filtered, mean removed, and full-wave rectified. The sEMG envelopes were obtained and normalized to their peaks across all trials. The CCI [2] was calculated for GL-TA, GM-TA, RF-BF, VL-BF, VM-BF and VM-VL muscle pairs. CCI values were categorized into five distance intervals: 1–4 km, 5–8 km, 9–12 km, 13–16 km, and 17–20 km. A one-way repeated measure ANOVA or Friedman test was employed to examine the main effect of distance on muscle co-contraction. Pairwise comparisons were conducted using the Wilcoxon signed-rank test with Bonferroni correction when significant main effect was identified. Additionally, linear regression analysis was performed to model the CCI trend over increasing distances.

Results and Discussion

The lower-limb muscle co-contraction patterns throughout the half-marathon are presented in Figure 1. A significant main effect of distance on CCI was identified only in RF-BF ($P<0.001$, Partial Eta Squared=0.23). Post-hoc analysis revealed significantly different CCI values between 1–4 and 9–12 kilometers compared to 17–20 km, as well as between 5–8 km and 13–16 km. Additionally, a significant decreasing trend in CCI was observed in the RF-BF muscle pair as running distance increased, whereas VL-BF and VM-BF muscle pairs exhibited significant increasing trends.

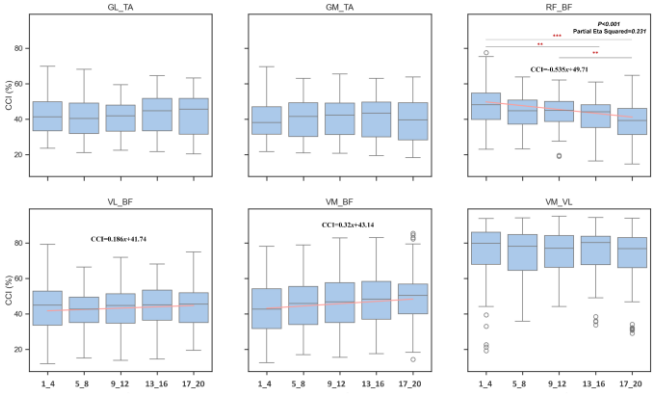

Figure 1: CCIs of GL-TA, GM-TA, RF-BF, VL-BF, VM-BF and VM-VL muscle pairs. ** and *** represent $p<0.01$ and $p<0.001$.

Conclusions

A significant difference in the CCI of the RF-BF muscle pair was observed, highlighting the importance of continuous monitoring and targeted strength training for this muscle group during marathon running.

References

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