Assessing the Reliability and Fatigue Sensitivity of Gait Line Variability During Walking and Running

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Summary

This study investigated the reliability of gait line variability and its sensitivity to fatigue during running. Ten healthy participants completed walking and running trials across two sessions, with gait line variability measured via a pressure mat integrated into a treadmill. Reliability analysis showed moderate-to-strong consistency for medial-lateral variability but inconsistent results for anterior-posterior variability, likely due to changes in foot-strike patterns. Despite clear physiological markers of fatigue, gait line variability did not significantly change over a 30-minute run, suggesting it may not be a valid indicator of fatigue-related neuromuscular impairments. These findings highlight the potential of medial-lateral gait line variability as a measure of movement stability but question its usefulness in fatigue monitoring.

Introduction

The gait line, defined as the trajectory of the center of pressure (COP) under the foot during walking or running can provide insights into neuromuscular control and movement stability [1]. Understanding the reliability of gait line variability is important for its application as a marker of neuromuscular control in gait analysis. However, the consistency of this metric across separate testing sessions remains unclear. Furthermore, the role of fatigue in gait variability has been explored [2] but the response of gait line variability to fatigue during prolonged running has not been well established. It is hypothesized that gait line variability will increase with fatigue, reflecting a decline in movement control and stability. This study aims to (1) evaluate the reliability of gait line variability across two testing sessions and (2) assess whether runners show adaptations in their gait line variability as they experience fatigue during a 30-minute continuous treadmill run.

Methods

Ten healthy subjects (3 male, 7 female, 23.7 ± 3.1 years old) completed treadmill walking (5 km/h) and running (8 km/h and a submaximal speed at 85% VO_2max) trials on two separate occasions. A capacitance-based Zebris pressure mat sampling at 120 Hz with a 1.2 cm^2 cell size recorded COP trajectories. During the first session, subjects completed 3-minute walking and running trials. The second session, conducted within two weeks, included the same trials plus a continuous 30-minute run at the submaximal speed, with COP data recorded for 30 seconds at 5-minute intervals. Fatigue was assessed via heart rate, BORG scale, and respiratory quotient (COSMED K5 metabolic cart).

Gait line variability was analyzed separately for the medial-lateral (x) and anterior-posterior (y) directions. Medial-lateral variability was quantified as the average standard deviation of the x-coordinate across stance phases. Anterior-posterior variability was defined as the standard deviation of the total COP trajectory length in the y-coordinates per stance phase. Intraclass correlation coefficients (ICCs) assessed reliability between sessions, and repeated-measures ANOVAs evaluated fatigue-induced changes over time.

Results

Reliability testing showed moderate (0.5–0.75) to strong (>0.75) ICCs for medial-lateral gait line variability across walking, 8 km/h running, and submaximal running. However, anterior-posterior gait line variability showed highly inconsistent ICCs (ranging from poor <0.5 to excellent >0.9).

At the end of the 30-minute submaximal run, heart rate (188 ± 7 bpm), respiratory quotient (1.05 ± 0.09), and BORG scores (16.5 ± 1.8) indicated high levels of exertion and fatigue. However, repeated-measures ANOVA revealed no significant changes in gait line variability in either direction over the 30-minute period.

Discussion & Conclusions

Medial-lateral gait line variability demonstrated moderate-to-strong reliability, suggesting it may be a useful measure of neuromuscular control during walking and running. However, anterior-posterior variability showed inconsistent results, likely influenced by noticeable variations in foot¨-strike patterns among some subjects, which compromised its reliability.

Despite clear physiological signs of fatigue, gait line variability did not significantly change over the 30-minute run, indicating that it may not be a sensitive marker of fatigue-related neuromuscular impairments. These findings suggest that while medial-lateral gait line variability may have applications in movement assessment, it is unlikely to be a reliable indicator of fatigue in runners.

References

[1] Rajachandrakumar R et al. (2018) *Gait & Posture*, **63:** 254-259.
[2] García-Pinillos F et al. (2020) *Gait & Posture* **76**: 259-263.