The Role of Treadmill Experience in Local Gait Stability Under Normal and Asymmetric Walking Conditions

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Summary

This study examined the relationship between treadmill experience and gait stability in participants while walking on a split-belt treadmill under normal and asymmetric conditions. The findings indicate that greater treadmill experience was associated with higher gait stability during normal walking. The intra-individual change in stability from normal to asymmetric walking revealed that participants with less treadmill experience exhibited higher stability in asymmetric conditions, while more experienced treadmill walkers displayed greater instability in asymmetric walking. This suggests a potential interaction between the development of a more stable walking pattern through familiarization and the manifestation of increased instability due to asymmetric walking conditions.

Introduction

Gait analysis on a treadmill offers controlled conditions but may also alter natural gait behavior. Nevertheless, specific asymmetric walking conditions can be simulated on a split-belt treadmill to quantify balance control and gait adaptability [1]. In this context, local gait stability describes the ability to resist small perturbations by maintaining a steady walking pattern. Less local gait stability is associated with falls and asymmetric walking conditions [2,3]. Concurrently, treadmill experience (TME) affects gait parameters in normal walking [3]. However, the extent to which TME influences gait stability in slightly more challenging asymmetric walking conditions, remains to be investigated.

Methods

26 participants (24.9±7.0 years, 17 males/9 females) with varying TME (self-reported on scale 1-5) completed the following trials on a split-belt treadmill subsequent to an individual familiarization period: The first trial involved normal gait (1 m/s) and the second trial involved asymmetric gait (right:left belt velocity ratio of 1:1.3). The participants' kinematic movement data were collected using an optical 3D marker-based motion capture system. Local gait stability was assessed via the maximum short-term Lyapunov exponent λ, with higher values indicating less stability. For this purpose, 150 strides from the anterior-posterior time series of the hip markers (an approximation of the Center of Mass, COM_{ap}) were analyzed. The embedding dimension was set to 3 with a subject-specific time delay applied to calculate the logarithmic divergence rate of points, resulting in λ_{s,com_ap}.

Results and Discussion

As shown in Fig 1A, gait stability exhibited an increase with greater TME (smaller λ_{s,com_ap}) for normal walking. However, no correlation between TME and gait stability was identified for asymmetric conditions (Fig 1B). When examining the intra-individual change in gait stability calculated as the difference between stability during normal and asymmetric walking a correlation was found: Counterintuitively, participants with limited TME appeared more stable during asymmetric walking compared to normal walking. However, participants with higher TME tended to exhibit a more unstable gait under asymmetric conditions (Fig 1C).

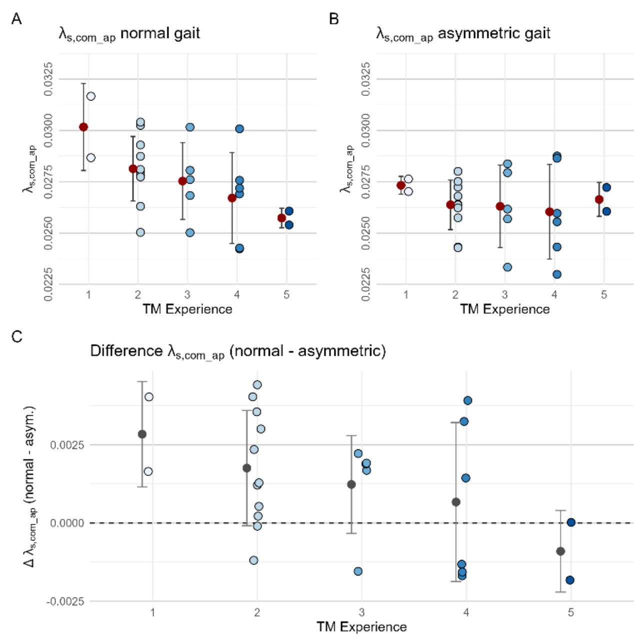

Figure 1: Correlation of gait stability and treadmill experience for normal gait (A) and asymmetric gait (B).
C: Difference in gait stability from normal to asymmetric gait in correlation to treadmill experience.

The findings might suggest an interaction between familiarization and instability effects due to walking conditions, even though the small sample size of this study is a limiting factor regarding the generalizability of the observed effects.

Conclusions

Future studies in the field of gait analysis should consider assessing TME and provide individualized familiarization time based on TME to avoid confounding effects.

References

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