Net external moment expressed at the Body Center of Mass under perturbations during gait

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Summary

Gait instability evaluation lacks consensus on the best parameter. Despite its understandability, the net external moment at the body center of mass ($\mathbf{M}_{BCoM}$) is poorly used. This study explores the impact of external perturbations on counter-rotation movements during gait using $\mathbf{M}_{BCoM}$. So far, eight asymptomatic participants walked on a dual-belt instrumented treadmill under controlled slip and trip perturbations. $\mathbf{M}_{BCoM}$ maximum value was significantly affected on the anteroposterior and mediolateral axes. This may reflect compensatory strategies to maintain balance, as seen in older adults. While findings offer insights into dynamic equilibrium and counter-rotation, this ongoing study needs more participants to strengthen conclusions.

Introduction

Whole body angular momentum (**WBAM**) is widely used to evaluate the full body's dynamic equilibrium [1–3]. Less common, but relevant, its time rate of change, a.k.a. the net external moment expressed at the body center of mass ($\mathbf{M}_{BCoM}$) is sensible to external perturbations [4]. This represents the sum of the external moments applied to the subjects computed at the BCoM. The goal was to understand how external perturbations delivered by an instrumented treadmill would impact the moment at the BCoM. We hypothesized that the response would be perturbation specific, with rapid variations of $\mathbf{M}_{BCoM}$ during the perturbation.

Methods

This protocol was ethically approved (RCB 2020-A01357-32). So far, eight asymptomatic volunteers (3 F/5 M, 25.6 ± 1.3 years, 73 ± 5 kg) walked on a dual-belt treadmill equipped with two force platforms (1000 Hz, Treadmetrix©) and a motion capture system (100 Hz, Vicon©). Following a stabilized walking phase at 1.2 m/s, participants experienced acceleration and deceleration phases (3 and 10 m/s²) with eight slips and trips induced, reaching 2.04 and 0.36 m/s. While aware of disruptions, they were not told their timing or type. A safety harness was used, and participants wore their own flat-soled sneakers. We analyzed 64 Slip-like perturbations trials that were normalized by gait cycles. We compared pre-perturbation to post-perturbation cycles.

Results and Discussion

We found significant differences in the maximum $\mathbf{M}_{BCoM}$ between pre-perturbed cycles and the perturbed cycle along the anteroposterior axis for both accelerations (10m/s2: p=.001; 3m/s2: p=.03). This was also found for the mediolateral axis (10m/s2: p<.001; 3m/s2: p=.02). Few significant differences were found between pre-perturbed cycles and the perturbed cycle (Figure 1). This is not exactly consistent with reduction in $\mathbf{M}_{BCoM}$ that have been presented as a compensatory strategy to enhance balance [5]. We also did not observe rapid changes in $\mathbf{M}_{BCoM,}$ that can be a marker of a balance disruption [5].

Conclusions

$\mathbf{M}_{BCoM}$ showed a sensitivity to external perturbations on an instrumented treadmill. While this gives insights on how counter-rotation movements are performed, more participants are expected.

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References

[1] Neptune R, Vistamehr A. (2018). *J Biomech Eng*; **141**: 0708011–07080110.
[2] Eichenlaub EK, (2023). *Hum Mov Sci*; **89**: 103070.
[3] Leestma JK, (2023). *J Exp Biol*; **226**: jeb244760.
[4] Pijnappels M, (2004). *J Biomech*; **37**: 1811–1818.
[5] Begue J, (2019). *Exp Gerontol*; **127**: 110714.

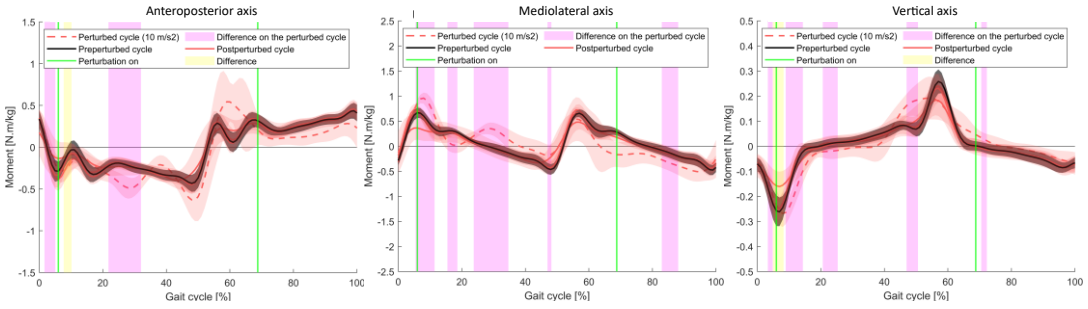

Figure 1: Body mass normalized net external moment expressed at the BCoM.for slip-like. Statistical non-parametric mapping results between pre-perturbed cycles (black line) and perturbed cycles, and post-perturbed cycles are respectively highlighted in magenta and yellow.