WEARABLE SENSOR DETECTION OF TREADMILL-INDUCED SLIP PERTURBATIONS

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INTRODUCTION

Monitoring instability is critical for the prevention of dangerous falls. Recent developments in the use of wearable sensors have shown promise in their application to monitor physical activity [1]. However, it is unclear whether and the extent to which wearable sensor thresholds for detecting locomotor instability resemble the biological threshold for perceiving that instability, even in otherwise healthy younger adults. This study in young adults aimed to build on previous studies using small-amplitude treadmill-induced slip perturbations [2] to establish and objectively compare a conscious threshold for perceiving instability to wearable-sensor based thresholds for detecting that instability.

Hypotheses:

1. Wearable sensors have the capacity to detect the instability elicited by treadmill-induced slip perturbations

2. Thresholds for conscious perception will be indistinguishable from thresholds for wearable sensor detection

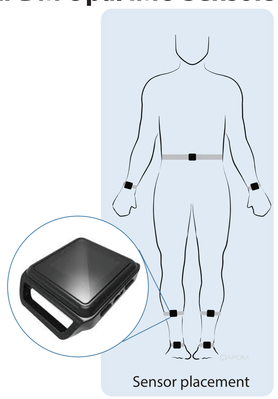
METHODS

Participants
15 young adults
8 Females / 7 Males
Age: 23.4 ± 3.7 years
Preferred Speed: 1.37 ± 0.11 m/s

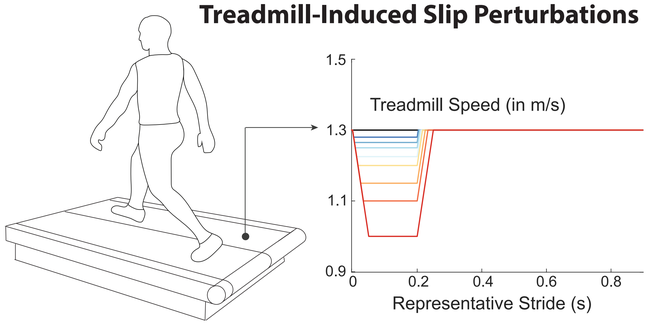
Protocol
8 perturbation magnitudes x 5 (Randomized)

Subjects responded "Yes" or "No" if they felt a balance disturbance.

APDM Opal IMU Sensors



Treadmill-Induced Slip Perturbations

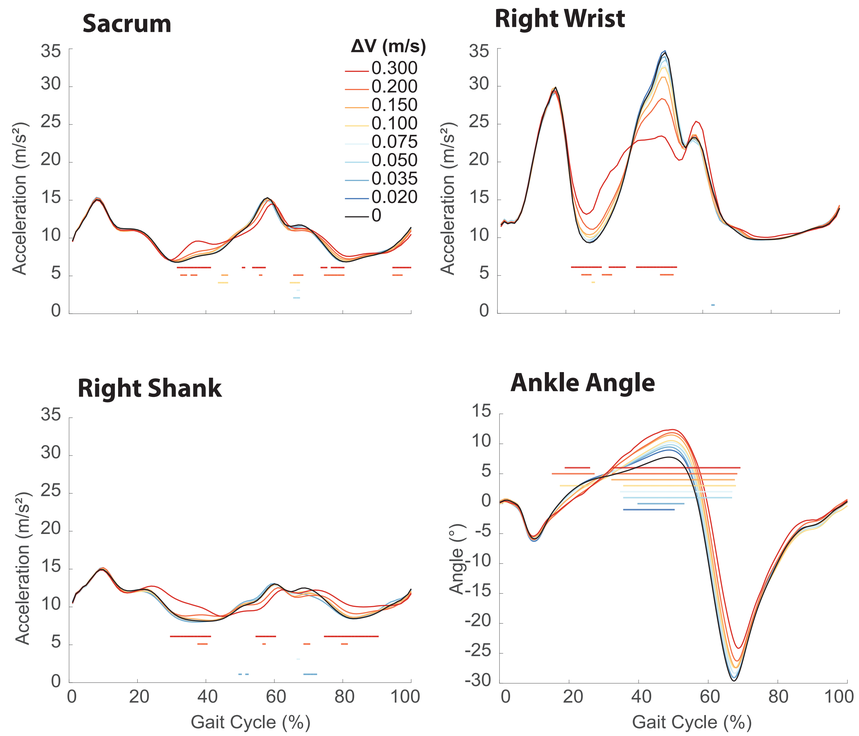


ΔV	.02 m/s	.035 m/s	.05 m/s	.075 m/s	0.10 m/s	0.15 m/s	0.20 m/s	0.30 m/s

Outcome Measures and Analysis
Acceleration vector magnitude (m/s²)
IMU-derived ankle joint angle (°)

Statistical Testing
Statistical parametric mapping

WEARABLE SENSOR DETECTION

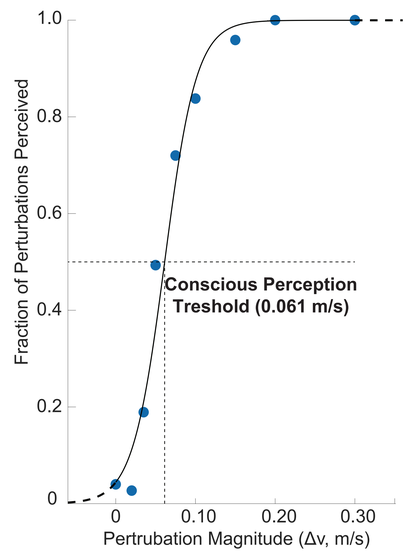


Perturbations elicited differences in most acceleration signals. Effects increased with perturbation magnitude and were most pronounced for an ipsilateral wrist-worn accelerometer

Acceleration signals had a higher threshold for detecting instability than conscious perception.

IMU-derived ankle joint kinematics were highly sensitive to all perturbation magnitudes, with a threshold for detecting treadmill-induced instability as low as 0.02 m/s.

CONSCIOUS PERCEPTION



The threshold perturbation amplitude for perceived instability averaged 0.061 m/s, which is highly consistent with previous work.

CONCLUSIONS

Take Home #1:

Acceleration signals alone perform worse than conscious perception in detecting the instability elicited by treadmill-induced slip perturbations.

Take Home #2:

IMU-derived ankle joint kinematics are highly sensitive to even the smallest amplitude perturbation, with thresholds ~3x smaller than conscious perception.

Continued work in this area seeks to investigate the generalization of these conclusions to individuals more representative of those at risk of falls.

Acknowledgements

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References
1. Kristoffersson & Lindén (2022)
2. Liss et al. (2022)

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