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Development of an Experimental Protocol for Fall Stage Classification Using Multiple Sensors

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Introduction

- Most existing fall-related studies have relied on artificially staged falls in non-disabled adults.
- However, such approaches are limited in capturing the physiological and kinematic characteristics of real-world fall processes.
- In particular, conventional methods often fail to represent the dynamic transition from initial perturbation to an actual fall, leading to insufficient understanding of fall mechanisms.
- Therefore, this study aims to establish a controlled slip-based experimental protocol to induce fall responses and to collect synchronized multi-sensor data, enabling analysis of fall progression as a continuous process.

Experimental protocol

- The experiment was conducted on an indoor walkway (8 m × 0.7 m) designed to allow sufficient steady-state gait before and after the slip event.
- A slip-inducing region was placed at the center of the walkway using a polyethylene film coated with a water–glycerin mixture to generate an unexpected low-friction surface (Figure 1).
- To prevent participants from anticipating the slip location, ambient illumination was reduced (3.5 lx), and a visual target was positioned at the end of the walkway to maintain a forward gaze and natural walking pattern.
- Participants walked at a self-selected comfortable speed under both normal and slip conditions while wearing an overhead safety harness, which was configured to prevent ground impact without interfering with natural gait.

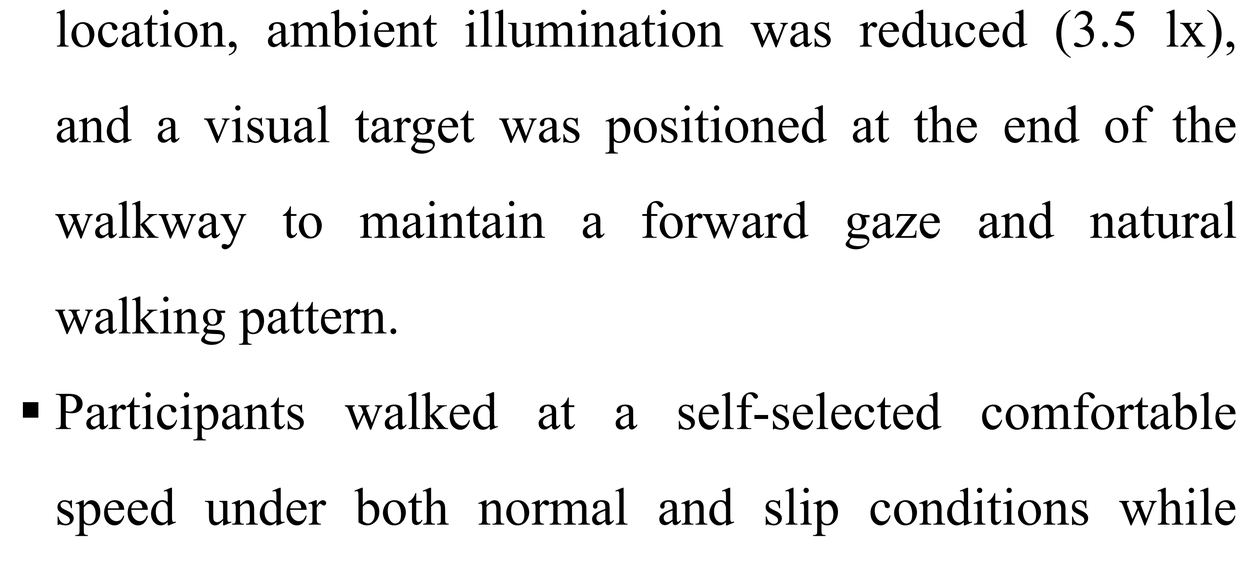

Figure 1. Overall experimental setup and measurement configuration

Data collection

- Participants walked at a self-selected speed toward a visual target while wearing an overhead safety harness.
- Whole-body three-dimensional motion capture markers were attached to capture joint kinematics at 100 Hz.
- Surface electromyography (sEMG) signals were acquired at 2000 Hz from bilateral lower-limb muscles, including the rectus femoris, biceps femoris, tibialis anterior, and medial gastrocnemius.
- All sensors were placed symmetrically on both sides of the body, and all data were recorded in a synchronized manner.

Conclusion

- This study established a controlled slip-based experimental protocol to elicit fall responses under reduced visual anticipation.
- The proposed framework enables synchronized acquisition of whole-body kinematics and lower-limb muscle activation, allowing fall events to be analyzed as a continuous progression including the transitional loss of balance (LB) phase.
- The resulting dataset provides a foundation for investigating fall mechanisms and developing control strategies for rehabilitation assistive devices.
- Unlike conventional staged fall studies, the proposed protocol captures more realistic fall responses by inducing unexpected slip perturbations in both healthy adults and stroke survivors.

Reference

[1] Gaya-Morey, F. X., Manresa-Yee, C., & Buades-Rubio, J. M. (2024). Deep learning for computer vision based activity recognition and fall detection of the elderly: A systematic review. *Applied Intelligence, 54*(19), 8982–9007.

[2] Pijnappels, M., Reeves, N. D., Maganaris, C. N., & van Dieën, J. H. (2008). Identification of elderly fallers by muscle strength measures. *European Journal of Applied Physiology, 102*(5), 585–592.

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