Ability to Predict Perturbation Timing Does Not Impact Center-of-Mass Displacement in Below-Knee Prosthesis Users and Controls

1,2,3 Matthew J Major, 1 Chelsi K Serba, and 1,3 Keith E Gordon

1 Northwestern University, Chicago, IL; 2 Jesse Brown VA Medical Center, Chicago, IL; 3 Edward Hines Jr VA Hospital, Chicago, IL

email: matthew-major@northwestern.edu, web: http://www.nupoc.northwestern.edu/

Introduction

- Despite a high fall prevalence (Miller 2001), factors that underlie postural control in lower limb prosthesis users have not been sufficiently explored.
- Knowledge of lateral perturbation timing evokes a proactive margin-of-stability increase on prosthetic limb side of below-knee (BK) prosthesis users (Major 2018)
- The consequences of a priori knowledge and proactive strategies on body center-of-mass (CoM) motion following a perturbation have not been characterized.

Aim: Assess effects of a priori knowledge (direction, timing) of a lateral perturbation on response of able-bodied and BK prosthesis users.

- **H1**: When directed towards impaired limb, prosthesis users would display increased CoM displacement during perturbation exposure.
- **H2**: When timing is known, prosthesis users would display reduced peak CoM displacement following perturbation onset.

Methods

Participants

- 13 Able-Bodied (29±11 yrs, 65±10 kg, 1.7±0.1 m)
- 6 Unilateral BK Prosthesis Users (48±8 yrs, 70±11 kg, 1.7±0.1 m)

Cable Robot

- **Lateral Perturbation**
- **12% Body Weight**
- **400 ms Exposure**
- **Optically-Tracker CoM**

(Wu 2017, Brown 2017)

a priori Knowledge

- Direction (Right/Left)
- 5 4 3 2 1 Timing (Known/Unknown)

Data Analysis

- **Time to Reversal**
- **Peak ∆CoM**
- **Perturbation Onset**
- **Exposure ∆CoM**

3-way ANOVA Direction x Timing x Group (α=0.05)

Results

- **Prosthesis User**
- **Able-Bodied**

Exposure ∆CoM as function of Gait Cycle

- **Known Timing**
- **Unknown Timing**

Discussion

- **H1 supported**: Perturbation towards the impaired/non-dominant limb increased Exposure ∆CoM (p=0.033), with no difference between groups or timing conditions.
- **H2 supported**: Knowledge of perturbation time reduced Peak ∆CoM (p=0.010) but increased time to reversal (p=0.043), with no difference between groups or direction.
- For unknown timing, a trend towards greater Peak ∆CoM but rapid return to center, whereas known timing generates less Peak ∆CoM by delayed response (‘riding it out’)
- Emerging pattern for influence of gait cycle phase and perturbation direction, but not timing, on Exposure ∆CoM which resembles CoM velocity temporal profile.

References


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