Effects of Upper Limb Loss and Prosthesis Use on Standing Balance

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Introduction

- Whole-body internal models influence the motor behavior required for controlling posture, with arms contributing to standing balance (Imaizumi 2016, Shafeie 2012).
- Nearly half of persons with upper limb (UL) loss fall at least once per year, with fall likelihood increasing by 6 times for those who use a prosthesis (Major 2017).
- Wearing an UL prosthesis may help center the body axis while standing, but evidence suggests it may also be perceived as a postural disturbance (Imaizumi 2016).

Aim: Evaluate the acute effects of UL loss and wearing an UL prosthesis, particularly matching the mass of both upper limbs, on standing balance.

- **H1**: Presence of UL loss will cause an increase in postural sway.
- **H2**: Wearing an UL prosthesis will improve bilateral weight symmetry.
- **H3**: Wearing an UL prosthesis will cause an increase in postural sway.

Methods

**Participants**

11 Able-Bodied (35±14 yrs, 174.7±8.2 cm, 78.9±13.4 kg)  
11 Persons with Unilateral UL Loss (8 Transradial / 3 Transhumeral, 50±18 yrs, 175.1±7.4 cm, 79.6±22.6 kg)

**Protocol**

- 30 Seconds × 3 Trials
- Focusing on a Target
- Force Plate-Tracker COP
- UL Loss Conditions:  
  1. No Prosthesis  
  2. Customary Prosthesis  
  3. Mock Prosthesis

**Data Analysis**

- **Able-Bodied vs. Upper Limb Loss**
  - Net COP
  - AP COP Range (cm)
  - ML COP Range (cm)

- **Symmetry Index**  
  \[ \text{Symmetry Index} = \frac{\text{Sound, Dominant Load} - \text{Impaired, Non-Dominant Load}}{0.5 \times (\text{Sound, Dominant Load} + \text{Impaired, Non-Dominant Load})} \]

**General Linear Model**

Persons with UL Loss: Side x Condition x Group (Fallers, Non-Fallers)  
Able-Bodied vs. UL Loss: Group  
Covariates: stance width, body mass index (α=0.05)

Results

- **Able-Bodied vs. Upper Limb Loss**
  - ML COP Range (cm)
  - AP COP Range (cm)
  - COP Sway Area (cm²)

- **Symmetry Index**
  - ±Sound/Dominant Side Bias
  - ±Impaired/Non-Dominant Side Bias

- **Data Analysis**
  - COP Sway Area (cm²)

Discussion

- **H1 supported**: Persons with UL loss not wearing a prosthesis displayed greater COP sway than able-bodied controls, with no significant difference in weight symmetry.
- **H2 supported**: Wearing a prosthesis improved weight symmetry with greatest symmetry when prosthetic limb mass is matched to the sound limb.
- **H3 supported**: Wearing a prosthesis appears to cause an acute increase in COP sway, but no difference between limb side or fallers versus non-fallers.
- UL loss may increase postural demands, while wearing a prosthesis may disturb standing balance, but the link to fall risk warrants further exploration (Pizzigalli 2016).

References

Major MJ. 16th ISPO World Congress, 2017.  

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