Measuring actual arm use during soft-robotic glove use at home

Single-case experimental design in patients with hand limitations

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Introduction

- Wearable soft-robotic glove for grip support
- Assists hand during activities of daily life (ADL)
- Six-week use led to improved hand function [1]
- Mechanism underlying training effect unknown
  ≡ Suspected role of increased arm use in ADL

Objective

To assess change in actual arm use in daily life during and after soft-robotic glove use at home

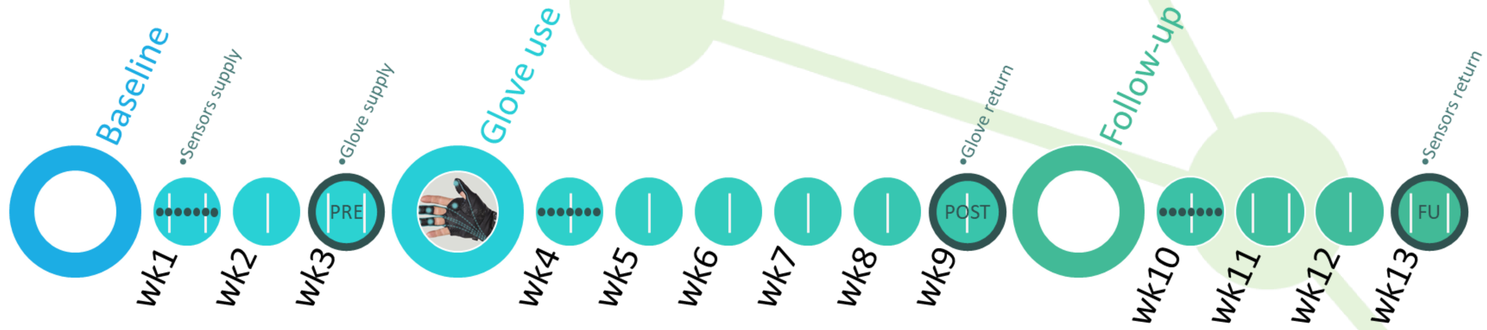


Figure 1. Single-case experimental design with three phases: **baseline**, **intervention**, **follow-up**, with concurrent multiple baselines (random length 14-28 days) and repeated assessments of actual arm use of both arms during 7 consecutive days at start of each phase (black dots), grip strength in minimal 5 video calls per phase (white stripes), objective and self-reported hand function at end of each phase (black circles)

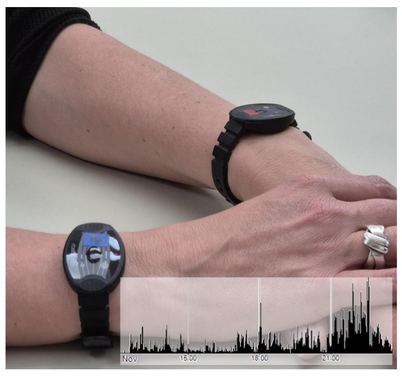


Figure 4. Wrist-worn accelerometers measuring actual arm use in ADL (MotionWatch8; CamNtech, UK)

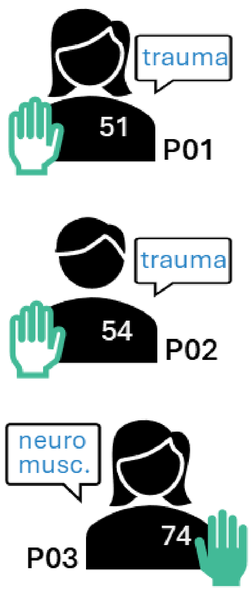


Figure 2. Graphical depiction of participants indicating age, gender, cause of hand function limitations, gloved hand (dominant = filled hand, non-dominant = open hand)

Methods

- Single Case Experimental Design (SCED) with three phases (Fig. 1)
- Participants (n = 3-5) with stable persistent hand limitations (Fig. 2)
- Soft-robotic glove worn on most-affected hand [2] for 6 weeks (Fig. 3)
- Intensity of arm use measured via wrist-worn accelerometers (Fig. 4)
  ≡ Sum of 1D accelerometer activity counts per day [3]
  ≡ Visual analysis of change in level and slope of data



Figure 3. Soft-robotic glove (Carbonhand; Bioservo, SV) actuating finger flexion via tendons activated through interaction forces

Results

- Three participants started in ongoing study (Fig. 2), P01 dropped out
  ≡ Compliance was good, except in P01 due to intensive study schedule
- Level and slope of daily intensity of use increased with glove use (Fig. 5)
- Total intensity of use of both arms summed increased with glove use (Fig. 6)

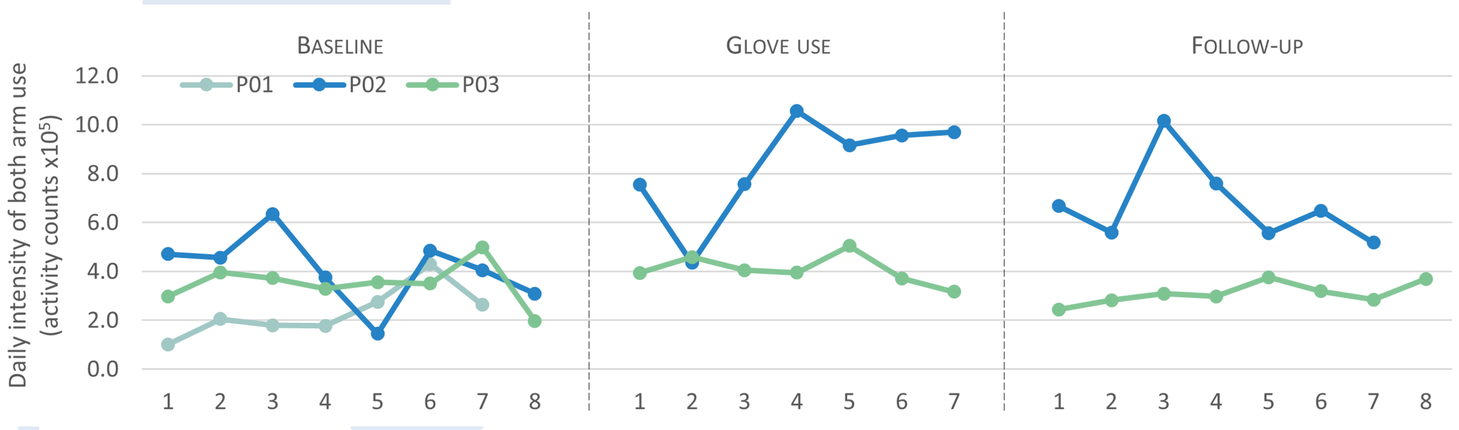


Figure 5. Daily intensity of arm use, summed for both arms, showing all measurements per participant per phase

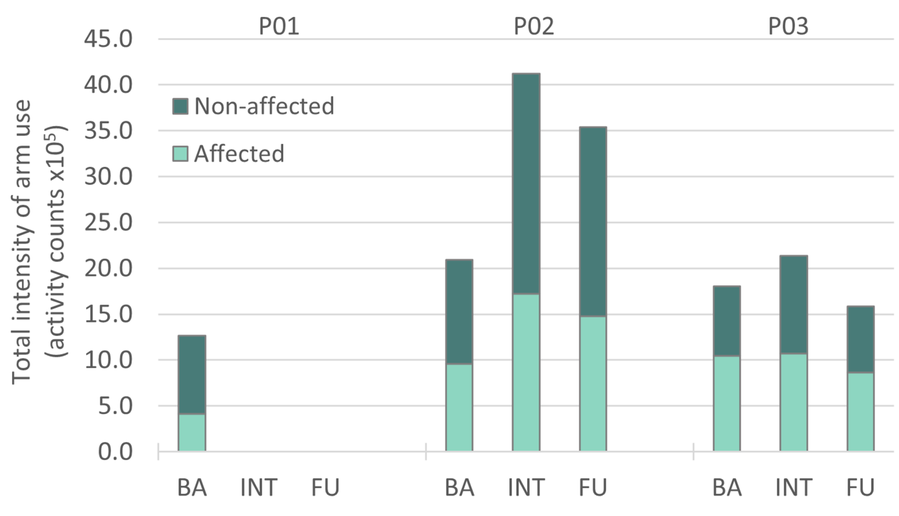


Figure 6. Total intensity of arm use of both arms, summed over middle 5 days per phase, for baseline (BA), intervention (INT) and follow-up (FU)

Conclusions

SCED with activity sensors accepted and adhered to by 2/3 participants

- Pro: insight into day-to-day variation in arm use w/ and w/o glove use
- Con: possible selection bias related to complex and intensive schedule

Increased arm use with soft-robotic glove observed to varying extent between participants

- Suggests possible role of reversal of learned non-use in training effect of glove use
- Next steps in ongoing research:
  ≡ Increase number of participants with completed datasets to at least n=3
  ≡ Assess whether increase in actual arm use relates to improved hand function



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[1] Kottink et al. 2024 PLoS One
[2] Kottink et al. 2022 JMIR Res Protoc
[3] Lemmens et al. 2014 PLoS One

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