

Surrogate Measure of Phantom Hand Motion

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Introduction

- The ability to move a phantom limb may impact phantom limb pain and overall function.
- Self-report questionnaires, typically used to quantify phantom limb movement, provide a rough assessment of a person's ability to move their phantom limb.
- A tool to objectively measure phantom limb movement could provide a standard for phantom limb research.

OBJECTIVES

- 1) Develop a low-cost and easy-to-use instrumented glove to track flexion/extension movements.
- 2) Measure a surrogate of phantom hand movement in people with upper extremity amputation.
- 3) Assess correlation of self-reported phantom hand control to measured values.

Population

- 14 Adults with upper extremity amputation (aged 49.9 ± 16 years)
- All reported ability to move the phantom limb
- Time since amputation: 18 ± 14.7 years
- Level of amputation:
 - Wrist disarticulation ($n = 3$)
 - Transradial ($n = 8$)
 - Transhumeral ($n = 2$)
 - Shoulder Disarticulation ($n = 1$)

Methods

- Participants answered a questionnaire describing their ability to move their phantom hand.
- The glove was donned to the intact hand and calibrated to full finger flexion and extension.
- Participants performed 3 sets of 10 close/open hand movements bilaterally with the intact limb mimicking phantom hand movement.

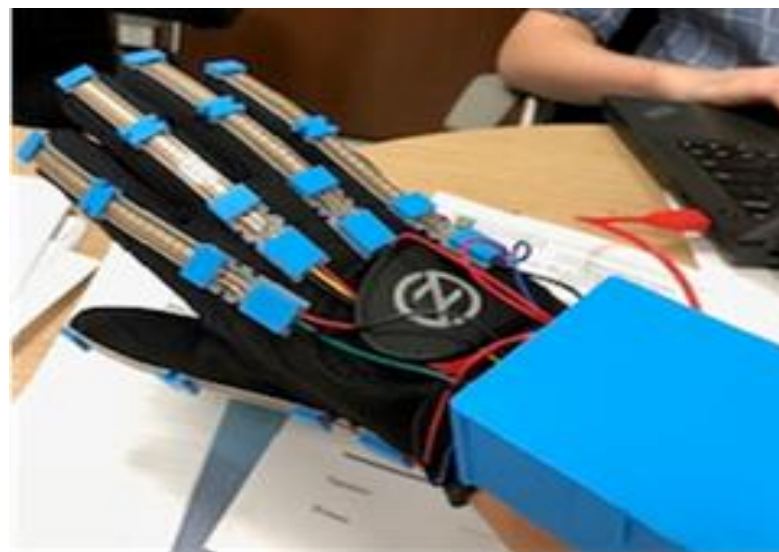


Figure 1 Motion tracking glove instrumented with strain-gauges. Flexion and extension of each digit is expressed as a percentage of full range of motion for each digit independently while being recorded in real-time.

EXPERIMENTAL OUTCOME VARIABLES

- 1) Percent range of motion (ROM) of the intact limb
- 2) Duration of peak-to-peak (P2P) flexion/extension

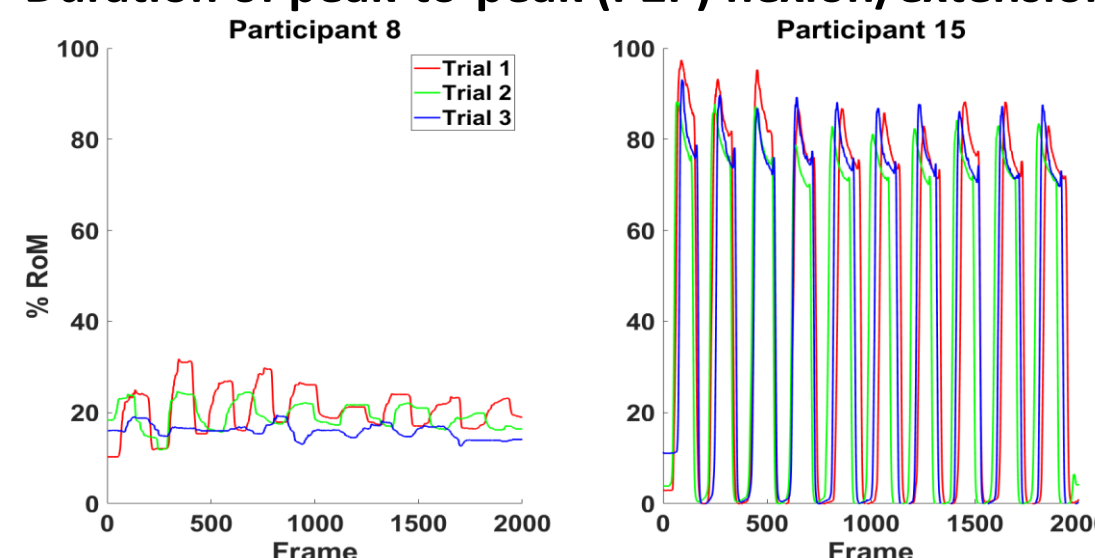


Figure 2 Comparison of poor (left) and good (right) phantom index finger flexion/extension control between participants 8 and 15. Data expressed as a percentage of intact limb full ROM. Left highlights a participant with poor control within trial 1 (red) and degradation over time (trial 3). Right highlights a participant with excellent ROM and timing control.

Results and Discussion

- Intra-rater reliability of the glove was high ($ICC_{3,1} > 0.965$, $p < 0.001$)
- The percent of ROM of all digits was 63.8 ± 23.1
- P2P timing of all digits varied among participants with an average of 3.4 ± 0.9 s
- Strong correlations between reported phantom control and:
 - P2P timing ($R^2 = 0.688-0.821$, $p = 0.007-0.002$)
 - Percent of ROM ($R^2 = 0.669$; $p = 0.028$)

CONCLUSION

- The glove appears to be a good surrogate measurement of phantom hand motion strongly correlating with self-reported phantom control.
- This low-cost glove may be a reliable tool to help assess phantom control.
- The glove could be used as a tool to train phantom limb control and improve prosthesis learning algorithms.

FUTURE WORK

- Compare low-cost glove measurements to gold-standard 3D motion capture equipment.

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