# ENCOURAGING LARGER MOVEMENTS OUTSIDE OF PHYSICAL THERAPY:

## PILOT RESEARCH WITH A NEW VIBRATORY-FEEDBACK DEVICE TO RETRAIN GAIT IN PEOPLE WITH PARKINSON'S DISEASE

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## BACKGROUND

Parkinson's disease (PD) leads to progressive movement problems[1]:

- Slow gait and movement
- Short, shuffling steps
- Smaller/asymmetrical arm swing in gait
- Tremor
- Balance loss

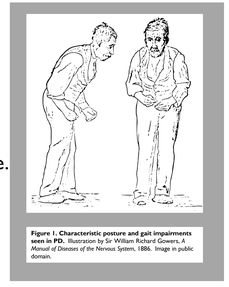


**Figure 1. Characteristic posture and gait impairments seen in PD.** *Illustration by Sir William Richard Gowers, A Manual of Diseases of the Nervous System, 1886.* Image in public domain.

These movement problems worsen with time, affecting independence, safety, and quality of life. Though dopaminergic medications are often effective in mitigating tremor, they are less effective for balance and gait problems,[1,2] and can lead to side effects such as dyskinesias.[2]

Movement problems in PD may be exacerbated by impaired sensory mechanisms or processing, decreasing an individual's awareness of their own movements.[3,4] As a result, more treatments have emphasized external encouragement (cuing) for high-amplitude movements. This training has shown benefits for normalizing movement amplitude.[5]

However, cuing-induced changes dissipate quickly after the cuing ends, meaning that clinic-based improvement may not carry over to a person's natural environment.[6] Longer carryover may be achieved with high frequency treatment for long sessions where therapists give frequent cuing for high-amplitude movement.[5,6] But for many medically fragile patients or those unable to make the time or transportation commitment, clinical treatment may not provide enough support to help their movement patterns.

ArmSense, a portable arm swing feedback device, was developed as a tool to cue movement outside of the clinic. ArmSense tracks the amplitude of arm swing during walking, compares it to a target amplitude set by the patient and their therapist, and delivers a vibratory cue when that target is reached. We hypothesized that ArmSense cuing would lead to increased amplitude of arm swing in walking. Because of the tight coupling between arm swing and lower extremity gait parameters,[7] we also hypothesize that wrist-based vibratory cues for a larger arm swing will also result in increased step length.

**Figure 2. ArmSense system.** Photo by E. Thompson

## PURPOSES

1. To explore the ability of a new wrist-based device, ArmSense, to measure arm swing and cue a larger swing.
2. To investigate the effects of this cuing on temporospatial parameters of gait, especially step length.

## METHODS

**Design:** Repeated-measures

**Participants:**

- Twelve individuals with PD (5 female, 7 male; mean age 63.5±9.5)
- All individuals with PD classified at Hoehn & Yahr stage 2
- All could ambulate at least 20m without assistance or devices
- All were free of neurological conditions besides PD

**Apparatus:**

- ArmSense system consisting of a unit on each wrist with accelerometers, gyroscopes, and a pager-style vibrating motor for cuing.
- Walking trials videotaped and analyzed with Dartfish 8.0 (Dartfish, Friebourg, Switzerland)
- Data processed using Excel (Microsoft, Redmond, WA), custom-written programs in MATLAB (The Mathworks, Natick, MA) and Labview (National Instruments, Austin, TX)

**Procedures:**

- Participants walked trials of 15m in a quiet gym environment under the following conditions:
- Two self-selected paces ("comfortable" and "fast")
- Five cuing conditions (order for visual and vibratory cue conditions pseudo-randomized)

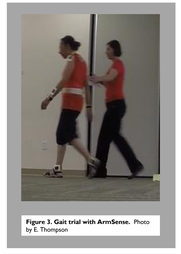


**Figure 3. Gait trial with ArmSense.** Photo by E. Thompson

- Baseline (no cues)
- Visual cues for a 20% longer step than baseline (via tape on floor)

* *Five minute break* *

- Test for retention (no cues)
- Vibratory cues for a 20% larger arm swing than baseline (via ArmSense)

* *Five minute break* *

- Test for retention (no cues)

**Statistical analysis:** Data analyzed in SPSS 22 (IBM, Armonk, NY), using paired t-tests with Bonferroni correction to detect any significant difference in gait parameters (velocity, cadence, or step length) between conditions.

## RESULTS

**Figure 4. Responses by condition for one representative subject:** Plots 4a-4c below indicate the trajectory of the arm swing (angular change from rest) in the anterior-posterior direction. Plot 4d shows changes across experimental conditions in spatiotemporal gait parameters.

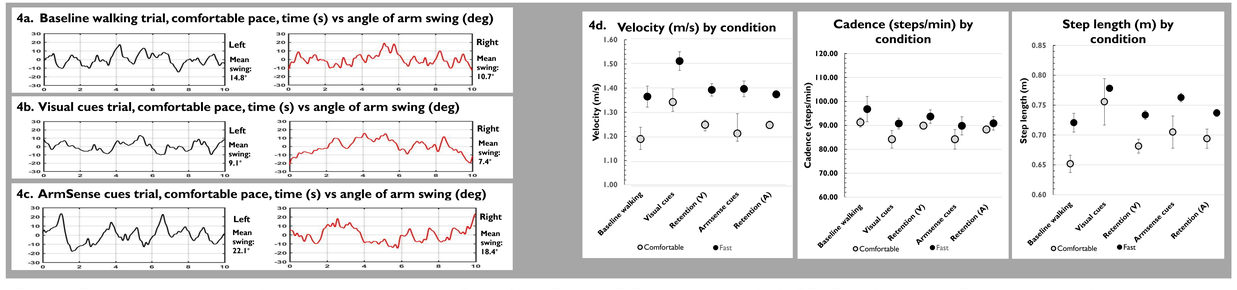
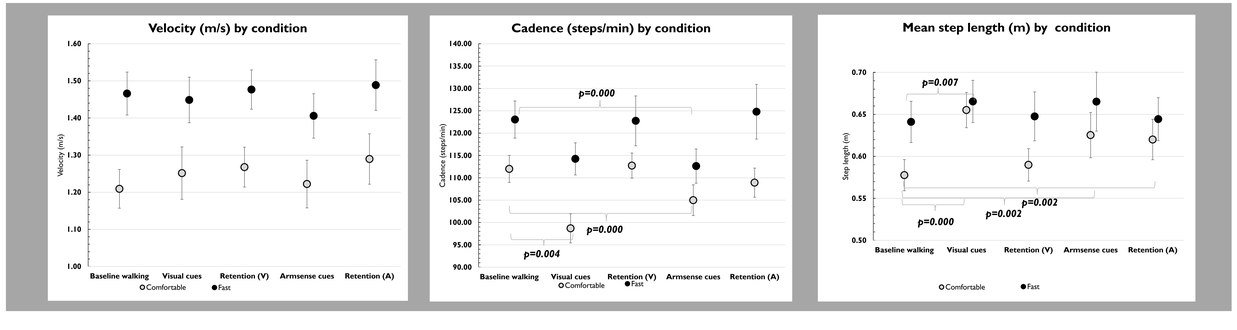



**Figure 5. Mean responses for total sample (n=12): *Significant difference at p≤0.0125 (Bonferroni-adjusted α level)**




## CONCLUSIONS

In this twelve-subject pilot study, statistically significant increases in step length from baseline were found using visual or ArmSense cues when walking at a self-selected comfortable pace, or using visual cues when walking at a fast pace. However, retention of this increase (maintaining statistically significant increased step length five minutes after cue removal) was only seen following use of the ArmSense cues at a comfortable walking pace. For cadence, statistically significant decreases from baseline were seen using visual cues (comfortable pace only) or ArmSense cues (both paces). These decreases rebounded back toward baseline in the retention conditions.

## CLINICAL RELEVANCE

Encouraging larger arm swing at normal walking speed can be accomplished with wrist-based vibratory cues. This larger swing may lead to increased step length in persons with PD, and may be retained longer than with visual cues alone. Given the increased ease and social acceptance of wrist-based activity monitors in many demographic groups, we hope this device can be a well-accepted option for delivering movement cues outside of a therapy clinic.

Volunteers reported the device as being large but lightweight and comfortable to wear. Several noted, however, that after walking with atypical arm swing for months or years, it was a challenge to regain the coordination between arms and legs when cued to use a larger arm swing.

## LIMITATIONS

- Since sample size was small in this preliminary study, limiting choices for sound statistical analysis
- Generalizability to the broader population with PD may be limited by inclusion requirement of walking unassisted, and by the fact that all volunteers were classified at H&Y stage 2
- While a 20% increase in movement amplitude was chosen as a target based on literature, increases this large may require more extensive training in some persons, or not be clinically feasible due to factors such as degenerative joint disease or adaptive soft tissue shortening

## REFERENCES

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