The Effects of Haptic Feedback on Postural Sway

Andrew Meszaros, PT, PhD, Brandon Crumpacker, SPT, Marc Gendelman, SPT, Peter Martin, SPT, Levi vanTol, SPT, Pierre Zook, SPT

George Fox University
Doctorate of Physical Therapy

INTRODUCTION

- **Purpose**: Effectiveness of haptic feedback on reducing postural sway
- **Hypothesis**: Haptic input improves static standing stability. Individuals with increased variability in sway may have an increased risk for falls. Therefore, our haptic feedback device may have the ability to reduce risk of falling.
- Postural control is a dynamic system involving vision, vestibular system, proprioception, and musculoskeletal system. Postural control enables people to maintain their balance, reduce their sway, and keep an upright posture.
- Haptic feedback is tactile or vibratory cues that assist a subject in determining where they are in space.

Fig. 1 illustrates the limits of sway, with the yellow bars representing where the device is engaged

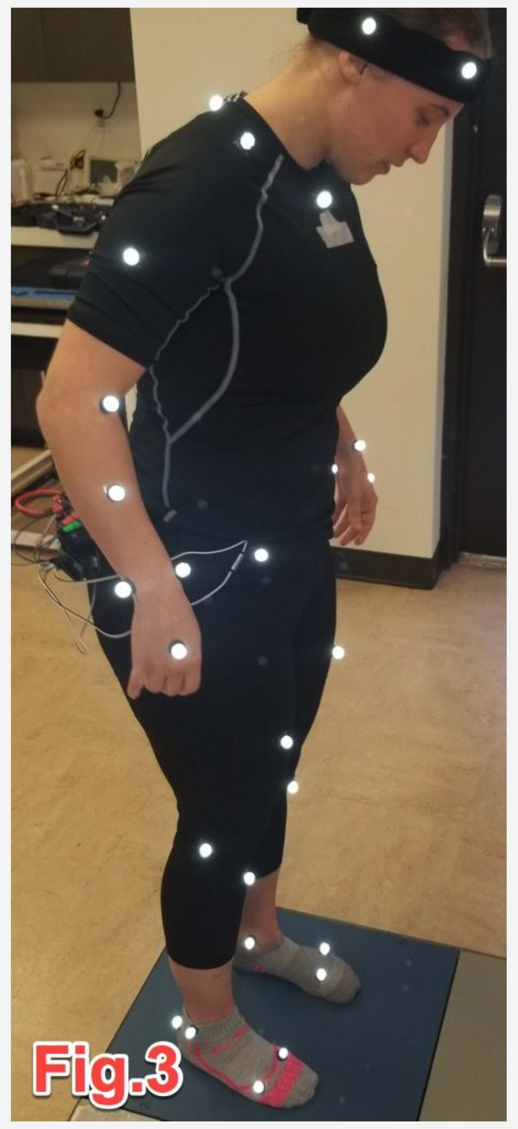


Fig. 3 shows a participant wearing the haptic feedback shirt, standing on a force plate, and equipped with markers

METHODS

- Data was collected during a protocol for testing the static balance of a vestibular-impaired participant in various conditions. Testing conditions included: eyes open/closed, standing on foam or firm surface, cognitive load, holding pole, light finger touch, or a combination of these conditions. Our participant was run through our protocol without any haptic feedback from devices. Then, the participant performed each trial with version 2.0 of our haptic feedback device (tactor array) and version 3.0 of our haptic feedback device (linear resonant actuator array). The participant took a sitting break between performing each protocol to avoid fatigue.

RESULTS

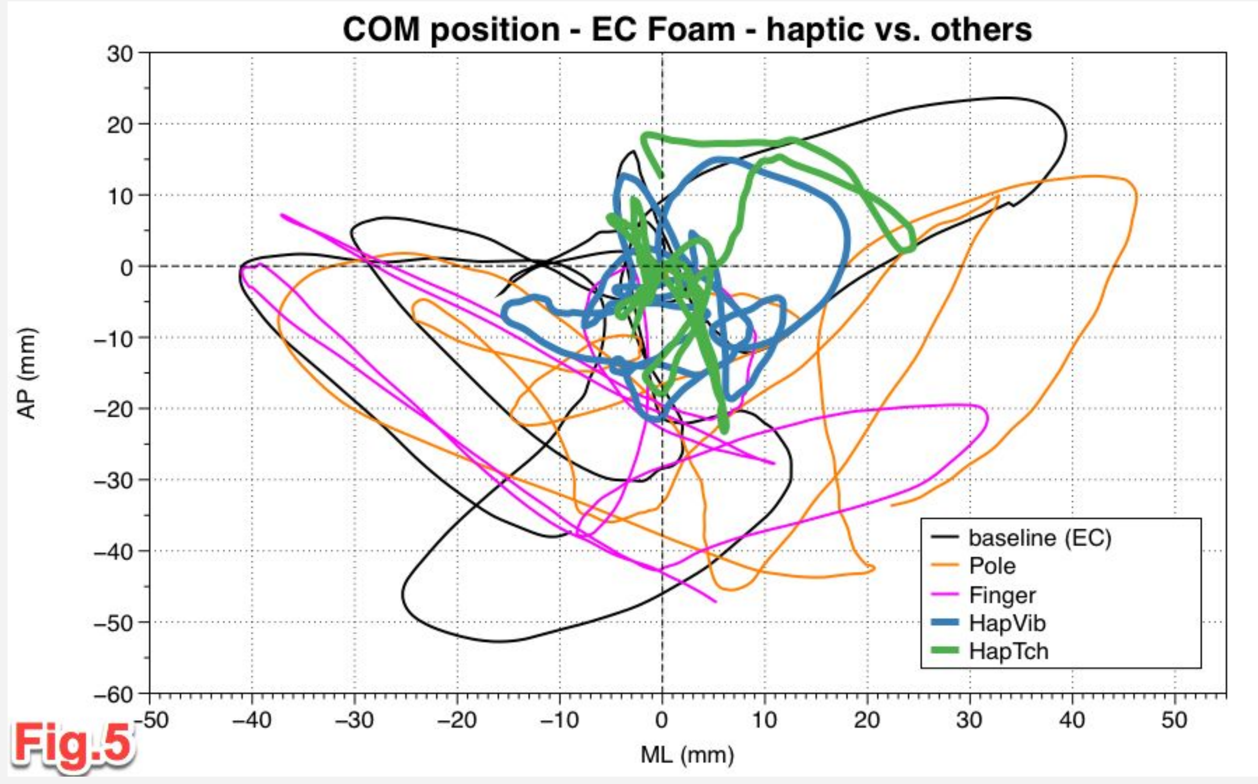


Fig.5 shows changes in COM positioning over the course of 15 second trials with eyes closed as participant stands atop foam surface

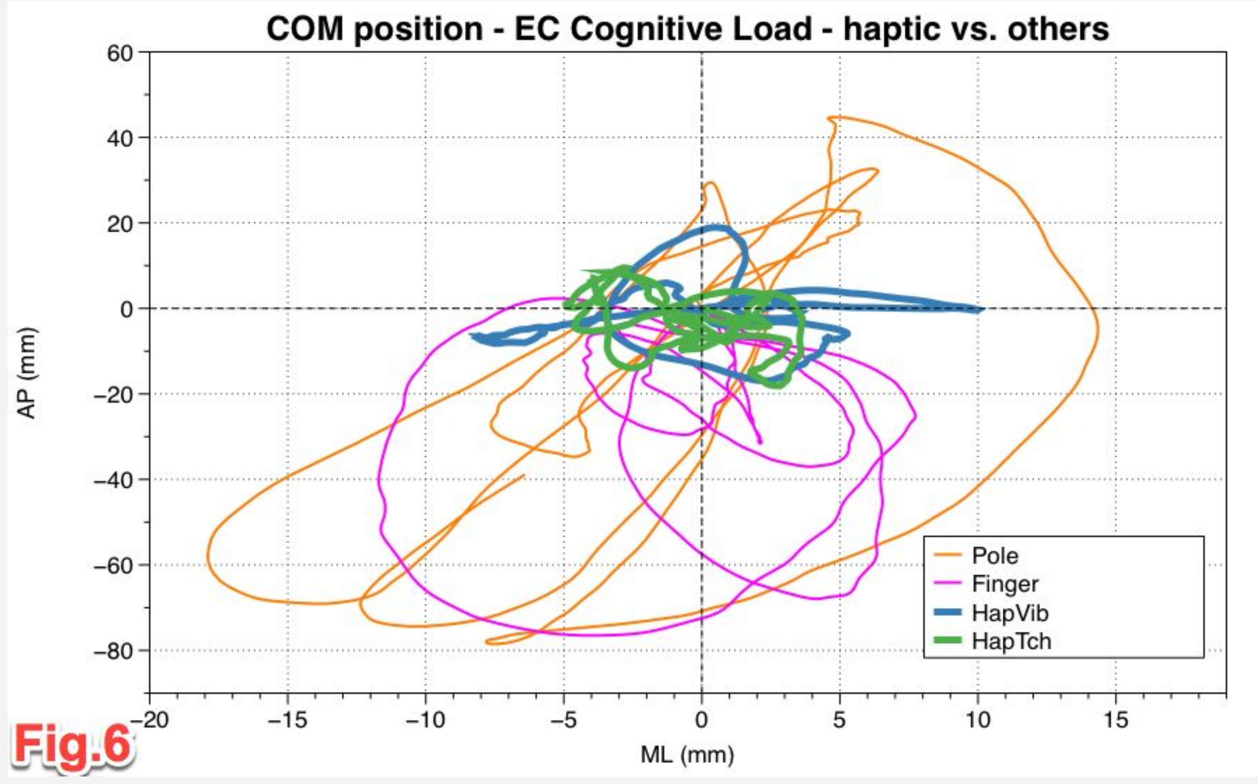
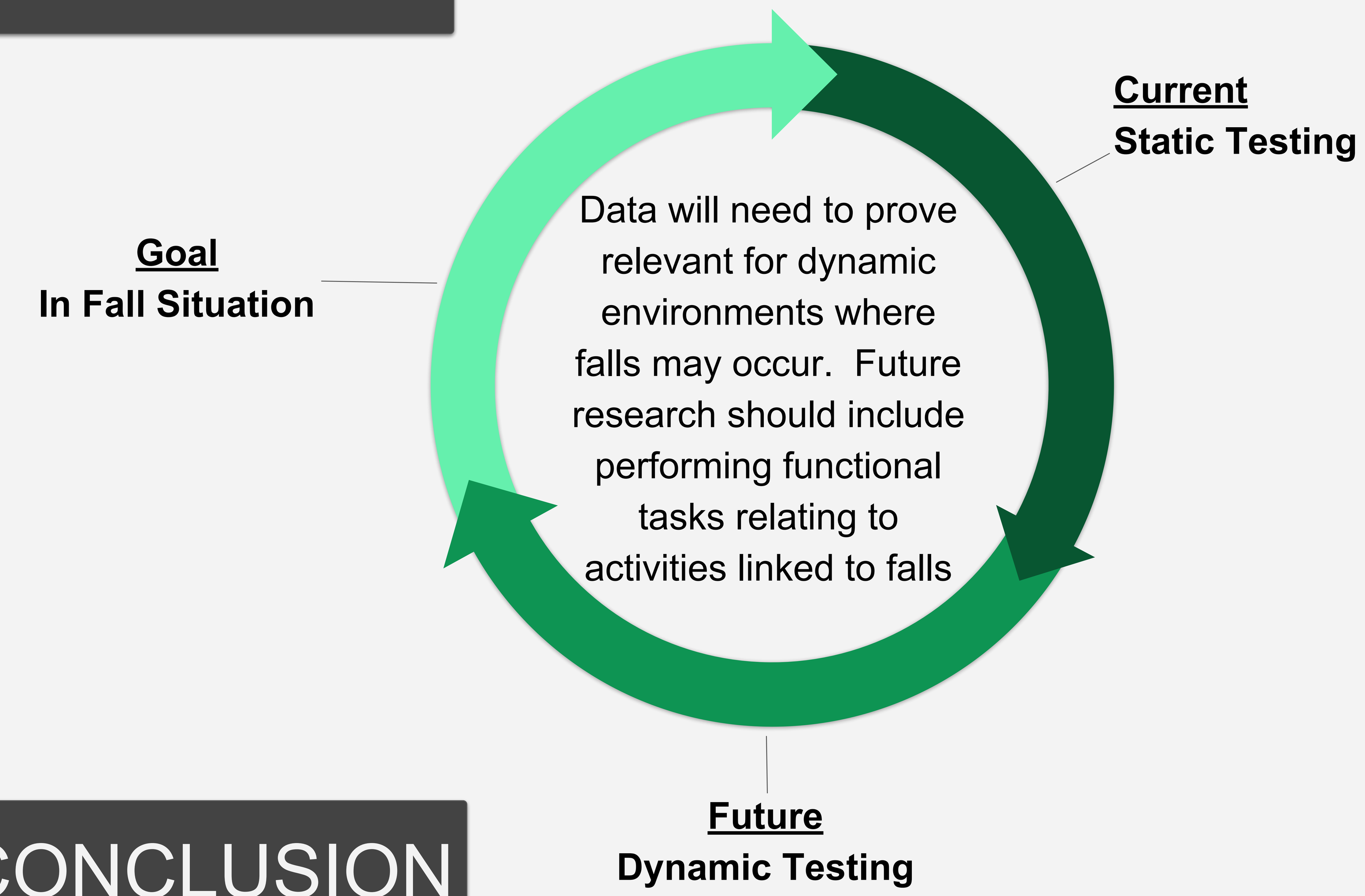


Fig. 6 shows changes in COM positioning over the course of 15 second trials with eyes closed and cognitive load of spelling word(s) backwards

COM MAX Range Summary (red = larger effect, green = smaller effect)

(Fig.5)	ECFo	0.0805	0.0763	0.0100
	ECFo Pole	0.0836	0.0581	0.0147
	ECFo Finger	0.0727	0.0544	0.0128
	ECFo HapVib	0.0335	0.0364	0.0070
	ECFo Hv2	0.0296	0.0417	0.0082
(Fig.6)	ECCog Pole	0.0322	0.1232	0.0123
	ECCog Finger	0.0194	0.0788	0.0044
	ECCog HapVib	0.0180	0.0358	0.0020
	ECCog HapTch	0.0085	0.0276	0.0023

DISCUSSION



CONCLUSION

- The haptic sway devices decreased values for Total path of excursion and Max range of excursion.
- Both haptic devices appear to constrain anterior/posterior motions more effectively then medial/lateral.
- Both haptic devices are positive in reducing excursion on foam (when somatosensory feedback is reduced).
- While holding the pole, subject's postural sway increased.
- Subjects generally preferred the haptic shirt as it was quiet and streamlined in appearance. Further testing will be required to assess whether shirt, belt, or a combination of the two is best for controlling sway.

LIMITATIONS

N=1	Sample Time	Product
Data was taken and analyzed from only one participant, which limits the study to extrapolate results	Trials were limited to 15 seconds to decrease participant fatigue	The haptic devices will continue prototyping to improve functioning

REFERENCES

1. Wall, C., Lyford, N. D., Sienko, K. H., & Balkwill, M. D. (2011). The design and development of a production prototype balance belt. 2011 Annual International Conference of the IEEE Engineering in Medicine and Biology Society. doi:10.1109/iembs.2011.6090585
2. Lackner, J., Rabin, E., & Dizio, P. (2001). Stabilization of posture by precision touch of the index finger with rigid and flexible filaments. Experimental Brain Research, 139(4), 454-464. doi:10.1007/s002210100775
3. Sienko, K. H., Balkwill, M., & Wall, C. (2012). Biofeedback improves postural control recovery from multi-axis discrete perturbations. Journal of NeuroEngineering and Rehabilitation, 9(1), 53. doi:10.1186/1743-0003-9-53