Can Cue Location Influence Postural Sway Control in a Post-Concussion Syndrome Case?

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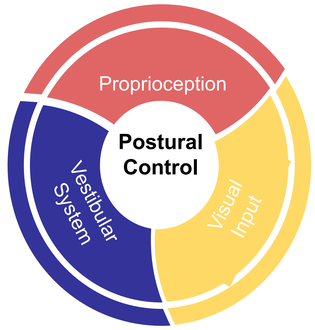
Introduction:

- Center for Disease Control reports the following as fall risk factors: lower extremity weakness, vision problems, and difficulty maintaining balance during walking. Greatest predictor for a fall, is prior fall within the last year.
- Injury from a fall leads to: fear of falls, inactivity, atrophy, higher risk for falls.
- Kouzake and Masani (2008) indicated that improvements in postural sway are attributed to light touch increasing proprioception, rather than through mechanical support.
- Examples of light touch-enhanced proprioceptive feedback: walls and assistive walking devices. Successful strategy in bimanual tasks?

25% of the geriatric population report having at least 1 fall per year + **50% of people over age 65 do not report falls to medical professionals**

= $50 Billion Dollar Health Care Cost for Falls



Purpose:

To explore the effectiveness of haptic feedback location along the waist (haptic belt) versus through the torso (haptic vest) under conditions altering somatosensory, visual, and vestibular variables.

Hypothesis 1:

Vest device will show greatest reduction in postural sway, rather than belt device or belt and vest devices together.

Hypothesis 2:

Light touch with belt and vest will lead to greater reductions in postural sway, than light touch with vest or light touch with belt.

Methods:

	baseline (mug)	Pole assist	Finger assist	Haptic Trunk	Haptic Belt	Haptic Trunk + Haptic B.	Haptic Trunk + Finger
EC	1	20	2	13 buzz: Y-N	15 buzz: Y-N	17 buzz: Y-N	11 buzz: Y-N
EC Fo	5	6	4	8 buzz: Y-N	7 buzz: Y-N	9 buzz: Y-N	10 buzz: Y-N
EC Cog	19 Alignment Lavender Equivocal	21 Technique Camouflage Postulate	3 Philosopher Foliage Actuarial	14 Sculptor Diaphragm Rapacious buzz: Y-N	16 Corruptible Nucleus Tributary buzz: Y-N	18 Hysterical Maneuver Lightning buzz: Y-N	12 Algorithm Obsequious Zucchini buzz: Y-N

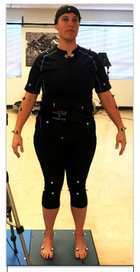


Figure 1. Subject set with markers, haptic belt, & belt

Results:

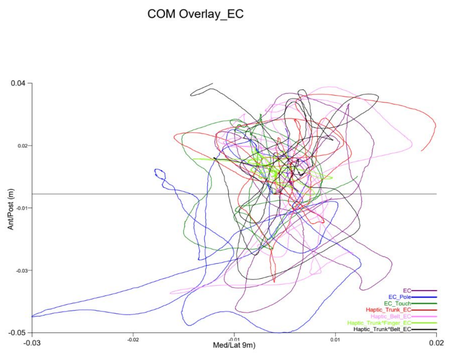


Figure 2. COM excursion over 30 seconds with eyes closed: Situations of more excursion (Eyes closed and Pole) showed decreased performance compared to baseline, whereas haptic trunk with eyes closed demonstrated less excursion. This suggests that hand-based postural control is an ineffective balance strategy.

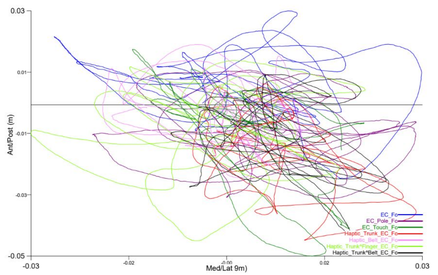


Figure 3. COM excursion over 30 seconds with eyes closed and subject standing on a foam: Haptic trunk with light touch showed more COM excursion compared to trials with either haptic trunk or haptic belt alone. This suggests that too many constraints on COM may lead to overstimulation.

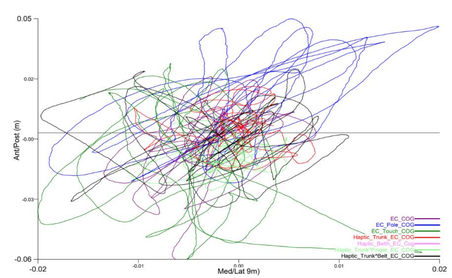


Figure 4. COM excursion over 30 seconds with eyes closed and cognitive challenge: Eyes closed with light touch showed more COM excursion compared to eyes closed with haptic trunk, suggesting that hands-free strategies are safer and more efficient in postural corrections in situations of cognitive challenge.

Discussion:

General trends tend to include larger amount of excursion reduction in haptic trunk feedback compared to haptic belt. This is limited in that there were several instances of unexpected decreases in sway during difficult balance perturbation scenarios, suggesting either device malfunction or learning effect. Data also suggests that current static standing strategies including utilizing a pole or touch alone, appear to be marginally better than the control. However, lack of large sample size to perform statistical analysis prevents any conclusive statements to be made. Potential causes for increased total sway between trunk and belt may stem from amount of subconscious interpretation of feedback limiting degrees of freedom to maintain balance across a singular joint versus multi-joint coordination (see figure 6).

COM M/L (mm)

	Baseline	Pole	Touch	Haptic trunk	Haptic Belt	Haptic Trunk + Haptic Belt	Haptic Trunk + Finger
EC	23.011	42.725	22.79	33.971	31.431	24.391	18.023
EC Fo	62.332	54.846	39.293	37.9	35.809	36.967	56.732
EC Cog	19.46	35.672	35.672	16.575	20.11	28.195	14.676

COM A/P (mm)

	Baseline	Pole	Touch	Haptic trunk	Haptic Belt	Haptic Trunk + Haptic Belt	Haptic Trunk + Finger
EC	83.123	77.485	51.614	71.299	78.425	74.347	18.289
EC Fo	58.164	44.553	71.778	54.287	46.227	55.619	62.596
EC Cog	83.285	74.877	89.099	37.904	56.744	62.771	33.436

COM Path (m)

	Baseline	Pole	Touch	Haptic trunk	Haptic Belt	Haptic Trunk + Haptic Belt	Haptic Trunk + Finger
EC	0.548	0.513	0.364	0.461	0.569	0.507	0.187
EC Fo	0.756	0.692	0.652	0.645	0.738	0.729	0.627
EC Cog	0.78	1.066	0.975	0.507	0.749	0.872	0.385

Figure 5. Amount of excursion in anterior/posterior, medial/lateral, and total excursion distance. Shade of red in each cell indicates difference in total excursion compared to baseline measurements within each condition with more intense red color representing larger differences.

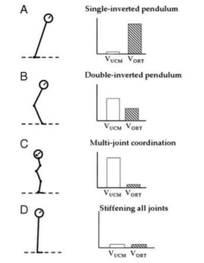


Figure 6. Application of Multi-joint coordination in maintaining upright balance strategies.

Hypothesis 1: Haptic trunk vs haptic belt vs haptic trunk + haptic belt. Haptic trunk alone will provide greatest amount of reduction in postural sway.

- Haptic trunk reduction from baseline across conditions = .471 m
- Haptic belt reduction from baseline across conditions = .028 m
- Haptic trunk + haptic belt reduction from baseline across conditions = increased sway by .024 m

Hypothesis 2: Light touch with vest vs light touch with belt vs combination of vest + belt + touch. Light touch with vest will show greatest amount of postural sway reduction (due to protocol changes mid-way through project, only light touch vs light touch with vest could be analyzed).

- Light touch reduction from baseline across conditions = .089 m
- Light touch + haptic vest reduction from baseline across conditions = .885 m

Conclusion:

- There is no definitive scenario in which the wearable haptic devices improved balance
- Most challenging position was EC Foam in the medial/lateral direction
- Learning effect or fatigue could influence subject performance over various trials
- Further research needs to incorporate inclusion of specific tactor feedback duration and location to extrapolate trends in loss of balance situation
- Further research needs to explore UCM analysis on the effect of haptic devices on constraining balance strategies

Limitations:

- Sample size n=1
- Device reliability
- Static standing positions only

References:

Baldan, A., Alouche, S., Araujo, I., & Freitas, S. (2014). Effect of light touch on postural sway in individuals with balance problems: A systematic review. Gait & Posture, 40(1), 1-10. doi:10.1016/j.gaitpost.2013.12.028

Hsu, W.-L., Scholz, J. P., Schöner, G., Jeka, J. J., & Kiemel, T. (2007). Control and Estimation of Posture During Quiet Stance Depends on Multijoint Coordination. Journal of Neurophysiology, 97(4), 3024–3035. doi: 10.1152/jn.01142.2006

Johannsen, L., Wing, A., & Hatzitaki, V. (2012). Contrasting effects of finger and shoulder interpersonal light touch on standing balance. Journal of Neurophysiology, 107: 216-225. doi:10.1152/jn.00149.2011

Johannsen, L., Wing, A., & Hatzitaki, V. (2007). Effects of Maintaining Touch Contact on Predictive and Reactive Balance. Journal of Neurophysiology, 97(4), 2686–2695. doi:10.1152/jn.00038.2007

Kouzaki, M., & Masani, K. (2008). Reduced postural sway during quiet standing by light touch is due to finger tactile feedback but not mechanical support. Exp Brain Res, 188, 153-158.

Means, K. M., Rodell, D. E., & O'Sullivan, P. S. (2005). Balance, mobility, and falls among community- dwelling elderly persons: effects of a rehabilitation exercise program. American Journal of Physical Medicine & Rehabilitation, 84(4), 238-250.

Nejc, S., Jernej, R., Loefler, S., Kern, H., (2010). Sensitivity of body sway parameters during quiet standing to manipulation of support surface size. Journal of Sports Science and Medicine, 9, 431-438

Rabin, E., Chen, J., Muratori, L., DiFrancisco-Donoghue, J., & Werner, W. (2013). Haptic feedback from manual contact improves balance control in people with Parkinson's disease. Gait & posture, 38(3), 373– 9. doi:10.1016/j.gaitpost.2012.12.008

Solnik, S., Qiao, M., & Latash, M. L. (2017). Effects of visual feedback and memory on unintentional drifts in performance during finger-pressing tasks. Experimental Brain Research, 235(4), 1149-1162. doi:10.1007/s00221-017-4878-7

Vuillerme, N., Isableu, B., & Nougier, V. Attentional demands associated with the use of a light fingertip touch for postural control during quiet standing. Exp Brain Res, 169: 232-236.