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Sway-Referenced Haptic Input Improves Static Standing Stability (Poster)

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Sway-Referenced Haptic Input Improves Static Standing Stability

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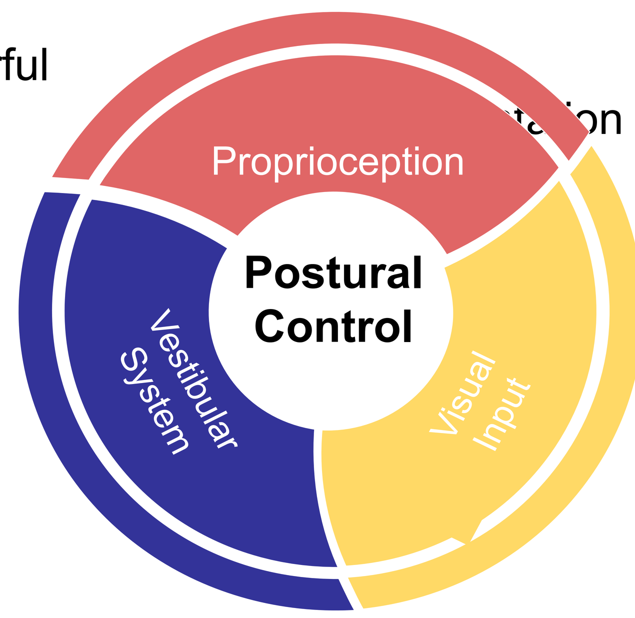
Introduction:

CDC reports that falls in the US cost $50 billion/year. Posture control relies on the integrity of a number of bodily systems to maintain center of mass (COM) over base of support (BOS).

- Light touch through the hand (<4N) has a powerful effect on organizing the body's sense of in space. (Lackner)
- Canes and walkers are often used for orientation. This is lost during bimanual activities (i.e. washing dishes)
- Wearable sway-referenced haptic feedback has the potential to reduce sway while freeing the hands (Meszaros 2019; Wall 20213)



Purpose:

To compare COM control with haptic feedback versus light touch feedback using VR-, Foam-, and Cognitive-induced instability in healthy subjects.

Hypothesis:

When assessed over 2-minute trials, under VR and cognitive challenge conditions, haptic assistance will reduce COM maximum and total excursion as good or better than light touch assistance.

Methods:

N = 16; Age Range=22-31 y/o (Chiarovano, 2017). Data shown for 2 subjects

DATA COLLECTION PROTOCOL

Spotters check: mug position? zero haptic? foot spacing? knee lock? fatigue? semi-tandem?

Comfort: can remove mask during testing; slide-up the headset between conditions

	baseline (mug)	Haptic assist	Finger assist
VR Semi-tandem video used:	1 | # steps:	4 | # steps: buzz #:	6| # steps:
Foam Cognitive: cross-off completed words	2 | # steps: Rapacious Diaphragm Allegory Philosopher Foliage Actuarial Alignment Lavender Equivocal Technique Camouflage Postulate Repugnant Androgyny	3 | # steps: buzz #: Obtunded Corruptible Nucleus Tributary Hysterical Maneuver Lightning Algorithm Obsequious Zucchini Shackle Tobacco Elementary Delicatessen	5 | # steps: Vexatious Average Vengeance Momentary Elegance Artificially Existential Orphan Pavilion Remembrance Plumber Momentous Superfluous Sculptor

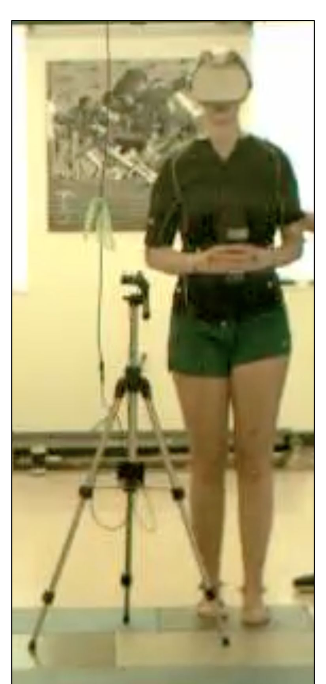


Figure 1. Subject set with markers, haptic belt, & belt

Results:

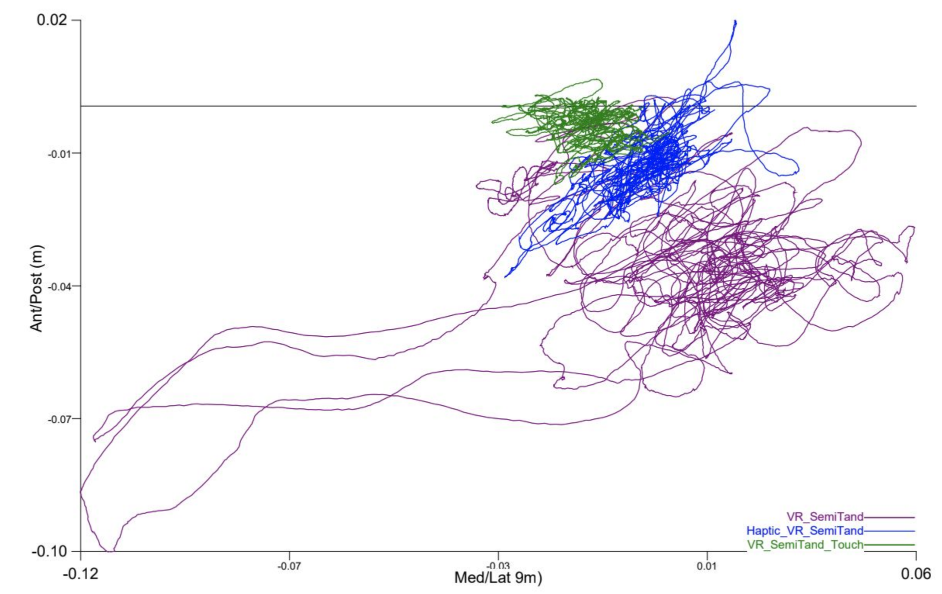


Fig-2. Subject-1 COM. Challenge = Semi Tandem VR

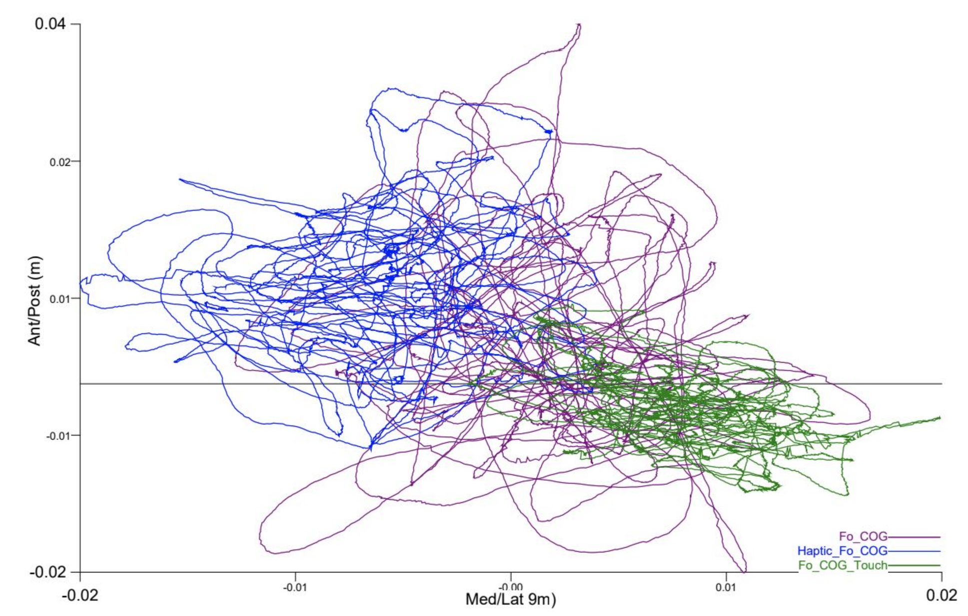


Fig-3. Subject-1 COM. Challenge = Foam Cognitive

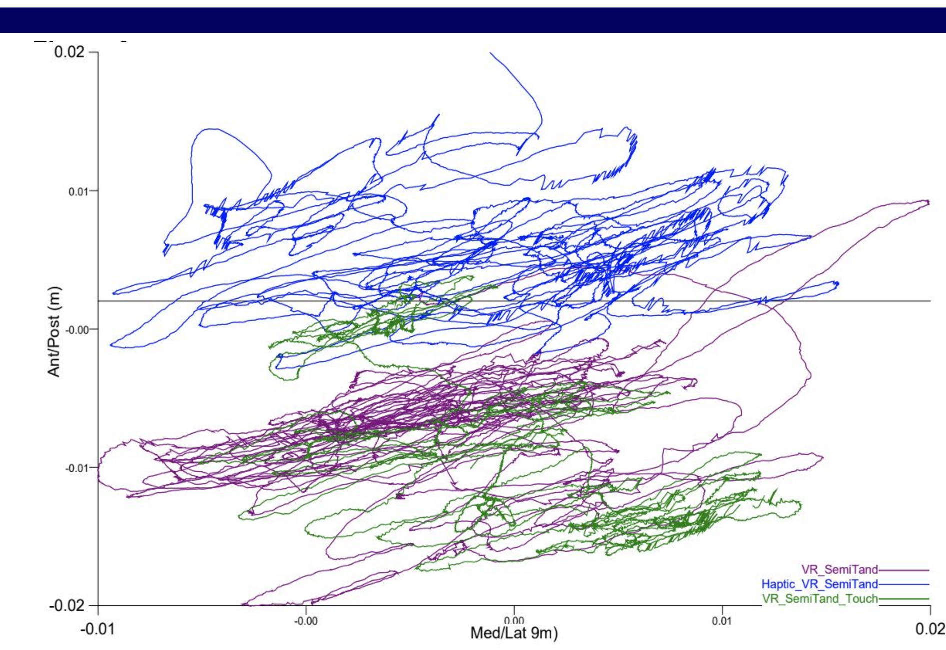


Fig-4. Subject-2 COM. Challenge = Semi Tandem VR

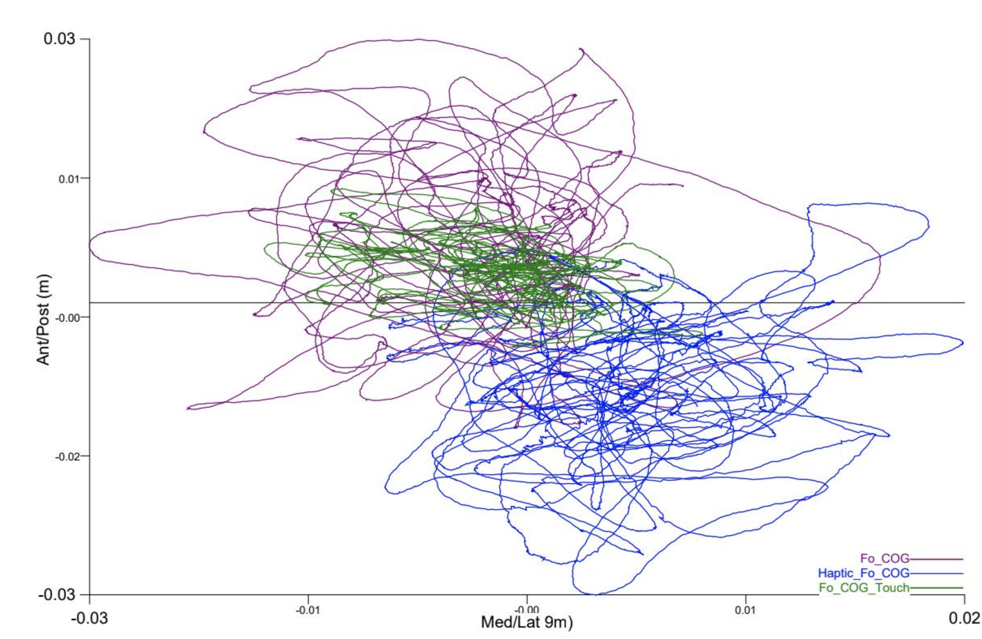


Fig-5. Subject-2 COM. Challenge = Foam Cognitive

Discussion:

A set of tables displaying the results from our two subjects is shown in (Figure 6;Figure 7.)

The first two tables for each subject show the maximum movement (mm.) of the COM of the subjects. The top table shows the farthest medial lateral sway recorded while the second table shows the farthest anterior posterior sway recorded. The third table shows the total distance (m.) the COM traveled during the trials.

From this data, we can see that both haptic feedback assistance as well as light touch assistance we see notably reduced postural sway for our two subjects. The reduction in maximum sway as well as total distance traveled by the COM was greater during the light touch trials.

Summary

COM Med/Lat Sway (mm)

	Baseline	Haptic	Touch
VR_SemiTand	174.350	61.443	36.983
Fo_COG	28.526	23.228	21.209

COM Ant/Post Sway (mm)

	Baseline	Haptic	Touch
VR_SemiTand	104.922	59.277	24.277
Fo_COG	59.525	39.328	20.778

COM Path (m)

	Baseline	Haptic	Touch
VR_SemiTand	0.600	0.439	0.268
Fo_COG	0.315	0.396	0.215

Fig-6. Subject-1 COM Sway and Path Summary

Summary

COM Med/Lat Sway (mm)

	Baseline	Haptic	Touch
VR_SemiTand	36.831	32.266	26.690
Fo_COG	40.897	29.887	22.644

COM Ant/Post Sway (mm)

	Baseline	Haptic	Touch
VR_SemiTand	31.788	24.799	23.146
Fo_COG	45.451	45.835	18.541

COM Path (m)

	Baseline	Haptic	Touch
VR_SemiTand	0.375	0.201	0.180
Fo_COG	0.378	0.290	0.177

Fig-7. Subject-2 COM Sway and Path Summary

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PERCENT CHANGE FROM BASELINE BY CHALLENGE (Haptic / Touch / [Diff])

      VR_SemiTand M/L      VR_SemiTand A/P     VR_SemiTand Path
S1 => 65% / 78%  [13%]     43% / 76%  [30%]    27% / 55%  [28%]
S2 => 12% / 27%  [15%]     22% / 27%  [5%]     46% / 52%  [6%]

      Fo_COG M/L           Fo_COG A/P          Fo_COG Path
S1 => 19% / 25%  [6%]      34% / 65%  [31%]    +25% / 31% [56%]
S2 => 27% / 44%  [17%]     0% / 60%   [60%]     23% / 53% [30%]
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Conclusion:

- Haptic assistance reduced COM excursion compared to baseline, for both subjects.
- Haptics were not as effective as light tough assistance in reducing COM sway.
- Light touch provides continues orientation, unlike haptic boundaries
- Plans: analyze full dataset; analyze touch force; haptic AI with gait.

Limitations:

- only 2 analyzed from dataset
- haptic device robustness
- VR acclimation

References:

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