

Standing Balance Improvements with Additional Sensory Input in Charcot-Marie-Tooth

Tarun Arora,^{1,2} Fredrik Stenseth,¹ Malin Eriksen,^{1,2} Andreas Rosenberger,³ Kristian B. Nilsen,² Christian Tronstad,⁴ Kristin Ørstavik¹

1: Section for Rare Neurological Disorders and EMAN, Department of Neurology, Oslo University Hospital; 2: Section for Clinical Neurophysiology, Department of Neurology, Oslo University Hospital; 3: Norwegian Centre for Rare Diseases- unit for neuromuscular disorders, University Hospital of North-Norway; 4: Department of Clinical and Biomedical Engineering, Oslo University Hospital. ✉ tararo@ous-hf.no

I. INTRODUCTION

- Charcot-Marie-Tooth (CMT)** is the most common inherited cause of peripheral neuropathy leading to balance impairments and falls [1].
- ~70% of individuals with CMT** report falls, highlighting the need for more effective strategies to improve balance.

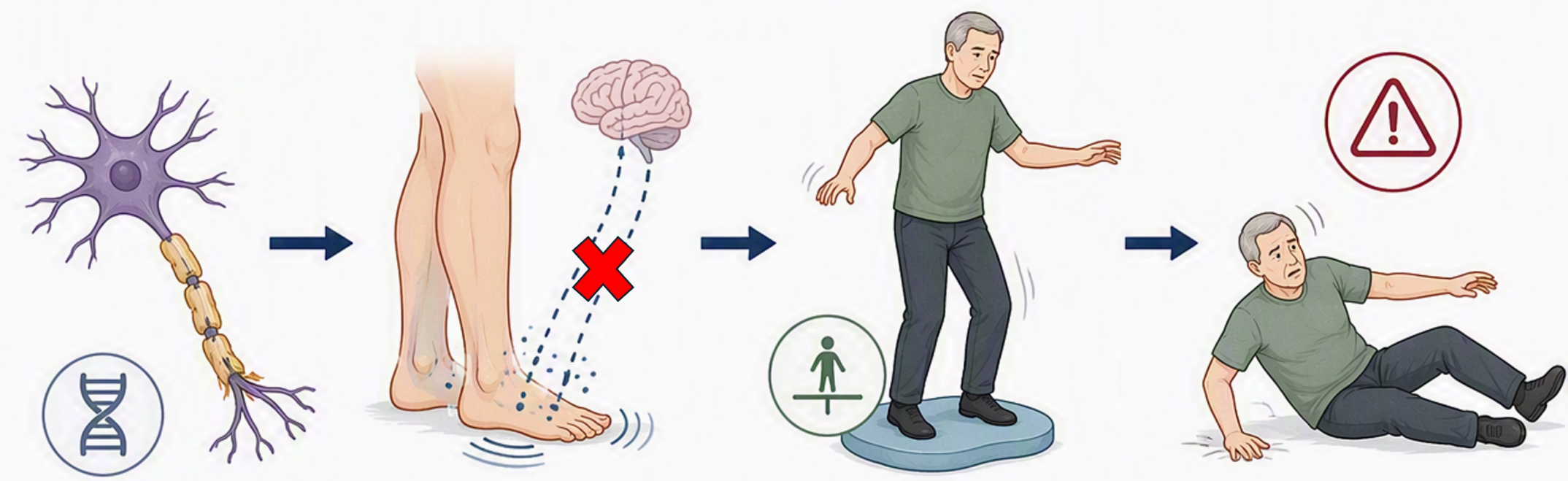


Figure 1. CMT-related somatosensory impairment → impaired postural orientation → balance deficits and falls

- Balance control** relies on sensory feedback from somatosensory, visual and vestibular systems [2].
- Additional sensory input may help compensate for sensory impairments in improving balance [3].

Can people with CMT improve their balance using sensory feedback through light fingertip touch?

II. METHODS

- Study site:** Rikshospitalet, Oslo University Hospital, Norway
- Cross-over design:** participants repeated standing tasks with and without light touch across varying sensory conditions (Fig. 2):

Eyes Open on Floor | Eyes Closed on Floor | Eyes Open on Foam

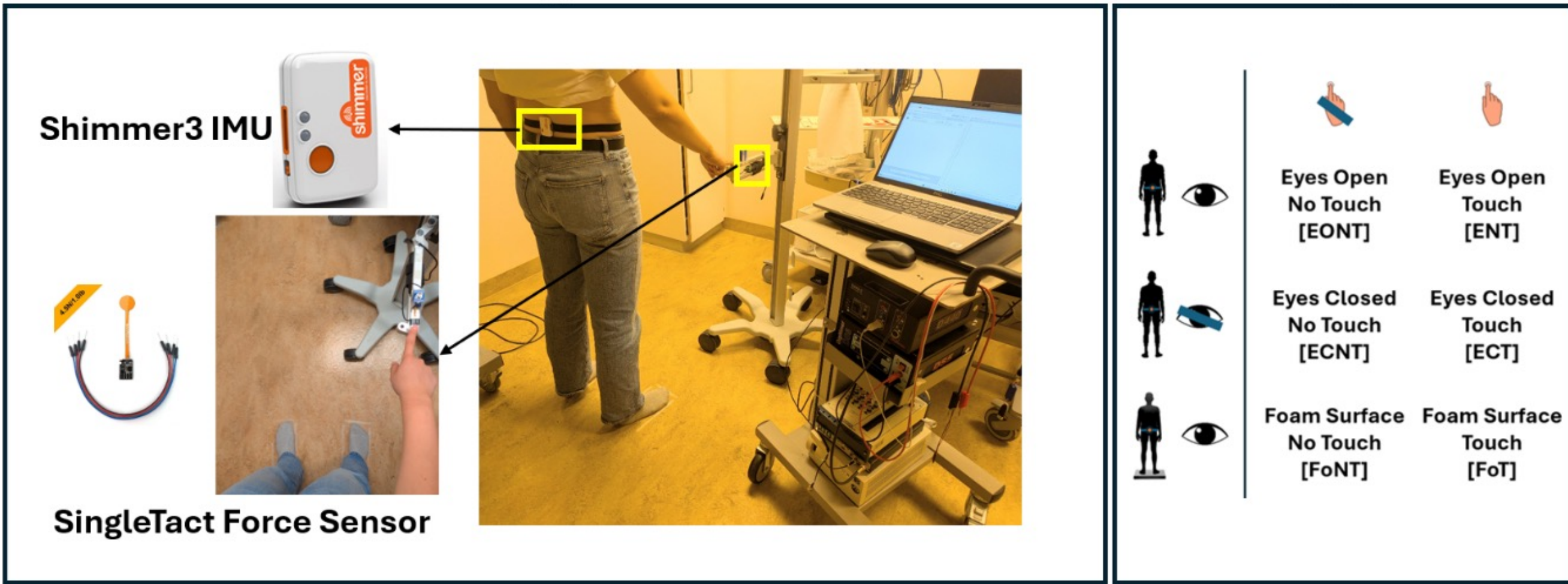


Figure 2. Experimental Setup. 60-sec standing trials with and without light-touch sensory input under eyes-open, eyes-closed, and foam-surface conditions. Each trial repeated three times, for 18 randomized trials. An inertial measurement unit (IMU) secured to the low back recorded accelerometer data to quantify postural sway. Touch force was maintained in the range of 0.5 N - 1.5 N (as monitored using a force sensor) to ensure no mechanical support.

- Outcome variables:**
 - Postural sway** → Area of circle encompassing 95% confidence acceleration path in the mediolateral-anteroposterior plane [4].
 - Clinical outcomes** → CMT Neuropathy Score2; CMTNS2 (disease severity) | mini-Balance Evaluation Systems Test; mini-BESTest (dynamic balance).
- Intervention:** light-touch sensory input (0.5 N - 1.5 N) (Fig. 2).
- Statistics:**
 - Intervention effect [Touch/No-touch]** → Wilcoxon Signed-Rank Test
 - Group effect [CMT/Healthy Control (HC)]** → Mann-Whitney U-test
 - Correlations (postural sway improvements & clinical outcomes)** → Spearman's Correlation Coefficient

III. RESULTS

DEMOGRAPHICS

- CMT (N=20):** 14F; 46.4±13.3y; CMT duration: 25.9±15.5y; CMTNS2 = 14(5-23) CMT 1A: 9(45%) | CMT 4C: 3(15%) | CMT 2A2: 3 (15%) | X-linked CMT1 (GJB1): 3(15%) CMTJ: 1(5%) | CMT 1A + CMT 4C: 1(5%)
- HC (N=22):** 14F; 46.2 ± 13.0 y

POSTURAL SWAY

- Effect of additional sensory input** → ↓ postural sway with light touch: **CMT:** large effect size vs **HC:** medium-large effect size (Fig. 3 and Table 1)
- Correlations** → negative correlation between light touch-related sway improvement and dynamic balance scores (Fig. 4)

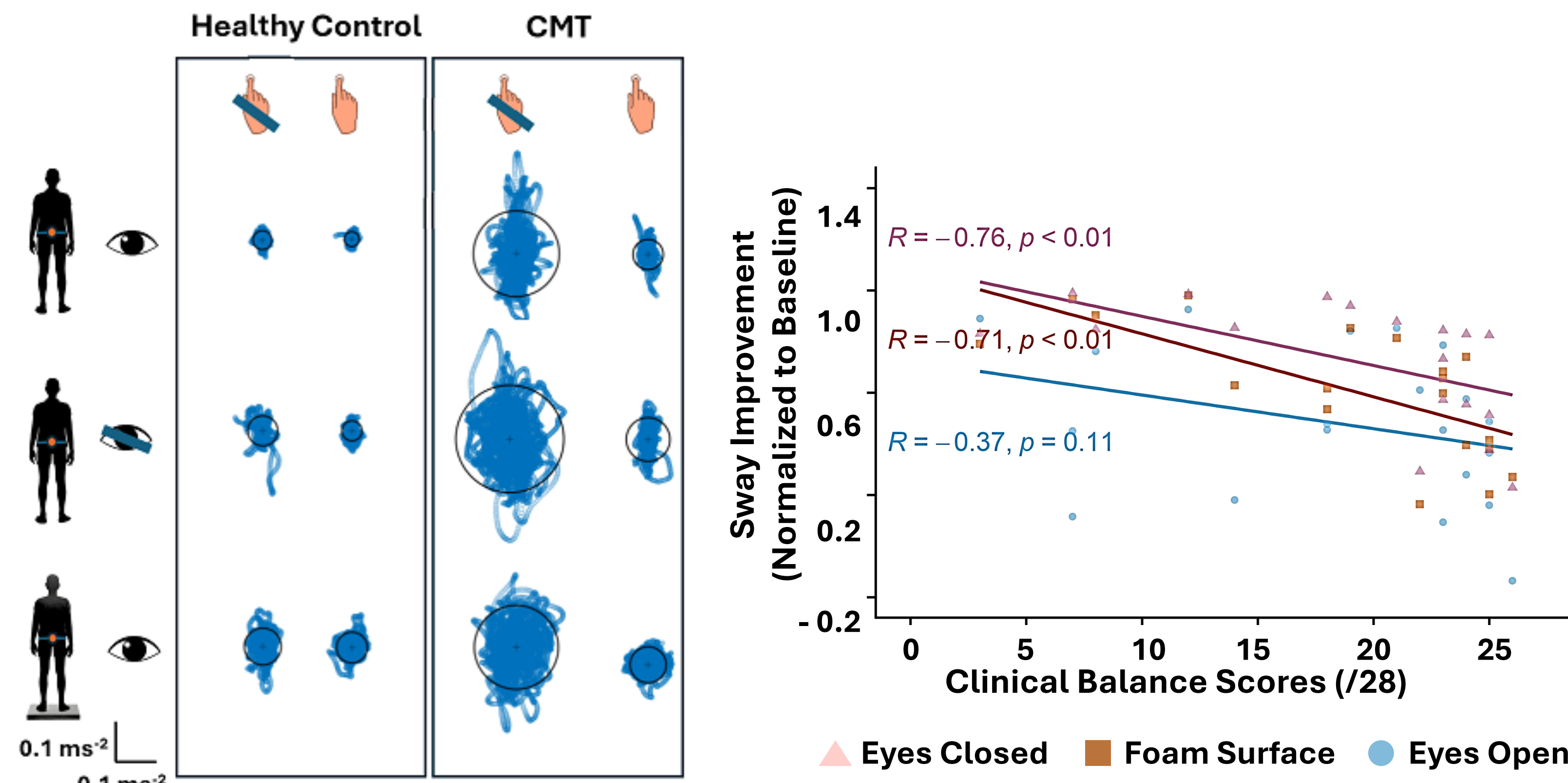


Figure 3. Representative postural sway trajectories (medio-lateral vs. antero-posterior acceleration) from two participants. Note: larger postural sway in CMT and the greatest improvement with light touch observed in CMT for eyes-closed and foam-surface conditions.

Figure 4. Spearman's Correlation Analysis. Greater improvements in postural sway associated with lower clinical balance (mini-BESTest) scores, especially during eyes-closed and foam-surface conditions.

Table 1. Sway area reported as median (IQR) across varying sensory conditions.

Sway Area (m ² /s ⁴)	Charcot-Marie-Tooth (CMT) [#]				Healthy Control (HC) [#]			
	N	No Touch	Touch	Effect size	N	No Touch	Touch	Effect size
Eyes Open	20	0.018 (0.035)	0.006 (0.007)	0.79*	22	0.005 (0.006)	0.003 (0.004)	0.48
Eyes Closed	18	0.081 (0.318)	0.009 (0.011)	0.88*	22	0.006 (0.007)	0.004 (0.004)	0.71*
Foam Surface	19	0.049 (0.083)	0.010 (0.014)	0.88*	22	0.010 (0.008)	0.007 (0.005)	0.68*

* touch vs no-touch condition; $p < .01$ # CMT vs HC for all conditions; $p < .01$

IV. CONCLUSION

- Individuals with CMT use additional sensory information from light fingertip touch to improve standing balance.
- Larger balance improvements with light fingertip touch are observed in those with poorer balance and under challenging sensory conditions.
- Clinicians should consider using sensory strategies for balance rehabilitation in individuals with CMT.
- Future work should focus on translating sensory feedback strategies to dynamic, real-world functional tasks.

REFERENCES

- [1] Williams et al., *Int. J. Ther. Rehabil.*, 25(1), 6–12, 2018
- [2] Horak. *Age Ageing*. 35 (2):ii7–ii11, 2006
- [3] Oates, et al. *Gait & posture*, 58, 232– 239, 2017
- [4] Mendez et al., *Comput. Methods Biomech. Biomed. Eng.*, 15, 899–910, 2012

