

Combining functional aging biomarkers and bioelectronic treatments to enhance multiple intrinsic capacity domains in older adults

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Massachusetts AI and Technology Center

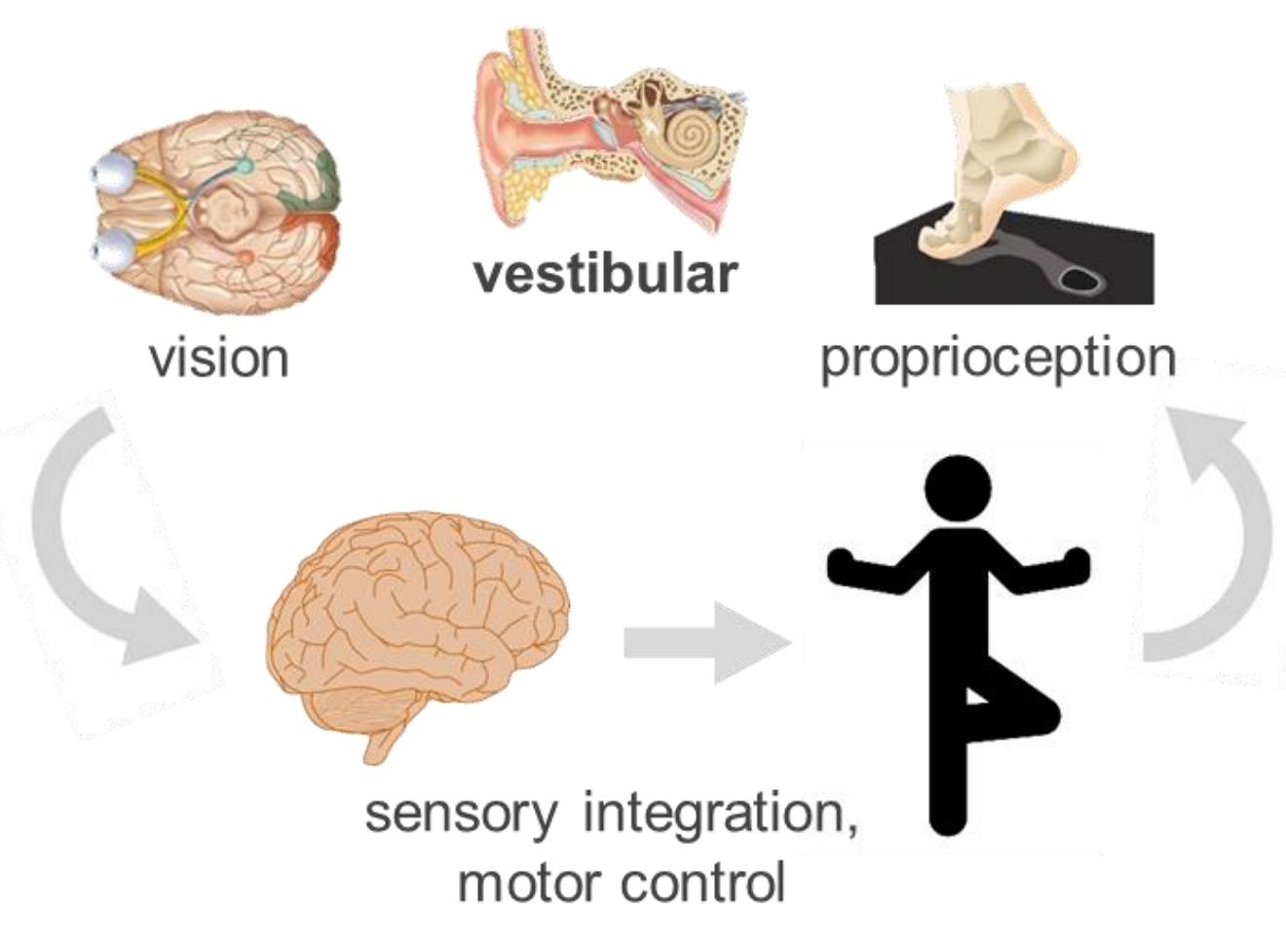
for Connected Care in Aging & Alzheimer's Disease

Digital Frontiers in Frailty: Opportunities for Early Detection and Clinical Action

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Age-Related Vestibular Balance/Mobility Decline

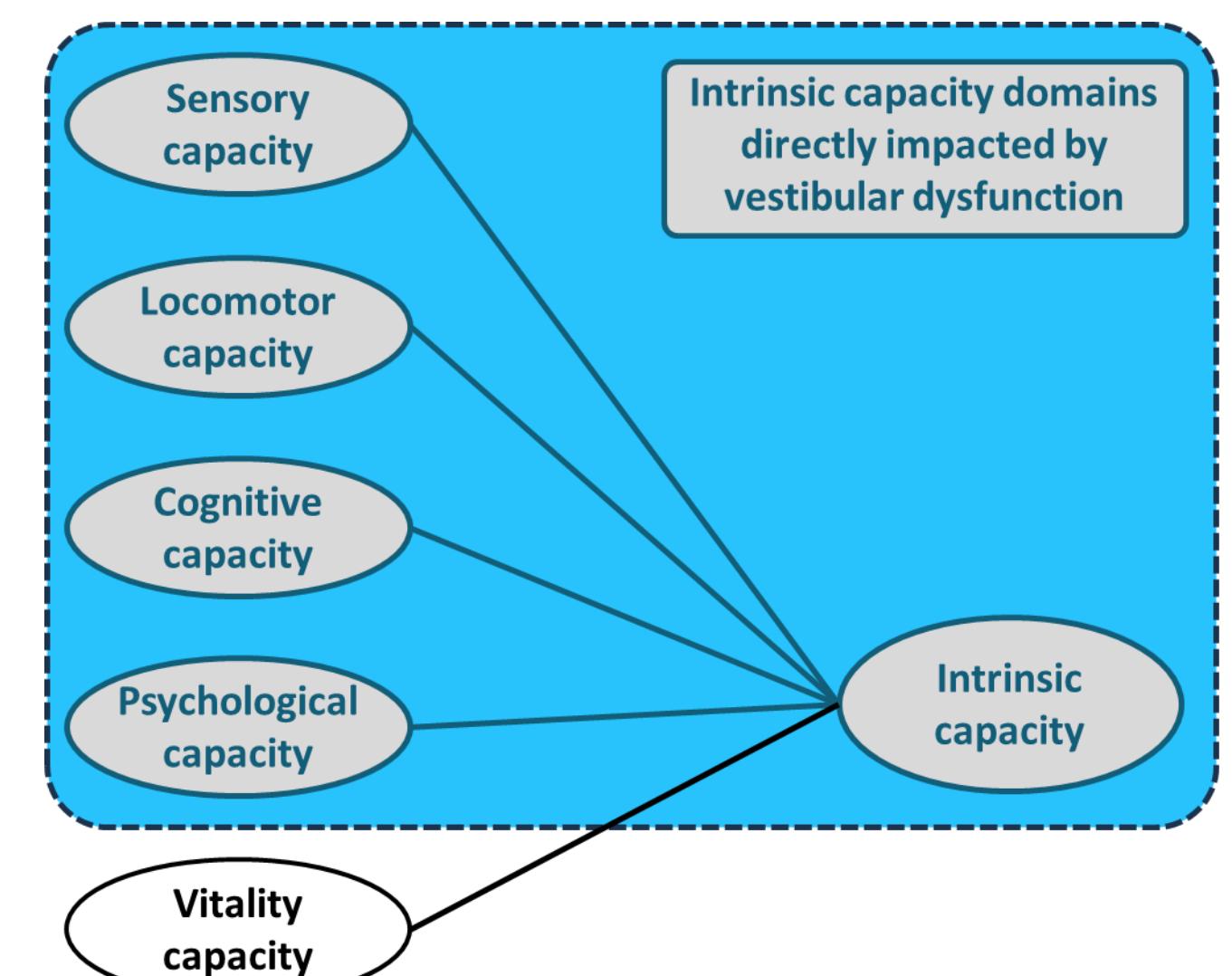
- Declining balance and mobility, or presbystasis [1], is one of the most visible, debilitating, and costly signs of aging
- Dysfunction of the vestibular balance organs in the inner ear, or presbyvestibulopathy [2], is the primary contributor to balance decline in more than 55% of adults over age 50 [3]
- 78 million people affected in Canada and U.S.
- \$300B economic impact [4,5]
- No easy-to-use tools or functional biomarkers exist to diagnose age-related vestibular changes
- Experimental high-risk surgical vestibular implants [6] remain the only available restorative treatment option



Introduction

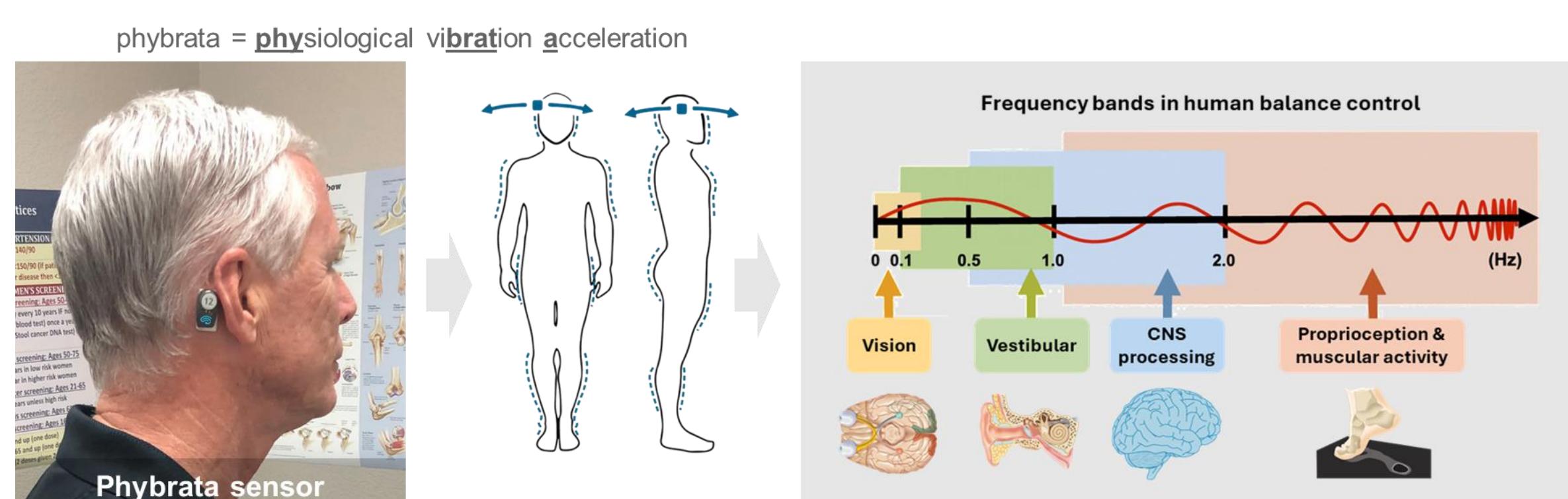
Impact on Intrinsic Capacity

- Research into aging has revealed underlying molecular and physiological mechanisms and identified promising biomarkers and potential interventions [7]
- Translating these findings into clinically effective longevity interventions that extend healthspan is lagging, with a lack of acute functional biomarkers that track age-related decline [8]
- Interventions that can turn back epigenetic clocks or reduce inflammatory markers are only a preliminary step towards enhancing key domains of intrinsic capacity [9]
- **Vestibular dysfunction triggers multi-domain downward spiral that impacts multiple domains of intrinsic capacity [10,11,12]**



1. Quantifying Balance System Impairments and Fall Risk with Phybrrata Sensor

- Phybrrata sensor detects and analyzes involuntary micro-movements of head and body during simple 2-minute balance and gait tests [13]
- Digital biomarkers derived from phybrrata data using ML models [14,15] quantify each person's (i) unique balance and gait profiles; (ii) impairments to sensory inputs, CNS processing for motor control; (iii) fall risk



- 516 participants aged 51 - 98 yrs (182 male, 334 female) in 4 residential senior living centers completed a questionnaire that included fall history in the past 6 months (170 participants reported falling one or more times)
- Phybrrata balance assessment data, fall risk biomarkers, and sensory reweighting biomarkers [15] compared for participants with no reported fall history and those reporting one or more falls in the past 6 months

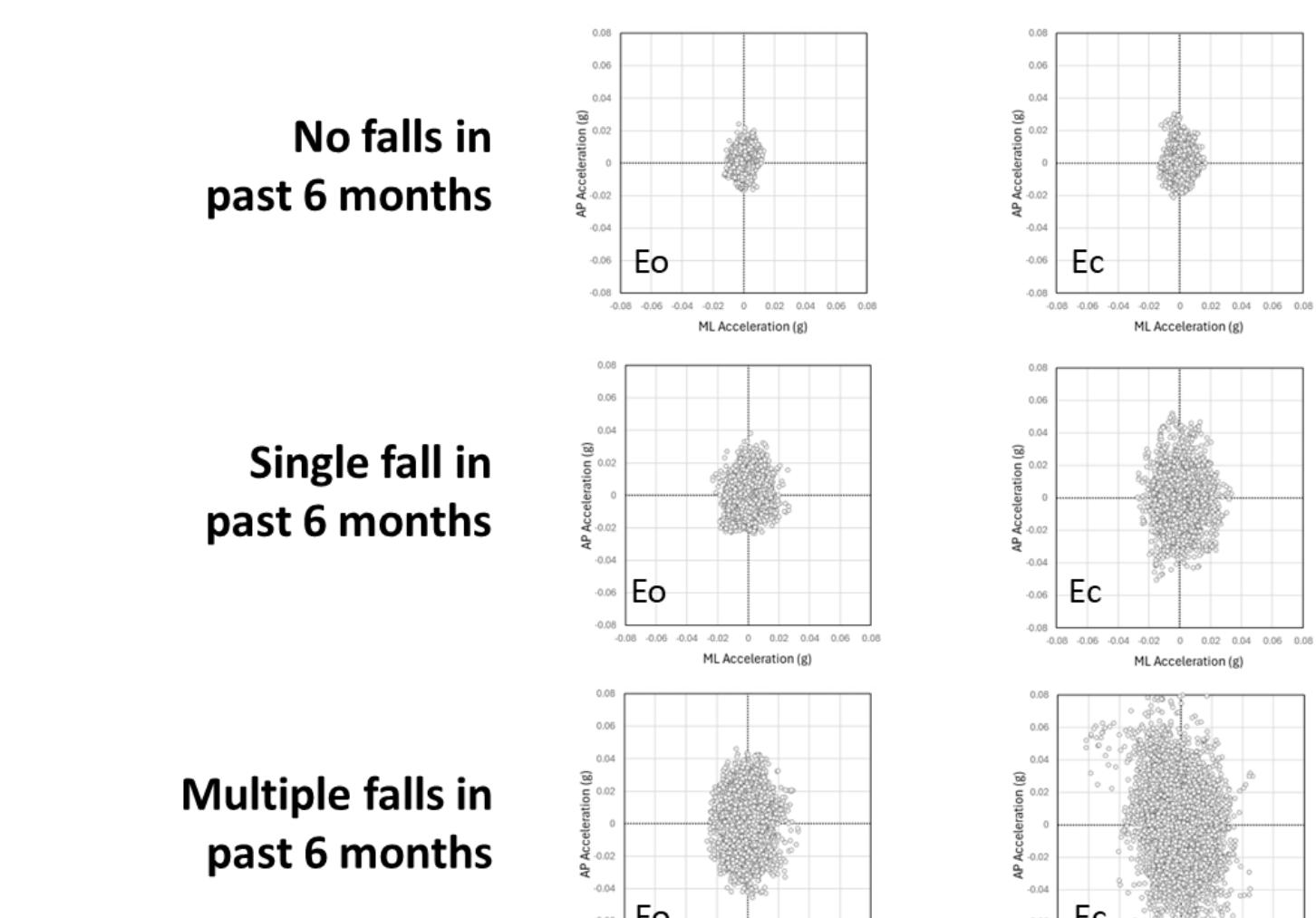
Methods

2. eVST Bioelectronic Balance Restoration Treatment Delivery in a Senior Living Community

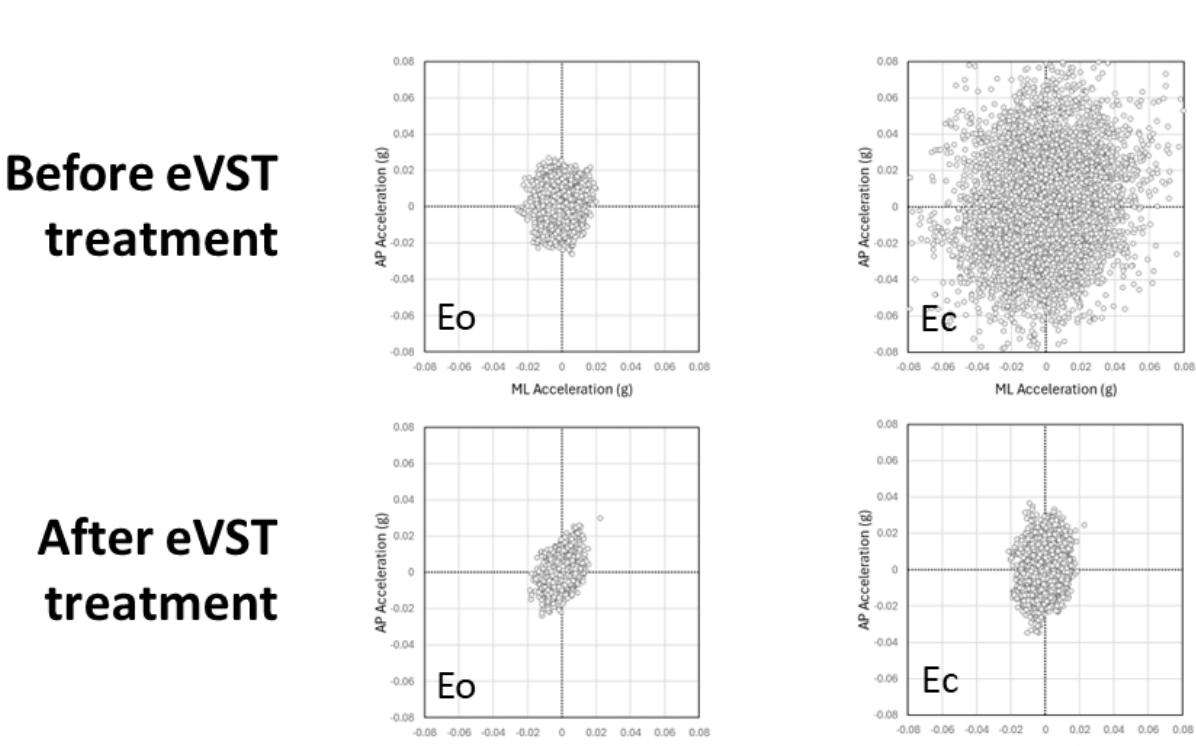
- Phybrrata sensor used to study responses to wide range of EVS waveforms, dosing regimens [16]. Led to discovery of unique class of "swsEVs" that activates long-lasting neuroplastic restoration of vestibular balance function [17]
- Enabled development of Neurvesta device and proprietary electrical vestibular stimulation therapy (eVST) protocol

- 32 residents aged 60 - 98 yrs (23 female, 9 male) from a continuing care retirement community administered 18-session eVST treatment protocol over a 4-6-week period by trained home care providers
- Balance performance, fall risk, and sensory reweighting biomarkers captured using phybrrata sensor
- Additional balance tests: (i) standing on 1 leg [18]; (ii) standing on foam pad with feet together, eyes closed [19]
- Gait performance measured using time-synchronized IMUs attached to shoes, waist, mastoid

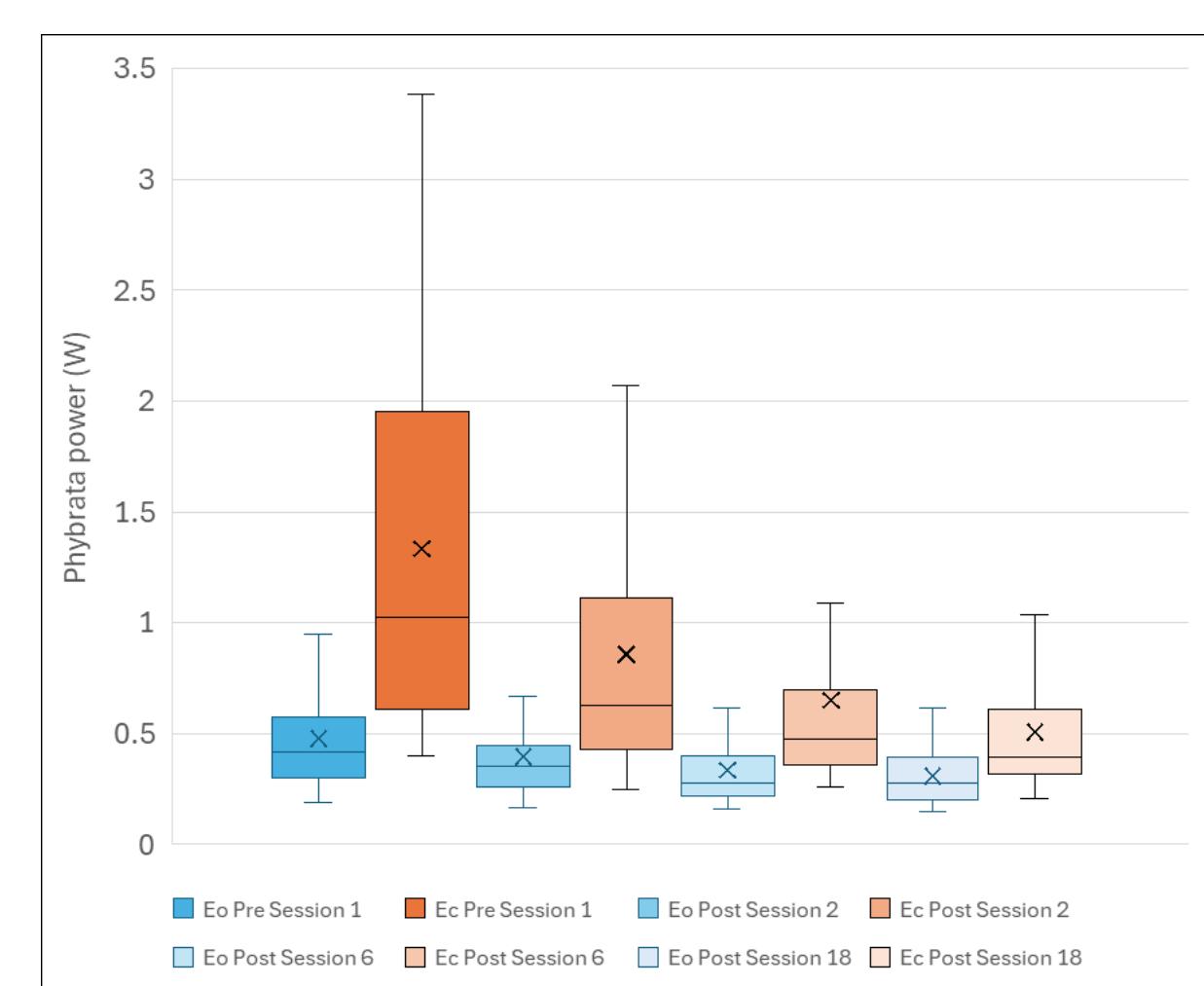
Results



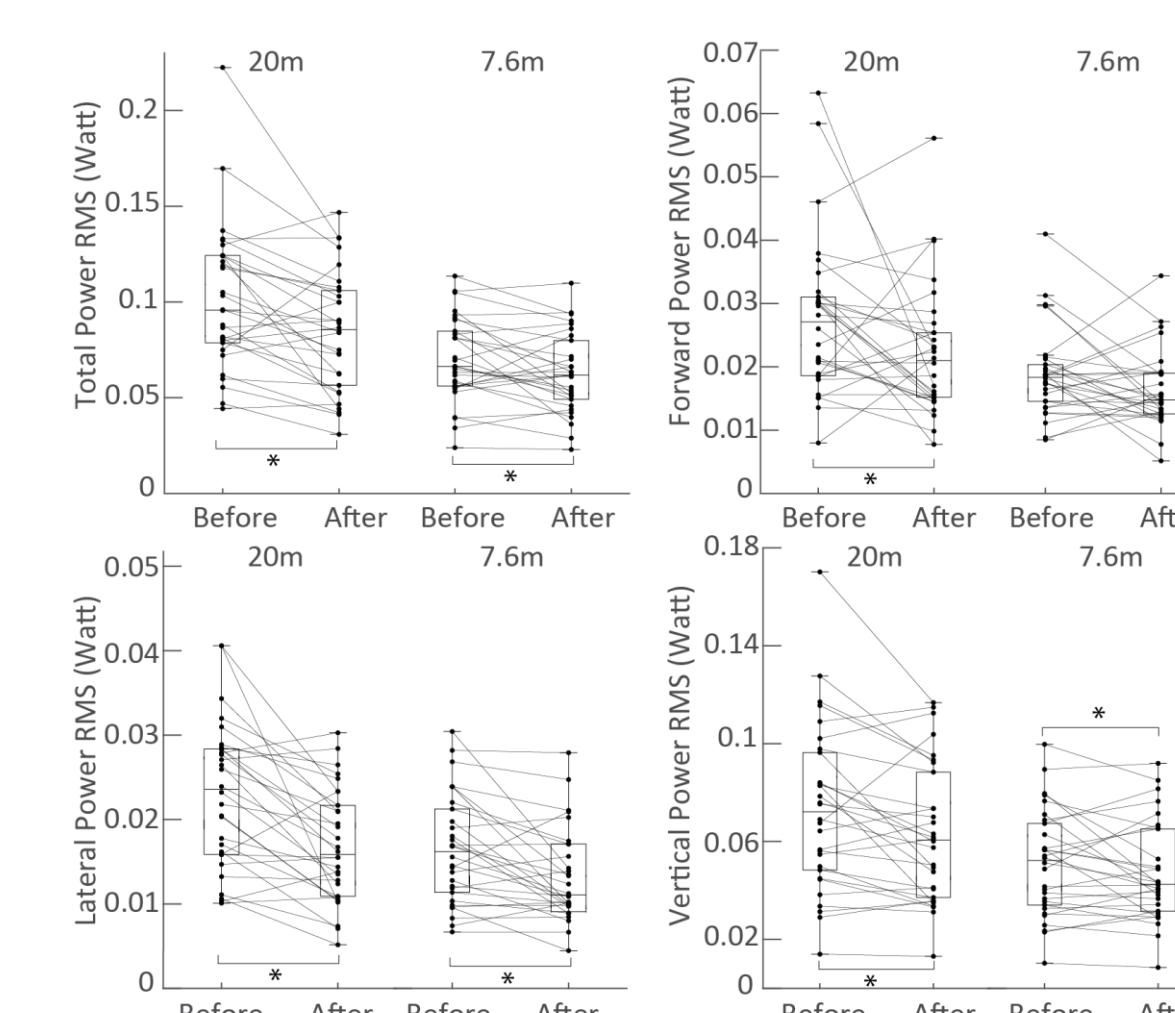
- 1 Phybrrata data quantify progressive age-related decrease in postural stability and increase in fall risk



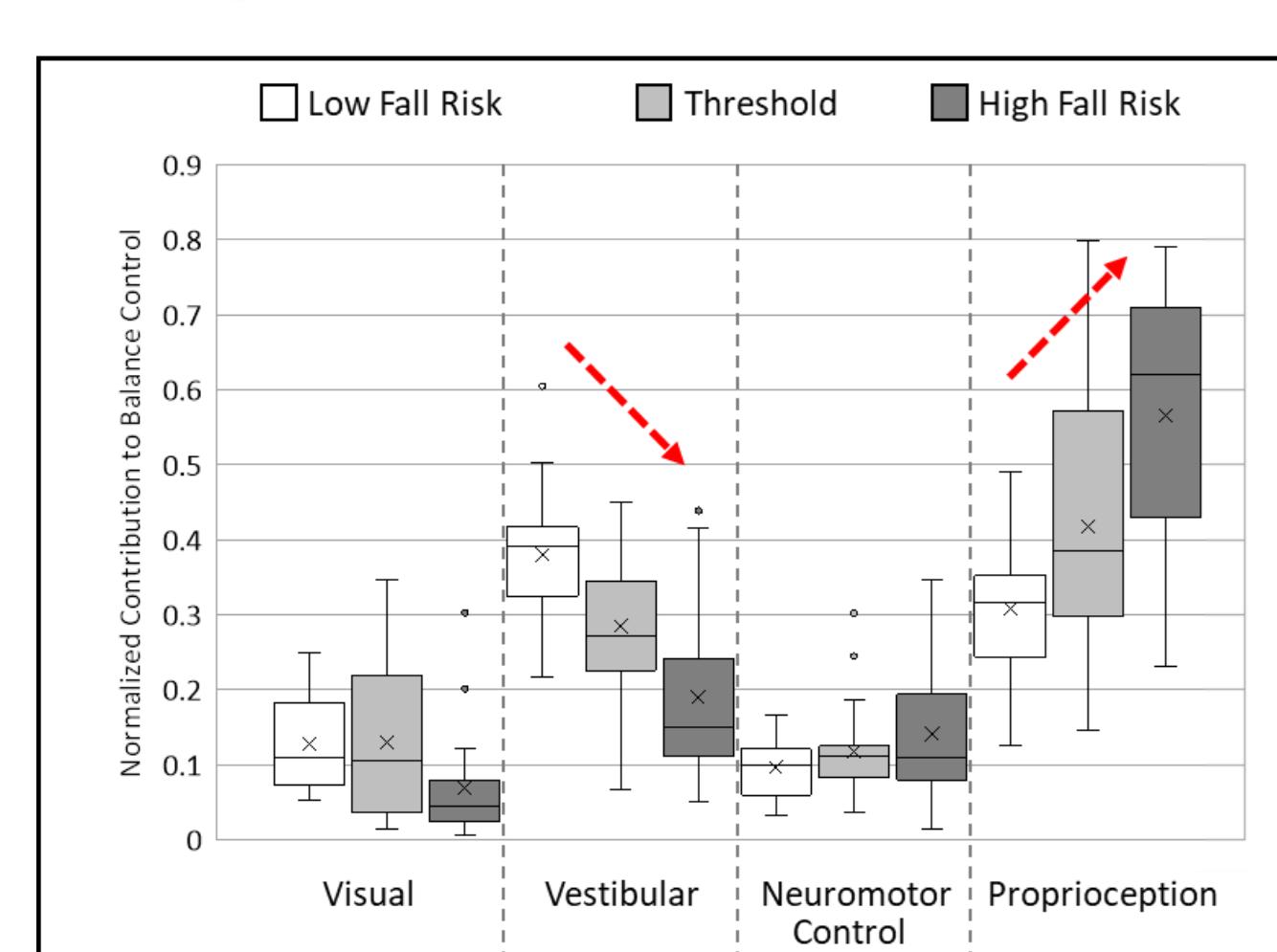
- 2 Phybrrata data quantify postural stability increase and fall risk decrease following eVST



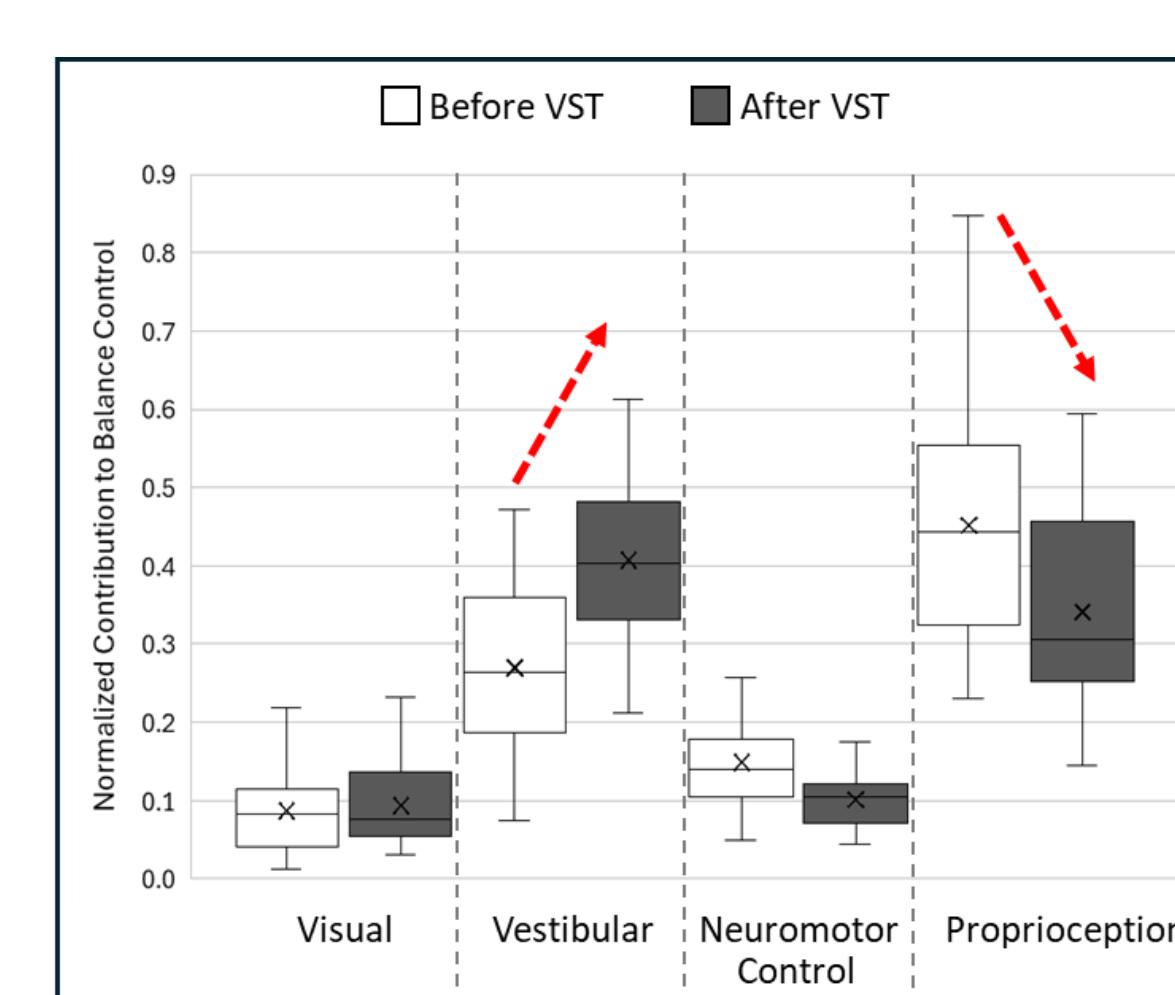
3 eVST balance restoration



4 eVST gait restoration



5 Age-related balance decline



6 eVST balance restoration



- 6 No specialized physical activity required during eVST, can be administered in very social group settings, leads to very high levels of adherence
- eVST uses stimulation current levels below perceptual threshold, very comfortable and well-tolerated
- Improved vestibular control, balance, and mobility allow patients to progress to more challenging physical therapy activities
- Increased cognitive function [20], increased dual-task capacity without instability
- Reduced fear of falling, greater willingness to engage, enhanced psychological well-being

Conclusions

- Phybrrata functional aging biomarkers have enabled the development of a non-invasive bioelectronic vestibular stimulation device and 6-week eVST treatment protocol that have been clinically validated to deliver large and persistent neuroplastic restoration of balance and mobility in study populations from 50-95 years of age
- Together, these technologies enable rapid diagnosis, targeted treatment, and long-term recovery across multiple intrinsic capacity domains — potentially transforming care for tens of millions of older adults

Restored vestibular function → decreased reliance on proprioception → improved balance, mobility → reduced fear of falling → increased cognitive reservoir → increased confidence, physical / social activity → increased psychological well-being

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