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Is standing sway an accurate measure of fall risk and predictor of future falls in older adults?

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ABBREVIATIONS
CoM center of mass
CoP center of pressure

In 1836, English physician Marshall Hall in his lectures on the nervous system posited that proprioception, vestibular function, and vision underlie postural control. In 1851, German physician Moritz Heinrich Romberg observed that patients suffering from tabes dorsalis lost their balance when they stood with eyes closed, giving rise to the Romberg test. In the 1880s, American neurologist Silas Weir Mitchell developed the first standing sway meter. This rudimentary device and the clinical observations over 180 years ago formed the neuromechanical basis of today's postural sway measurements during quiet standing tasks on a force platform used to 'measure' fall risk and 'predict' future falls.

Annually, 30-50% of adults age 65-90 experience a fall. Falls are the leading cause of fatal and non-fatal injuries and will result in 3M injuries, 27,000 deaths, and incur medical and social costs of ~$67B in 2020 in the USA. In Brazil and in many other countries, including the Netherlands, public healthcare reports reveal a trend toward increasing rates of fall-related morbidity and mortality among older adults. The most frequently declared causes of falls among the elderly being tripping, slipping, dizziness, and uneven flooring[1]. A massive international research effort is underway to identify accurate measures of fall risks and predict future falls. Such data could inform therapists to develop targeted interventions to reduce fall risks and delay a first-ever fall in older adults.

While the measurement of postural sway is relatively straightforward, it is challenging to establish a mechanistic link between the magnitude and velocity of postural sway and fall risk as well as future falls. Fundamental inconsistencies between studies complicate our current understanding and perhaps even the validity of postural sway during balancing tasks as a predictor of fall risk and future falls. In standing, muscles generate corrective moments to counteract gravity's pull but a putative role has been also assigned to the availability and accuracy of sensory information, sensory weighting, delays and gains of control loops, and system noise. Muscle moments shift the center of pressure (CoP) and control center of mass (CoM) movements, which, if 'too large' or 'variable', are presumably undesirable and should be limited by feedforward or feedback mechanisms. Like Romberg's ill patients with a lesioned dorsal column, healthy older adults also increase sway magnitude in standing with eyes closed. Nevertheless, older adults with a history of falls are able to modulate and reduce their postural sway when performing a visual-cognitive task (the adapted visual Stroop test)[2]. Heightening the conflicting data further are the observations that Parkinsonians often show less sway than healthy controls but are more fall prone. Then, there is no clear understanding of the source and meaning of postural sway. Some authors posit that sway is not even a valid measure of postural control with respect to fall prediction because metabolic costs increase with decreasing sway. From this perspective, the variable neuromuscular system optimizes in standing would not be CoP or CoM sway magnitude and variability but metabolic cost. It is also not possible to make inferences on the functionality of postural responses to perturbations because we cannot tell if the motor actions observed accelerate the CoM towards or away from the target state[3]. There is, then, the view assigning a beneficial, 'exploratory' role to a 'certain magnitude' of sway[4]. Thus, we cannot tell how much of sway is 'good' or 'bad' for estimating balance stability or its association with fall prevention. Our opinion resonates with the conclusion that the fall risk assessment tools, including standing sway CoP metrics, currently in use to test older adults, do not have sufficiently high predictive validity for differentiating high and low fall risks and to predict future falls on an individual level[5]. Falls also often occur in dynamic situations and rarely during quiet standing.

The future perspective is that age-related increase in balance sway magnitude could be a valid risk factor for falls and predict future falls if we could verify that sway magnitude or velocity in unperturbed standing were markers of neural and mechanical dysfunctions that also fail at the time of a fall. That is, we need to link sway outcomes, measured during standing under sensory challenges, to dysfunctions at the time of a fall. Until we have such data, it remains indeed difficult to explain why standing trials with eyes opened instead of eyes closed predicted future falls more accurately in 1,877 community-dwelling adults age 70[6] and why inexplicably both anterior-posterior and mediolateral CoP velocity predicted future falls[7,8]. We need to develop innovative experiments to understand the relationship between sensory acuity, sensory processing, sensory and motor noise, contractile properties of key muscles and standing sway and see if changes in these outcomes would reduce fall risks and prevent future falls[9]. There is also a need to complement the static CoP measures with dynamic ones, provided by moving platforms[10].

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