POSTURAL LOCAL DYNAMIC STABILITY IS NOT PREDICTIVE OF THAT DURING LOCOMOTION

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INTRODUCTION

Clinical measures of postural stability have been used to predict falls in the elderly with variable success. In particular, several do not predict falls that occur during walking well [1] and these constitute the majority of falls [2]. This could be because inherently different control mechanisms are used to maintain stability during standing and walking [3].

Prior studies comparing postural to locomotor stability [4,5] used different metrics for the different tasks and used metrics that were not *direct* measures of stability *itself*. We resolved these problems by using appropriately defined metrics to define *local dynamic stability* [6] in the same way for standing and walking. We hypothesized that standing stability would be different from walking stability and would not predict walking stability. We also validated our metrics for standing stability against traditional center of pressure (COP) measures.

METHODS

20 healthy subjects (age 18-73) performed three 5-min. trials walking on a motorized treadmill at their preferred speed, and three 5-min. trials standing eyes open on a force plate. Trunk motions were recorded using VICON and used to construct a 12-dimensional state space comprised of the 3D linear and angular trunk positions and velocities. Local dynamic stability was quantified using these trunk trajectories in the 12-D state spaces. The mean divergence over time $\langle d_j(i) \rangle$ of locally perturbed trajectories was calculated to quantify local dynamic stability [6,7]. Mean divergence curves were parameterized using a double exponential function (Equation 1):

$$\left\langle d_j(i) \right\rangle = A - B_S e^{-t/\tau_S} - B_L e^{-t/\tau_L} \qquad (1)$$

The parameters (A, B_S, τ_S, B_L, and τ_L) were averaged over the 3 trials of each task. A repeated measures ANOVA was used to determine if standing and walking exhibited different stability properties. Pearson correlations were used to determine if standing stability predicted walking stability. Correlations were also computed between standing stability metrics and traditional COP measures of standing balance: COP excursion, mean speed and mean power frequency (MPF).

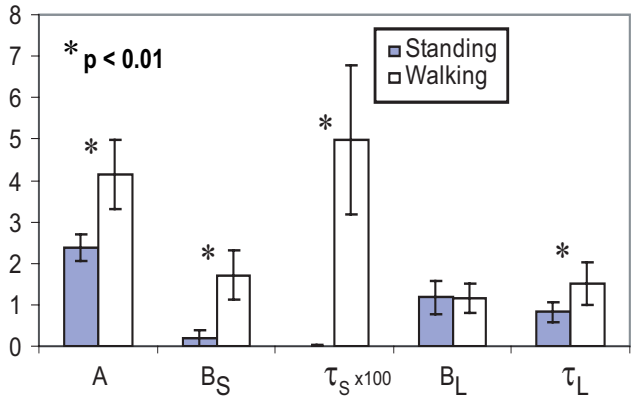

Figure 1: Magnitudes of all mean local divergence curve parameters except for B_L were significantly larger ($p < 0.01$) during walking than during standing.

RESULTS AND DISCUSSION

Local dynamic perturbation responses during standing and walking exhibited different magnitudes and different time scales (Figure 1). Furthermore, local stability metrics for standing were not correlated with those for walking (Figure 2). These results support the idea that postural and locomotor stability are indeed governed by different mechanisms.

COP mean speed and MPF were significantly correlated to A and B_L for standing ($r^2 > 47\%$; $p < 0.001$). Thus, our local dynamic stability metrics are consistent with traditional COP measures for standing balance. None of the COP measures were correlated to any of the local stability metrics for walking ($r^2 < 14\%$; $p > 0.12$). These findings support the notion that traditional postural stability measures based on COP measurements are not predictive of locomotor stability.

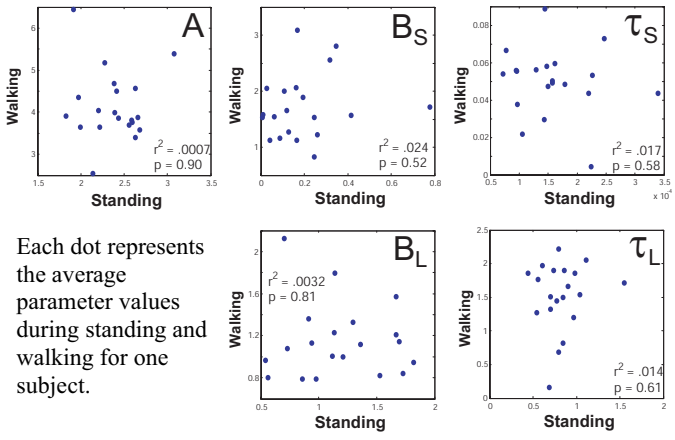

Figure 2: Local dynamic stability of standing did not predict local dynamic stability of walking ($r^2 < 2.5\%$; $p > 0.50$).

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