POSTURAL STIFFNESS MODEL AND DUAL TASK IN OLDER ADULTS: THE MOBILIZE BOSTON STUDY

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INTRODUCTION

Cognitive distractions that divert attentional resources seem to impair postural control, and thus may increase fall risk. However, the mechanism by which dual-task affects postural sway or fall risk is not clear, as inconsistent effects have been reported [1]. Standing posture is hypothesized to be controlled through maintaining postural stiffness and damping [2], which represent muscle tone, reflexes, and anticipatory control. During dual task, the lack of attentional resources may lead to the inability to maintain adequate muscle tone to maintain upright standing, reducing postural stiffness, and would increase sway. We tested the effect of dual task on postural stiffness, damping and sway in a representative sample of community-dwelling older adults.

METHODS

The MOBILIZE Boston Study (MBS), which stands for "Maintenance of Balance, Independent Living, Intellect, and Zest in the Elderly of Boston" is a prospective study examining risk factors for falls, including pain, cerebral hypoperfusion, and foot disorders in the older population [3]. The study includes a representative population sample of 765 elderly volunteers age 70 or above from the Boston area. Center of pressure (COP) data were available in 725 participants, who were 77.9±5.3 years old, with height of 1.63±0.10 m and weight of 74.1±19.7 kg. 64% were female.

Subjects stood barefoot with eyes open on a force platform (Kistler 9286AA). The center of pressure (COP) data were sampled at 240 Hz in anteroposterior (AP) and mediolateral (ML) directions. Subjects performed two sets of five quiet standing trials, 30 seconds each. One set included a serial subtractions from 500 by 3 task (S3 task).

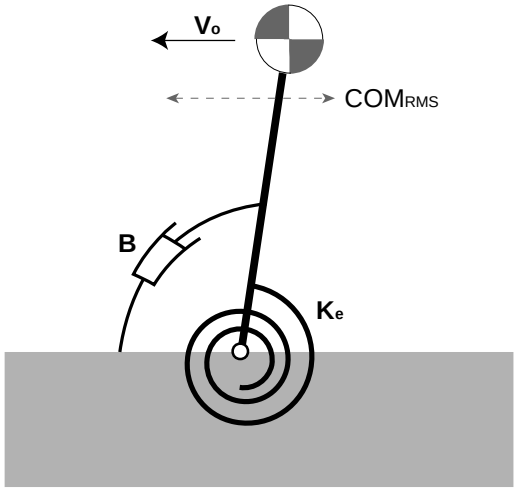

Figure 1. Inverted pendulum model of quiet standing. Its dynamics can be described using stiffness K_e, damping B, RMS amplitude of the COM, and the pendulum velocity at vertical V_o.

Postural stiffness was calculated as previously described [2], where the postural system is modeled as an inverted pendulum with stiffness and damping. Movement of center of mass (COM) was estimated. Fourier transform of the difference between COP and COM was fit to a damped oscillator model to determine K_e (stiffness) and B (damping). Velocity of the inverted pendulum at vertical V_o was also calculated. RMS amplitudes for COP and COM (COP_{rms}, COM_{rms}) K_e, B, and V_o values were determined for each trial using MATLAB 7.4. Because 39% of the subjects had difficulty performing the S3 task (≥5 errors), the subjects were divided into two groups (S3 pass vs. S3 fail groups). The effect of dual task on the parameters was assessed using mixed-model ANOVA (SAS 9.1).

RESULTS AND DISCUSSION

Sway amplitudes and *B* increased with the dual task (Figures 2, 3). V_o increased only in AP direction. K_e decreased only in ML. Yet the S3-fail group increased K_e in AP direction (Figure 2). The S3 task could still independently explain increases in COM_{rms} ($p \leq 0.005$) after including V_o or K_e as a covariate. Thus changes in V_o or K_e did not fully explain increase in sway due to dual task.

Reduction in stiffness in the ML direction may mean a decrease in postural tone. The brain may be prioritizing the maintenance of postural tone in AP direction given the limited attentional resources because the feet may provide "free" stability in ML but not in AP direction. The inverted pendulum model did not fully explain the increase of sway with the dual task. A more sophisticated model of postural control may better explain the role of attention.

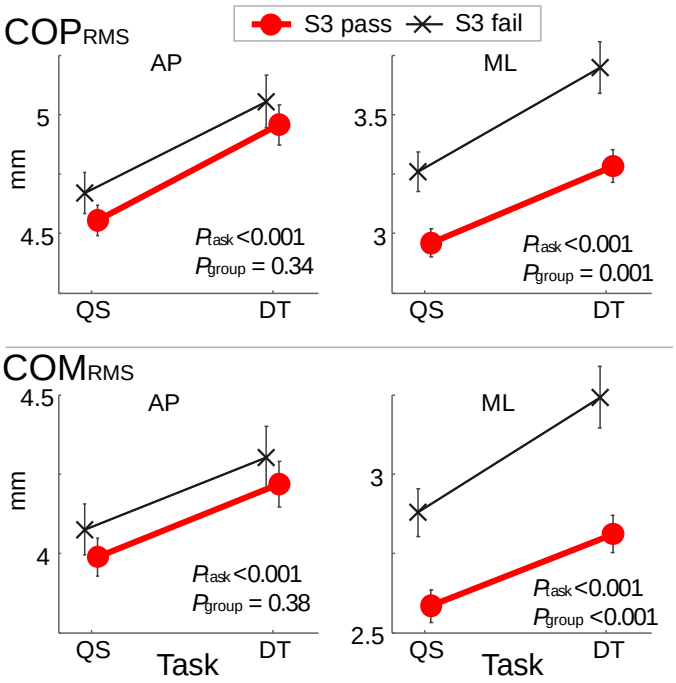

Figure 2: Postural sway (**COP_{RMS}** and **COM_{RMS}**) increased when performing the dual task.

CONCLUSIONS

In community-dwelling older adults, serial subtractions dual-task led to increased sway amplitude and damping. Postural stiffness in the ML direction decreased with dual task, but increased in the AP direction in those who could not perform the S3 task. Changes in stiffness or pendulum velocity did not fully explain the changes in sway. The lumped-parameter model did not fully explain the increase of sway with the dual task.

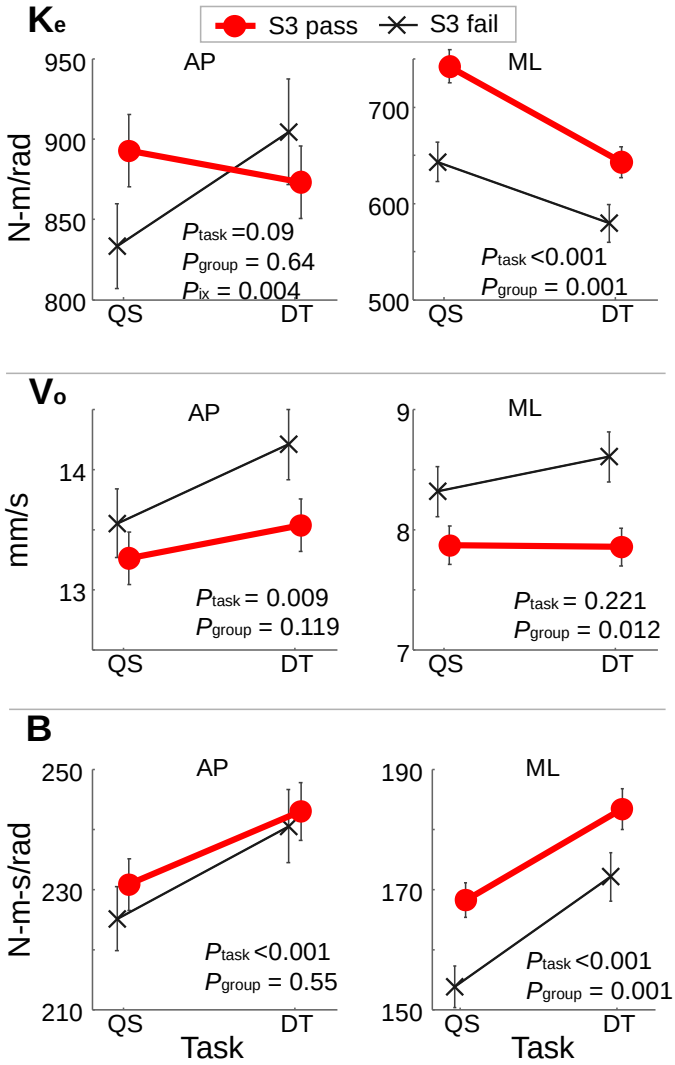

Figure 3. **K_e** increased only in the S3-fail group in AP, and decreased only in ML direction with dual task. **V_o** increased only in the AP direction with dual task. Group differences were found only in ML direction. Damping increased with dual task.

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