POSTURAL STABILITY IN THE YOUNG AND ELDERLY AS A CONSEQUENCE OF PERTURBATIONS

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INTRODUCTION

The elderly are the most rapidly increasing proportion of society (Fuller, 2000). A major problem confronting this cohort is their susceptibility to falls (Jantti et al., 1995). A number of studies have demonstrated a link between postural stability in quiet standing and the ability to avoid falls (e.g., Fernie et al., 1982; Wolfson et al., 1985). During upright stance the maintenance of balance can become problematic, particularly for the elderly, if a simultaneous cognitive task is performed (Rankin et al., 2000). Given that in many everyday activities postural perturbations occur while also performing a cognitive task, understanding more about the response under such conditions is important.

The purpose of this study was to examine stability in both young and older subjects when postural perturbations are combined with a cognitive task. In particular the focus was on how long it takes to re-establish stability after a postural perturbation.

METHODS

Two groups of 10 subjects were recruited for this study, a young group between the ages of 21 and 25 years old (age - 22.50 ± 1.35 years; height - 1.70 ± 0.10 m; mass - 70.86 ± 8.33 kg), and a young-old group between the ages of 65 and 73 years old (age - 69.8 ± 3.05 years; height - 1.67 ± 0.12 m; mass - 66.36 ± 13.6 kg). All subjects provided informed consent. Subjects were medically screened to ensure they had no medical problems which could affect their balance.

Subjects performed three trials of four different standing tasks. They adopted the same standardized foot position for all trials on a force plate (Kistler, Model 9287A), from which center of pressure (COP) data were sampled at 500 Hz. The tasks were quiet standing (task 1), a mechanical perturbation achieved by dropping a 1 kg mass (task 2), a cognitive perturbation achieved by performing mental arithmetic (task 3), and finally a task which combined both a mechanical and cognitive perturbation (task 4). The specific conditions for each task were,
Task 1 **–**quiet standing on a force plate for 30 seconds.
Task 2 - quiet standing on a force plate while holding a mass (1.0 kg) at arms length for 20 seconds then on a signal dropping the mass and maintaining balance for a subsequent 40 seconds (Perturbation Task).
Task 3 **–** as task 1, but during the task counting backward from 100 in jumps of 3 for 30 seconds (Cognitive Task).
Task 4 **–** as task 2, but during the task counting backwards from 100 in jumps of 3 (Perturbation and Cognitive Task)

For tasks 1 and 3 the motion of the COP was quantified in the anterior posterior direction by computing its standard deviation, and range of motion. For tasks 2 and 4 the motion of the COP in the anterior posterior direction, after mass release, was quantified by computing its range of motion, peak velocity, and time to stability. Time to stability was defined as the time to that instant at which the absolute velocity of the COP was maintained below a criterion value. The criterion value was the mean plus four times the standard deviation of the absolute velocity of the COP during task 1. Repeat measures analysis of variance was used to examine differences between the two groups, and the tasks ($\alpha = 0.05$).

RESULTS AND DISCUSSION

During quiet standing, task 1, there was no statistically significant difference between the two groups of subjects for the measured parameters. This lack of a difference persisted when the subjects were asked to simultaneously perform a cognitive task. There were statistically significant changes in the COP motion for both groups when the cognitive activity was added to quiet standing. These results indicate that the populations studied responded similarly for these two tasks.

After release of a mass, task 2, the young-old group demonstrated greater peak velocity compared with the young, but had similar COP ranges of motion, and times to obtain a stable stance. When a cognitive challenge was added (task 4), the young-old had a statistically significant different peak velocities, and greater times to stability than the young group. Time to stability was statistically greater for both subject groups for task 4 compared with task 2.

These results indicate that older subjects are more influenced during quiet standing by perturbations to their stability if they are also performing a cognitive task. When there are simultaneous physical and cognitive challenges it takes much longer for the young-old subjects to return to a stable posture. The time duration for this re-establishment of normal levels of postural stability (30 seconds) may be the source of guidelines for the elderly when being advised about recovering from perturbations. It would be interesting to examine the effect of another perturbation during this period of regaining stability. These results will be of interest to clinicians interested in establishing 'biomarkers' of diminished motor control in the elderly.

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Table 1: Mean ± standard deviation of metrics of the COP motion for the different tasks.

Variable	Task 1		Task 3	
	Young	**Young-Old**	**Young**	**Young-Old**
Standard Deviation (mm)	5.2 ± 2.3	4.3 ± 2.26	6.1 ± 2.1	6.5 ± 2.4
Range of Motion (mm)	15.5 ± 7.0	9.4 ± 4.5	33.9 ± 12.5	32.5 ± 11.5
	Task 2		**Task 4**	
	Young	**Young-Old**	**Young**	**Young-Old**
Range of Motion (mm)	37.3 ± 18.5	46.8 ± 15.0	31.5 ± 12.1	41.2 ± 14.7
Peak Velocity (mm/s)	81.0 ± 36.9	162.4 ± 94.8	72.1 ± 29.4	114.1 ± 54.8
Time to Stability (s)	20.2 ± 11.2	19.6 ± 13.0	21.3 ± 10.0	30.1 ± 10.9