Dual-task interference during obstacle clearance in healthy and balance-impaired older adults

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ABSTRACT. Background and aims: To investigate dual-task interference between a concurrent cognitive task (auditory Stroop test) and obstacle avoidance in older adults with or without a history of falls. Methods: Gait performance (temporal-distance parameters, range of motion and peak velocity of the center of mass) and verbal reaction time (VRT) in the secondary auditory Stroop task were monitored in 12 healthy young adults, 12 healthy older adults and 12 balance impaired older adults (BIOA) while they sat or walked with and without an obstacle in their path. VRT was used as an indicator of attention given to the secondary Stroop task. Results: Under dual-task situations, all older participants reduced their gait velocity, taking longer strides and wider steps. BIOA significantly increased toe clearance of their trailing limb during obstacle avoidance. In all participants, cognitive attention to the Stroop task, as measured by VRT, was diminished as the level of difficulty in the activity increased; however, the effect was blunted in BIOA compared to healthy subjects. Conclusions: Performing two tasks was highly inefficient among BIOA, as their performance in the gait and secondary task were both modified under dual-task situations. It is possible that dual-task interference in BIOA may be due to the inability to shift attention between the two tasks without primarily prioritizing gait. The findings suggest that BIOA should perform one task at a time in daily activities in order to reduce the risk of falling. (Aging Clin Exp Res 2008; 20: 349-354)

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INTRODUCTION

Previous research in balance-impaired participants has shown that the ability to recover stability after external perturbations is greatly decreased under dual-task conditions (1, 2). An inability to recover from disturbances during gait may account for the majority of falls in balance-impaired older adults (BIOA) (3, 4). Since many falls occur while simultaneously walking and performing a secondary task (such as engaging in conversation or carrying an object) (5-7), examining the attentional demands of secondary tasks on balance control in gait is a critical research area.

Studies have found that, compared to young adults, healthy older adults demonstrate a reduction in the ability to efficiently perform a gait and cognitive task simultaneously (8, 9). BIOA either stopped (10) or required a longer time to complete a gait task with an additional secondary task (11). While recent research has begun to explore age-related changes in the ability of older adults to perform balance tasks, only a few studies were conducted to examine their ability to step over an obstacle under dual-task conditions (12-14). Those studies found that obstacle avoidance was degraded in older adults when their attention was distracted by a secondary task. However, those research findings were limited to healthy populations.

In fact, trips or slips during obstacle avoidance are one of the most common reasons for falls among older adults (15); no one has characterized the ability to maintain and recover stability during perturbed locomotion (for example, obstacle avoidance tasks) in older adults with balance impairments under dual-task conditions. The purposes of this study were to examine the attentional demands of postural control in young, older adults and elderly fallers during obstacle crossing and to better understand the dual-task interference in different postural tasks (seated, level walking and obstacle avoidance) in BIOA. It was hypothesized that attentional demands of postural control would be much greater in fallers than healthy adults during obstacle avoidance. It was predicted that a greater impact on gait performance would be found for BIOA, compared to young and healthy older adults.

Key words: Aging, attention, dual-task, falls, gait.

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Received October 25, 2006; accepted in revised form July 7, 2007.

Aging Clin Exp Res, Vol. 20, No. 4 349
of two steps was calculated from the joint center between the ankles at heel strike. Gait velocity was calculated from the time and position change of the COM.

Ground reaction forces and moments were collected by two in series force plates (Advanced Mechanical Technologies Inc. Watertown, MA) with a sampling rate of 960 Hz. A lightweight PVC pipe crossbar was used as an obstacle set at 10% of the participant’s body height. For obstacle-crossing trials, the toe-obstacle clearances (TOC) for the trailing and leading limbs were determined from the vertical position of the toe marker. All elderly participants wore a safety harness to prevent injury from accidental falls.

Verbal responses to the Stroop task were recorded through a microphone (AKG Acoustics, Vienna, Austria). The four photocells (RadioShack, Fort Worth, TX) and walkway are shown in Figure 1. The first photocell served as the trigger for initiating the Stroop task program and the other three photocells were placed to randomly trigger a Stroop stimulus at heel strike before and after obstacle crossing and during swing phase of the gait cycle. Analog signals from force plates, the Stroop stimulus and microphone recordings were collected at 960 Hz.

**Experimental design**

Testing began with eight seated Stroop trials. Motion data collection started with four single task trials (two for level-walking and two for obstacle-crossing conditions) at a comfortable self-selected pace. Dual-task conditions were then performed with the auditory Stroop test during either level walking or obstacle crossing. Location of the auditory stimulus presentation was randomized across trials, except during randomly dispersed catch trials (5%) with no stimulus. Vision was occluded prior to each trial so that the participant could not preprocess the information about the type of walking condition for that trial. Finally, another set of four single task trials (two for

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**METHODS**

**Participants**

Prior to testing, each participant signed informed consent approved by the University of Oregon Institutional Review Board. Twelve healthy young adults (HYA) (age 22.8±2.7), 12 healthy elderly adults (HOA) (age 74.1±5.0) and 12 BIOA (age 81.0±4.5) were recruited. Percentage of women in HOA and BIOA groups were 75 and 66.7%, respectively. All elderly participants had no history of neurological or musculoskeletal deficits that might contribute to instability and falls. All BIOA were greater than 65 years of age, lived independently in the community, had confirmed balance control complications on the Berg Balance Scale (score <52, out of a total of 56) (16), and self-reported one or more falls in the previous 12 months.

**Auditory Stroop test**

The Stroop task itself consisted of the recorded words “high” or “low” spoken with a high or low pitch. Congruency between pitch and the word was randomized. The participant was to verbally respond the pitch of the voice as quickly and accurately as possible. Accuracy and reaction times were recorded during each trial. Verbal reaction times (VRT) during Stroop tasks were calculated from the time difference between Stroop stimulus onset and the onset of the verbal response. Differences in VRT between congruent and incongruent conditions were used to calculate the congruency effect. The auditory Stroop task was implemented by SuperLab Pro v.2 (Cedrus, San Pedro, CA), with stimuli relayed via two speakers.

**Experimental apparatus**

All data with 3D marker trajectories were collected by an eight-camera motion analysis system (MotionAnalysis, Santa Rosa, CA) with a sampling rate of 60 Hz in the Motion Analysis Laboratory of the University of Oregon. Twenty-nine retro-reflective markers were placed bilaterally on bony landmarks of the body similar to previously validated marker setups (17). EVaRT 4.4 (MotionAnalysis, Santa Rosa, CA) was used to track the markers in space. Virtual markers were created at joint centers and combined with anthropometric data to determine the center of mass (COM) locations for each of thirteen body segments (18). The whole-body COM was then calculated from each segment COM with a weighted sum method (18). The velocity of the COM was estimated with the use of Woltring’s generalized cross-validated spline algorithm (19).

Stride length and stride time were determined from the position change of the heel marker. Average step width