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Age-associated differences in global and segmental control during dual-task walking under sub-optimal sensory conditions

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ABSTRACT

The ability to safely perform cognitive-motor dual-tasks is critical for independence of older adults. We compared age-associated differences in global and segmental control during dual-task walking in sub-optimal sensory conditions. Thirteen young (YA) and 13 healthy older (OA) adults walked a straight pathway with cognitive dual-task of walking-while-talking (WT) or no-WT under four sensory conditions. On randomly selected trials, visual and vestibular inputs were manipulated using blurring goggles (BV) and Galvanic Vestibular Stimulation (GVS), respectively. Gait speed decreased more in YA than OA during WT. Gait speed increased with GVS with normal vision but not BV. Step length considerably decreased with WT. Trunk roll significantly decreased only in OA with GVS in WT. Head roll significantly decreased with GVS regardless of age. Results indicate GVS-induced adaptations were dependent on available visual information. YA reduced their gait speed more than OA to achieve a similar pace to safely perform WT. GVS resulted in both age-groups to reduce head movement. However, with the addition of WT during GVS, OA also stiffened their trunk. Therefore, with increased attentional demands healthy OA employed different compensatory strategies than YA to maintain postural control.

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1. Introduction

Performance on cognitive-motor dual-tasks requires dividing attentional resources and deteriorates with increasing age (Woollacott & Shumway-Cook, 2002; Yogev-Seligmann, Hausdorff, & Giladi, 2008). Previous research has shown that dual-task walking results in cautious adaptations to gait (Al-Yahya et al., 2011; Beauchet et al., 2009; Plummer-D'Amato et al., 2012). In isolation, adaptations in gait parameters have also been documented under sub-optimal sensory conditions (Deshpande & Patla, 2005, 2007). The possibility of performing dual-task walking under sub-optimal sensory conditions can be presented in the natural environment and may severely impact postural control of older adults.

The execution of dual-task walking has been shown to have a detrimental effect on gait parameters in healthy adults of all ages, however, greater effects are often seen in older adults (Amboni, Barone, & Hausdorff, 2013; Hollman, Kovash, Kubik, & Lindo, 2007). This may be attributed to physiological changes that occur with aging in the prefrontal areas of the brain which can lead to reduced processing speed and an inability to quickly integrate sensory information from individual sensory systems (Grady & Craik, 2000; Mozolic, Hugenschmidt, Peiffer, & Laurienti, 2012). Changes in gait parameters that have been documented with dual-task performance include reduced gait speed, decreased step length, increased step width and increased step variability (Hausdorff, Schweiger, Herman, Yogev-Seligmann, & Giladi, 2008; Hollman et al., 2007; Verghese et al., 2007). The impact on axial segmental control has not been studied as rigorously. Precision in trunk control is critical for stable performance as it is the heaviest and largest body segment (Winter, 1995). Two studies could be cited that demonstrated reduced trunk control under challenging dual-task conditions, with greater declines in the frontal than sagittal plane (Al-Yahya et al., 2009; Asai, Misu, Doi, Yamada, & Ando, 2014). Specifically, these studies found that walking while performing a secondary cognitive task significantly increased center of mass displacement (Al-Yahya et al., 2009) and resulted in greater trunk oscillations (Asai, Doi, Hirata, & Ando, 2013) in the medio-lateral direction. Further, head stabilization in space is important as it helps to stabilize gaze and may possibly improve interpretation of vestibular inputs for overall postural control (Cattaneo, Ferrarin, Frasson, & Casiraghi, 2005). However, no study could be cited that has investigated age-associated differences in head and trunk control under dual-task task conditions.

Sensory function and the ability for the central nervous system to reweight sensory information are also known to decline with age (Maki & McIlroy, 1996; Rosso et al., 2013). In older adults the visual system is dominantly used to provide feedback on the location of the body in space to judge distances and plan motor responses (Rossignol, 1996). The vestibular system provides information about gravitational vertical and about changes in movement with respect to the head (Bent, McFadyen, & Inglis, 2005). Our previous work has shown that the ability to reweight sub-optimal vestibular inputs while walking is affected in older adults despite the availability of normal vision (Deshpande & Patla, 2007; Deshpande & Zhang, 2014). Further, the central nervous system has a limited capacity to process information and increased attentional demands have been shown to impair the ability for the central nervous system to reweight sensory inputs (Teasdale & Simoneau, 2001). However, the effect of aging on the ability for the central nervous system to reweight sensory inputs during dual-task walking has not yet been investigated. Therefore, the purpose of this study was to investigate age-associated differences in the effect of sub-optimal sensory information on trunk and head control during dual-task walking. It was hypothesized that older adults would show greater deterioration in the ability to reweight sensory inputs to control both the head and trunk segments during dual-task walking when compared to young adults due to increased attentional demands of the secondary cognitive task.

2. Methods

2.1. Participants

Thirteen young (YA age: 25.1 ± 2.7 years; 6 women) and 13 healthy older (OA, age: 74.0 ± 4.8 years; 6 women) adults participated in this study. All participants were physically active community