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The effects of dual-tasking on arm muscle responses in young and older adults

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ABSTRACT

This study examined whether dual-tasking affects an individual's ability to generate arm muscle responses following a loss of balance. Nineteen young and 16 older adults recovered their balance in response to a surface translation. This balance task was either completed on its own or while counting backwards by 2's (easy counting difficulty) or 7's (hard counting difficulty). With increasing counting difficulty, less attentional resources were assumed to be available for balance recovery. The ability to generate arm muscle responses was quantified through the measurement of electromyographic (EMG) onset latencies and amplitudes from three arm muscles. Results indicated that the attentional requirements of the counting task did not greatly affect EMG onset latencies or amplitudes for both young and older adults. Even when an effect was observed, the magnitude of change was small (e.g., ~3 ms earlier EMG onset and ~2.0%MVC smaller EMG amplitude during the dual- compared to the single-task conditions). Thus, the generation of arm muscle responses do not appear to require a significant amount of attentional resources and the decreased ability to cope with cognitive interference with ageing is unlikely to explain why older adults have difficulty in generating arm responses following a loss of balance.

1. Introduction

The extent to which a balance task requires attentional or cognitive resources has been assessed using a dual-task paradigm, where an individual is asked to perform two tasks at the same time. When the attention requirements of dual-tasking exceed an individual's attentional capacity or interference occurs between cognitive and sensorimotor processes, performance declines on one or both of the tasks can be observed (Teasdale, Bard, LaRue, & Fleury, 1993; Woollacott & Shumway-Cook, 2002). While findings from dual-task research generally suggest that static balance control is attentionally or cognitively demanding, the effects of dual-tasking on standing balance performance have been quite variable. Previous studies have reported less (Andersson, Hagman, Talianzadeh, Svedberg, & Larsen, 2002; Dault, Yardley, & Frank, 2003; Maylor, Allison, & Wing, 2001; Swan, Otani, & Loubert, 2007), more (Melzer, Benjuya, & Kaplanski, 2001; Pellecchia, 2003), or even no change in postural sway (Vuillerme, Nougier, & Teasdale, 2000). This contrast in findings may explain why it is important to consider the choice of the balance and cognitive tasks (e.g., as more difficult cognitive or balance tasks are introduced, there is a progressive change in balance performance) (Kerr, Condon, & McDonald, 1985; Maylor & Wing, 1996) as well as how individuals are instructed to perform the dual-tasks (e.g., focusing attention on the cognitive or the balance task) (Huxhold, Li, Schmiedek, & Lindenberger, 2006).

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Researchers have extended these initial findings obtained from quiet standing to examine whether attentional resources are required to generate lower limb reactive balance control strategies. Although postural responses to an unexpected loss of balance have traditionally been assumed to be simply reflexive in nature, results from dual-task studies have shown that lower limb postural responses are influenced by dual-task interference effects. For example, more time is required to control the centre of pressure (Brauer, Woollacott, & Shumway-Cook, 2001), stepping responses are initiated earlier (Brown, Shumway-Cook, & Woollacott, 1999), and leg muscle response amplitudes are smaller when dual- compared to single-tasking (Burleigh & Horak, 1996; Norrie, Maki, Staines, & McIlroy, 2002; Rankin, Woollacott, Shumway-Cook, & Brown, 2000). These dual-task effects are often exacerbated in older compared to young adults, suggesting that attentional demands for balance recovery become greater or the ability to cope with dual-task interference effects become diminished with age (Brown et al., 1999; Redfern, Jennings, Mendelson, & Nebes, 2009).

While it is evident that dual-tasking impacts the ability to generate lower limb postural responses, it is not yet known whether the same is true for the upper limbs. Understanding how upper limb postural responses to a loss of balance are controlled is important because they help to restore balance by counteracting trunk rotation (Allum, Carpenter, Honegger, Adkin, & Bloem, 2002; Pijnappels, Kingma, Wezenberg, Reurink, & van Dieen, 2010) and allowing more time for proper foot placement (Roos, McGuigan, Kerwin, & Trewartha, 2008). The ability to generate arm movements in response to a loss of balance has been shown to improve recovery time and ultimately, the likelihood of successful balance recovery (Cheng, Wang, & Kuo, 2015). If reactive postural control of the upper limbs can be shown to be controlled similarly as the lower limbs, the increased dual-task interference effects associated with ageing may partially explain why older adults have difficulty initiating arm muscle responses as rapidly (Mansfield & Maki, 2009) and to the same extent as young adults (Allum et al., 2002), or why older adults have different arm movement strategies than the young (Allum et al., 2002; Roos et al., 2008).

Therefore, the purposes of this study were to investigate whether dual-tasking influences an individual's ability to generate arm muscle responses and whether these dual-task effects become disproportionately larger with ageing. If arm postural responses rely on the same pool of attentional resources as a concurrent cognitive task, it would be expected that these responses would become smaller as the dual-tasking requirements become more difficult. Further, it was hypothesized that the ability to produce arm muscle responses would be more affected in older compared to young adults. This is because older adults require or allocate a greater proportion of their total attentional resources for balance and balance recovery (Li, Lindenberger, Freund, & Baltes, 2001; Teasdale & Simoneau, 2001).

2. Methods

2.1. Participants

Nineteen young adults and sixteen older adults participated in this study (Table 1). None of the participants reported any history of neurological disorders that could affect their balance. Participants provided written informed consent prior to commencing the study. All procedures were in accordance with the Declaration of Helsinki and were approved by the university research ethics board.

2.2. Experimental protocol

Participants first completed the Activities Specific Balance Confidence scale to assess their balance confidence during various activities of daily living (Powell & Myers, 1995), the Edinburgh Handedness Inventory to determine the participant's dominant hand (Oldfield, 1971), and the Montreal Cognitive Assessment questionnaire to assess for cognitive function (Nasreddine et al., 2005). Next, participants performed the Timed Up and Go (TUG) and two difficulty levels of the Timed Up and Go Cognitive ($TUG_{cognitive}$) tests to assess for functional mobility and the impact of a concurrent cognitive task (Shumway-Cook, Brauer, & Woollacott, 2000). The TUG required participants to stand from a seated position, walk 3 m,

Table 1
Participant characteristics. Unless otherwise noted, values are expressed as the mean ± one standard deviation. M = male; F = female. R = right-handed; L = left-handed; I = indifferent. ABC = Activity Specific Balance Confidence scale. MoCA = Montreal Cognitive Assessment score.

	Young adults	Older adults
Sex (#)	13 M, 6 F	5 M, 11 F
Age (y)	23 ± 2 (range of 20–27)	71 ± 4 (range of 62–77)
Height (m)	1.75 ± 0.09	1.66 ± 0.09
Mass (kg)	73 ± 13	67 ± 14
Handedness (#)	14 R, 2 L, 3 I	14 R, 1 L, 1 I
ABC (%)	94.5 ± 4.9	94.9 ± 6.0
MoCA (/30)	28 ± 2	27 ± 2