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OLDER ADULTS WITH HISTORY OF FALLS ARE UNABLE TO PERFORM WALKING AND PREHENSION MOVEMENTS SIMULTANEOUSLY

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Abstract—Older adults have a greater incidence of falls, and risk of falls will increase when combining two motor tasks. Thus, it is interesting to investigate the effect of fall history on motor performance in older adults when combining walking with another task such as grasping an object. The aim of this study was to investigate the combined task of walking and prehension with different levels of manual task difficulty in older adults with and without a history of falls. Thirty older adults participated in this study; groups were designated as fallers ($n = 15$) and non-fallers ($n = 15$). Participants were asked to reach-to-grasp a dowel during quiet standing and during walking. Level of manual task difficulty was manipulated by the type of dowel support and obstacles located at different distances to the sides of the dowel. Fall history influenced the performance of this combined task for the most difficult manual conditions. Fallers were able to be identified due to differences in the grasping strategies used while walking compared to non-fallers. In addition, walking and grasping were mutually modulated due to the level of difficulty of the manual task. © 2015 Published by Elsevier Ltd. on behalf of IBRO.

Key words: aging, falls, locomotion, prehension, dual task.

INTRODUCTION

It is estimated that one-third of community-dwelling people aged 65 and older fall every year (O'loughlin et al., 1993; Perracini and Ramos, 2002). Consequently, fall-related injuries are associated with a poorer quality of life due to restricted mobility and functional decline (Tideiksaar, 1996). In addition, one of the major intrinsic risk factors for falls in older adults is deficit in static and dynamic postural control (Verghese et al., 2007). Importantly, more than 50% of falls occur during locomotion (Barak et al., 2006).

Older adults with a history of falls (FOA) present some gait impairments (Hausdorff et al., 2001), such as a decrease in stride length and velocity, and an increase in gait variability and double support time (Kirkwood et al., 2011; Toebes et al., 2012). These changes in the walking pattern are even more evident when two motor tasks are combined (Nordin et al., 2010). FOA have a slower swing time and step velocity than older adults without a history of falls in a dual task paradigm (Springer et al., 2006). These results suggest that FOA may have problems switching their attention between two motor tasks due to neuromuscular problems (Hawkes et al., 2012). The changes in the walking behavior during a dual task paradigm can predict falls in older adults (Beauchet et al., 2009). Moreover, the level of difficulty of the secondary task can also influence how dual-task-related changes are associated with a history of falls (Chu et al., 2013). Nordin et al. (2010) investigated, in FOA, gait changes during dual task conditions at different levels of difficulty. They found that FOA increased their step width in the two most difficult tasks (task 1: carry a saucer with a coffee cup in one hand; task 2: perform serial subtractions by three starting from 50). These results indicated the usage of sensory-motor resources in a flexible manner to decrease the risk of falls (i.e., a protective strategy). Hall et al. (2011) investigated the impact of cognitive task level of difficulty on walking of FOA. FOA reduced gait speed when cognitive task demand increased, suggesting that the more difficult the secondary task is, the greater the impact on gait performance. Furthermore, FOA performed the alphabet and alternate letters tasks more slowly in walking than in the seated condition. With an increase in task difficulty, older adults must allocate more attentional resources to walking to compensate for the reduction in sensory-motor control (Stelmach et al., 1990).

The combined task of walking and prehension (i.e., reach-to-grasp) is widely performed during activities of daily life. Older adults exhibit smaller peak wrist velocity and greater movement times than young adults when reaching for an object (Roy et al., 1996). Furthermore,

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Abbreviations: ANOVAs, analysis of variances; AP, anterior–posterior; COM, center of mass; FOA, Older adults with a history of falls; HCs, heel contacts; MDS, margin of dynamic stability; ML, medial–lateral; MMSE, Mini Mental State Examination; OA, older adults with no history of falls; SB, stable base; SLD, stable base with obstacles at long; SSD, stable base with obstacles at short; UB, unstable base; WT, walking baseline.

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older adults have reduced tactile sensitivity and, consequently, increase the grip force as a compensatory strategy (Gorniak et al., 2011). During walking aging has been found to affect prehension. Diermayr et al. (2011) investigated the aging effects on grasp control when walking and transporting an object. They found an increase in grip force while walking, indicating a decline in manual dexterity while performing functional tasks.

Interestingly, Delbaere et al. (2004) found that walking and reaching are the most avoided tasks in older adults with fear of falling. When reaching for an object in an upright position older adults adopted a hip strategy to perform the task, which is different than that of young adults who preferred an ankle strategy (Delbaere et al., 2004). Additionally, Huang and Brown (2015) found that older adults showed a larger center of pressure excursions compared to young individuals when combining upright stance with reach-to-grasp. These different strategies are likely to compensate for constraints in balance-related functions. Thus, it becomes interesting to combine these two tasks because they have the potential to challenge dynamic stability due to mechanical constraints and, at the same time, increase cognitive load because this combined task is also a dual task.

Many studies have investigated the interference of motor/cognitive tasks on walking and the relationship to fall risk in older adults (Menant et al., 2014). However, most of these studies involving dual task paradigms and FOA investigated primarily the main task (i.e., walking) (Beauchet et al., 2009). Recently, we found modifications in walking and prehension when combining these two tasks in young adults (Rinaldi and Moraes, 2015). We suggested that prehension was superimposed on gait, although the adaptations in motor behavior were global because both motor patterns were modified to guarantee the execution of prehension with different levels of difficulty while walking without stopping. Then, in this context of dual task and falls, it is important to analyze both tasks to investigate the level of interference between these two motor tasks in FOA. Possible changes in the prehension control, such as, reduced movement time, wrist velocity and grip aperture velocity could be related to changes in walking control. Changes in gait stability could be part of a compensatory strategy to accommodate the control of upper body movements toward an object in FOA. Furthermore, this combined motor task is different from other dual task paradigms in the literature (Yamada et al., 2011), because most studies have older adults perform the secondary task during the entire pathway (e.g., carrying a tray). Thus, they do not need to change their motor strategy to perform the secondary task, since they could preprogram their movement from the beginning of the walking task. However, to perform daily life activities, older adults are required to change their walking patterns to accommodate other tasks (e.g., prehension). Based on these assumptions, our combined motor task can contribute to investigate the motor strategies used by FOA when they have to disrupt the walking pattern to superimpose a voluntary, discrete task.

Based on these considerations, this study presents two main research questions: (1) what are the changes in prehension and walking when these tasks are combined in FOA? (2) Do these changes occur as a function of the manual task difficulty? To answer these questions, we analyzed variables based on whole body center of mass (COM) (including stability measures) and spatiotemporal gait parameters to describe the possible changes in walking of the FOA due to manual task difficulty. We analyzed two steps before object grasping to investigate the changes in walking during the approach phase. In relation to reach-to-grasp, we analyzed the reaching and grasping components, such as reaching duration and velocity, and hand grip aperture and velocity. We also investigated prehension variables in the upright stance to identify changes in reach-to-grasp due to the addition of walking. Therefore, the aim of this study was to investigate the combined task of walking and prehension with different levels of manual task difficulty in older adults with and without a history of falls.

EXPERIMENTAL PROCEDURES

Participants

Thirty individuals participated in this study. They were distributed in two groups (n = 15): older adults with no history of falls (OA) (15 females); older adults who experienced at least one fall in the 12-month period prior to data collection (FOA) (15 females). Participants were screened before starting the experimental task by filling out a clinical questionnaire to check the history of falls, health status, physical activity level (Baecke) (Voorrips et al., 1991), cognitive function (Mini Mental State Examination, MMSE) (Folstein et al., 1975) and balance performance (Mini-BESTest) (Maia et al., 2013). Participants were excluded if they had cognitive impairment (< 24 points in the MMSE), vestibular dysfunction, and/or if they were unable to walk without assistance. We invited participants through local media (newspaper, television and radio). Forty-eight older adults returned to our invitation. We did an initial contact by phone and we asked them whether or not they experienced a fall in the last 12 months, after explaining to them that a fall was an event in which they came to the ground or to some lower level unintentionally, regardless of the consequences of the fall. After this screening, 28 older adults reported a recent history of fall and 20 older adults did not experience a fall in the last 12 months. However, regarding the FOA, seven individuals did not attend to the inclusion criteria (visual problem [n = 1] and use of assistive devices [n = 6]). Yet, six individuals refused to participate in the study. For the OA, five individuals did not attend to the inclusion criteria (neurological disorders [n = 3] and musculoskeletal problems [n = 2]).

All participants had normal or corrected-to-normal vision and no neurological/musculoskeletal disorders that would affect task performance. The local ethics committee approved all procedures and participants signed a consent form before starting the experiment.

Experimental protocol

For data collection, we used an 8-camera motion analysis system (MX-T40S, Vicon) with a sampling rate of 100 Hz.