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Full Length Article

The effects of a simultaneous cognitive or motor task on the kinematics of walking in older fallers and non-fallers

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ABSTRACT

Human gait has been widely investigated under dual-task conditions because it has been demonstrated to be an important way to uncover differences in gait biomechanics between older fallers and non-fallers. However, exactly how simultaneous tasks affect the kinematics of walking remains unclear. In the present study, gait kinematic properties of older fallers and non-fallers were compared under cognitive and motor dual-task conditions. The gait kinematic properties of interest were recorded under three different conditions: walking at preferred speed, walking when performing a cognitive task (naming animals), and walking when performing a motor task (transferring a coin from one pocket to the other). The following variables were analyzed: gait speed, cadence, stride time, step length, single support, stride time variability, and the dual-task cost. In addition, functional balance was evaluated by means of the Balance Evaluation – Systems Test (BESTest). Two-way repeated-measures ANOVAs revealed significant main effects of walking conditions. However, no significant main effects of group (fallers vs. non-fallers) and no significant interaction effects between group and walking condition were observed. The BESTest revealed that functional balance in fallers was worse than in non-fallers. The cognitive task leads to more significant changes in gait kinematics than does a motor task and the step length and stride time variability were variables more sensitive to that cognitive influence.

1. Introduction

The dual-task paradigm has been widely used to investigate the link between the risk of falling, cognition, and gait. This paradigm taps the ability to combine a balance task (such as walking) with a cognitive one (i.e., talking or performing math calculations) or a motor task (i.e., carrying an object or performing a manual task). The study of so-called dual-task gait is clinically relevant because it represents similar situations to activities of daily living (Beurskens & Bock, 2013; Montero-Odasso, Muir, & Speechley, 2012).

Age-related neuromuscular changes appear to aggravate the magnitude of abnormalities observed in dual-task gait. Priest, Salamon, and Hollman (2008) found that older adults had greater instability during walking than younger participants when performing a second task. This increased instability was reflected in a reduction in gait speed and an increase in the

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variability in stride velocity, which may put this older population at a higher risk of falling. Previously, researchers have suggested that the inability to maintain balance in older adults during dual-task gait may be related to age-related impairments in cognition and motor control, such as changes in executive function (Lacour, Bernard-Demanze, & Dumitrescu, 2008; Yogev-Seligmann, Hausdorff, & Giladi, 2008). Additionally, changes in sensorial functions, age-related strength loss, and slower conduction of psychomotor processes may affect the ability of older adults to perform the dual-task gait (Bock, 2008; Doi et al., 2014; Tseng, Cullum, & Zhang, 2014). The link between cognition and gait abnormalities in a dual-task condition was also observed in studies with older adults with cognitive impairments (Montero-Odasso et al., 2012; Taylor, Delbaere, Mikolaizak, Lord, & Close, 2013).

Although the effect of aging on gait kinematics during performance of a second task has been explored, it is not yet clear whether gait kinematics can be used clinically to predict the risk of falling in older adults, especially when analyzing other spatiotemporal variables rather than gait speed (Beurskens & Bock, 2012; Muhaidat, Kerr, Evans, & Skelton, 2013; Wiel et al., 2003).

In fact, a systematic review by Menant, Schoene, Sarofim, and Lord (2014) concluded that gait speed has been the variable most extensively studied in the dual-task paradigm, although it was not possible to determine the clinical or statistical advantage of assessing gait speed during a dual task rather than during a single task to discriminate between fallers and non-fallers. The authors suggested that walking speed measured in a dual-task condition may not be a sensitive enough measure to discriminate fallers and non-fallers.

Another recent systematic review (Muir-Hunter & Wittwer, 2016) showed a significant association between the deterioration of gait under dual-task conditions and the risk of falls. However, the authors noticed that divergent results from the studies limited the possibility of using dual-task gait in clinical practice to identify the risk of falls. Thus, studies should be conducted to evaluate the biomechanical aspects of dual-task gait in older fallers and non-fallers and to determine if these aspects are useful in predicting falls in the elderly. The present study has been designed to this aim by comparing kinematics of single task gait, cognitive dual-task gait, and motor dual-task gait in both older fallers and non-fallers. Therefore, it was hypothesized that the older adults who have already fallen have more abnormalities in gait kinematics than non-fallers in the dual-task conditions, especially when associated with the cognitive task.

2. Methods

2.1. Participants

The data of 62 older adults (60 years old or older) of both sexes recruited from a community setting were considered for this study. Considering gait speed as the main variable, a power analysis, using the G ∗ Power Software, version 3.1.92 (Universität Kiel – Germany), indicated that an alpha level of 0.05 and an effect size of 0.90 (based on a pilot study) would require a minimal sample of 50 participants (25 in each group) to attain a power of 0.85.

The exclusion criteria were as follows: an inability to walk without help from others; a severe impairment of balance; and the presence of cognitive impairment identified by the Mini-Mental State Examination (MMSE). The participants with the following MMSE scores were excluded from the study: a score of less than 13 points for elderly who were illiterate; 18 points for those with 1–7 years of education; and 26 points for those who had eight or more years of education (Bertolucci, Brucki, Campacci, & Juliano, 1994). The study was approved by a local ethics committee, and all participants signed the informed consent form.

2.2. Procedures

The data collection was conducted during a single session. The weight and height of participants were recorded, and a questionnaire about their history of falls in the six months prior to the assessment day was administered. Using the information from the falls questionnaire, the participants were classified in two groups: non-fallers (n = 35), which comprised participants who had no history of falls in the last six months, and fallers (n = 27), which comprised older adults who had experienced one single fall in the past six months before the study. The definition of a fall was considered to be "an unexpected event in which the participant comes to rest on the ground, floor or lower level" (Hauer, Lamb, Jorstad, Tood, & Becker, 2006).

The Balance Evaluation Systems Test (BESTest) was used to evaluate functional balance. This tool consists 36 items grouped into six sections: (1) biomechanical constraints; (2) stability limits; (3) anticipatory postural adjustments; (4) postural responses; (5) sensory orientation; and (6) stability in gait (Horak, Wrisley, & Frank, 2009). All scores were converted to percentages (0–100%), and higher scores indicated better balance performance. With an ICC of 0.91, the interrater reliability of the total score of the BESTest was excellent (Horak et al., 2009; Mancini & Horak, 2010).

The gait kinematics were recorded by an instrumented walkway system (GAITRite® Platinum 26', CIR Systems Sparta, New York, USA), measuring 800 cm in length and 90 cm in width. The walk started 1 m before the electronic carpet and ended 1 m after, so that the participant's acceleration and deceleration could be excluded. For each participant, 25–36 steps were collected to examine the variability (Lord, Howe, Greenland, Simpson, & Rochester, 2011; Schwenk et al., 2014). Three gait collections were carried out for each individual, and all trials were randomized. The variables recorded during the gait