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Quality of standing balance in community-dwelling elderly: Age-related differences in single and dual task conditions

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ABSTRACT

Aim: To examine the relationship between age and quality of standing balance in single and dual task conditions.

Methods: A cross-sectional study was conducted using a sample of 243 community-dwellers aged ≥65 years. Quality of standing balance was assessed by measuring the center of pressure (COP) sway with a pressure platform. Measurements were performed under single task (orthostatic position) and dual task (orthostatic position while performing a verbal fluency task) conditions.

Results: The mean age of the participants was 79.1(±7.3) years and 76.1% were women. Older age was associated with an increased COP sway, mainly in the medial/lateral (ML) direction. Most COP sway parameters were higher under dual task conditions than under single task. After controlling for the effect of the number of words enunciated in dual task conditions, only the differences in COP sway parameters in the ML direction remained significant. There was no significant interaction between age group (65–79; ≥80 years) and condition, which indicates that differences in COP sway caused by performing a secondary task were similar for younger and for older participants.

Conclusion: Age did not seem to influence significantly the decline in the quality of standing balance triggered by performing a concurrent cognitive task. However, older age was consistently associated with poorer standing balance, both in single and in dual task conditions. Therefore, performing a secondary task may lead older individuals to reach their postural stability limits and, consequently, to fall.

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1. Introduction

The ability to maintain standing balance influences the risk of falling while performing everyday activities (Piirtola & Era, 2006; Zijlstra, Ufkes, Skelton, Lundin-Olsson, & Zijlstra, 2008). Particularly in the elderly population, falls are a major health problem (Gelbard et al., 2014; Takeshima et al., 2014). Indeed, mainly due to the high prevalence of comorbidity and frailty, the clinical outcomes of falling are worse for older adults than for younger individuals (Gelbard et al., 2014). These adverse consequences include fractures, prolonged hospitalization, disability, institutionalization and death (Ayoung-Chee et al., 2014; Gelbard et al., 2014; Rubenstein, 2006).

As age increases, neuromusculoskeletal and sensorial changes may lead to an impaired postural control and difficulties in maintaining balance (Hiyamizu, Morioka, Shomoto, & Shimada, 2012; Takeshima et al., 2014; Winter, 1995). The loss of muscle fibers and the decline in the amount of force that each fiber can produce are examples of age-related modifications in muscle properties that have an impact on postural stability (Bello-Haas, 2009). Concomitantly, the function of the visual, vestibular and proprioceptive systems, which provide crucial information for an effective postural control, also suffers a deterioration with aging, thus influencing balance (Bello-Haas, 2009).

However, it is similarly important to consider that preserving balance in daily activities also depends on cognition, particularly attentional resources (Doumas & Krampe, 2016; Swanenburg, de Bruin, Uebelhart, & Mulder, 2009; Zijlstra et al., 2008). Usually, a

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single task such as postural control may be performed requiring minimal attention, but when a person is presented with a secondary task (e.g. having to answer a question), task-related cognitive demands increase, and attentional resources have to be divided between both tasks (Doumas & Krampe, 2016; Kang & Lipsitz, 2010; Woollacott & Shumway-Cook, 2002). Performance in simultaneous tasks is thus influenced by the ability to effectively focus attention in concurrent stimuli. This flexible control of attention, a cognitive function associated with the frontal lobes of the brain and with executive functioning, seems to be impaired in older adults (Glisky, 2007; Sheridan, Solomont, Kowall, & Hausdorff, 2003; Yogev, Hausdorff, & Giladi, 2008). Therefore, elderly individuals may have an increased difficulty to maintain balance while performing activities that require multitasking (Doumas & Krampe, 2016; Hiyamizu et al., 2012; Piirtola & Era, 2006). Nonetheless, there is conflicting evidence regarding how secondary tasks influence postural stability in older adults (Bergamin et al., 2014; Boisgontier et al., 2013; Swanenburg et al., 2009).

Maintaining standing balance relies upon the ability to keep the body's center of mass inside the base of support while in an upright position (Pasma et al., 2014). The corrective forces that control the center of mass can be measured by assessing center of pressure (COP) sway, which represents the vertical ground reaction forces (Moghadam et al., 2011; Pasma et al., 2014). This assessment allows for the detection of subtle changes in postural stability and, consequently, COP sway can be considered as an indicator of quality of balance (Moghadam et al., 2011; Pasma et al., 2014; Takeshima et al., 2014).

A better understanding of how age influences standing balance under single and dual task conditions, as well as an increased insight regarding the impact of specific secondary tasks on postural stability, would allow for an enhanced comprehension of the risk of falling of older adults. Therefore, the aim of the present study was to examine the relationship between age and quality of standing balance (assessed by measuring COP sway parameters) in single and dual task conditions, in a sample of community-dwelling elderly. Particularly, this study intended to test the following hypotheses: (1) if older age is associated with a higher COP sway; (2) if performing a secondary task is associated with an increased COP sway; (3) if the effect of performing a secondary task on COP sway is greater for older individuals.

2. Methods

2.1. Study design and participants

A cross-sectional study was conducted using a non-probabilistic sample of 243 community-dwelling elderly (≥65 years) individuals from Porto, Portugal. After information about the study was disclosed in local institutions, 257 elderly volunteered to participate. Exclusion criteria consisted of severe physical, sensorial or cognitive impairments, as well as inability to speak Portuguese. Two individuals were excluded as result of being unable to stand, two were excluded due to recent history of stroke, one was excluded for having a fractured foot, one was excluded for reporting major feet sensory loss and five were excluded due to severe cognitive deficits (i.e., scored < 10 in Mini Mental State Examination (Folstein, Folstein, & McHugh, 1975; Guerreiro, Botelho, Leitão, Castro-Caldas, & Garcia, 1994), according to guidelines of the National Institute for Health and Care Excellence (NICE, 2011)). Three participants were not included in the study after refusing to complete the assessment.

Data collection was carried out by trained researchers, using structured assessment protocols. The study was approved by institutional review boards and by the ethics committee of the Ph.D.in Gerontology and Geriatrics (Institute of Biomedical Sciences Abel Salazar—University of Porto). All participants gave their written informed consent.

2.2. Measurements

A questionnaire was used to assess the sociodemographic characteristics of the participants. Cognitive deficit and depression were screened using the Mini Mental State Examination (MMSE) (Folstein et al., 1975; Guerreiro et al., 1994) and the 15-item version of the Geriatric Depression Scale (GDS-15) (Sheikh & Yesavage, 1986; Simões, Prieto, Pinho, Sobral, & Firmino, 2015), respectively. Height and weight were also measured in order to calculate the participants' Body Mass Index (BMI).

Quality of standing balance was assessed by measuring COP sway parameters (total path length, average velocity, maximum velocity, and maximum range) both in medial/lateral (ML) and anterior/posterior (AP) directions. These measurements were performed using a pressure platform (Emed-AT25 D, Novel Inc., Munich, Germany), which contained 4000 capacitive sensors within a sensing area of $380 \times 240\,mm^2$ (sensor resolution of two $sensors/cm^2$), and had a 25 Hz recording frequency.

Balance in single task was examined by requiring the participants to stand on the platform and to maintain an orthostatic position for 60 s. To assess balance under dual task conditions, participants were asked to maintain an orthostatic position for the same period of time while performing an additional verbal fluency task. This latter measurement was performed twice, with different tasks (Fernandes et al., 2015): a semantic fluency task (subjects had to enunciate as many species of animals as possible during 60 s) and phonemic fluency task (individuals had to enunciate as many words as possible beginning with the letter R within the same period). In the present study, the mean number of enunciated words and the mean COP sway parameters were calculated (from both measurements in dual task) in order to produce a single score for dual task performance.

All subjects were asked to perform the balance tasks while barefooted and looking directly at a target placed two meters away at the height of the participants' eyes. The order of each condition was randomized to avoid possible fatigue and learning effect. Only the most stable 30 s period of each measurement was considered.

2.3. Statistical analysis

The characteristics of the participants are reported using proportions and measures of central tendency and dispersion. Hierarchical regression analyses were conducted to examine if age allows for the prediction of each COP sway parameter, both in single and in dual task conditions, after adjusting for the effect of the following covariates: sex, education, BMI, cognitive deficit and depression. Mixed ANOVA analyses of variance were conducted to ascertain if any change in COP sway between conditions (single × dual) is different across age groups (65–79 years × ≥80 years), i.e. if there is an interaction effect. Differences in COP parameters between conditions (within-subjects) and between age groups (between-subjects) are also presented separately. Results of the mixed ANOVA analyses are reported with adjustment to sex, education, BMI, cognitive deficit and depression. Secondarily, the mixed ANOVA analyses were repeated adjusting for the effects of an additional variable: the number of words enunciated in dual task.

Two-tailed tests were used throughout all analyses and a p-value < 0.05 was considered statistically significant. All statistical analyses were performed with IBM SPSS Statistics 22.0 (SPSS, Inc., Chicago, IL, USA).

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