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Development of predictive models for the estimation of the probability of suffering fear of falling and other fall risk factors based on posturography parameters in community-dwelling older adults

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ABSTRACT

Falls pose an important problem for older adults. Balance training is one of the main prevention strategies, but there is a lack of objective measurement methods that would allow the effectiveness of the treatments employed to be assessed. This study aimed to analyse the relationship between posturographic parameters and risk factors associated with falling, including the fear of falling (FoF). Forty-one healthy community-dwelling older adults were surveyed on their perception of problems considered to be fall risk factors. Balance measurement with posturography was performed. The relationships between risk factors and falls and risk factors and posturography were analysed by means of cross-tabulation and logistic regression, respectively. Experimental results showed a significant relationship between some of the posturographic parameters and various fall risk factors. Stability limits were related to FoF, and results from the Romberg test with eyes closed with and without foam correlated with problems in kneeling/crouching. The results from the Romberg test with eyes closed and foam correlated with osteoarthritis. Equations were developed to estimate the probability of having such problems. In conclusion, posturography is useful for the estimation of fall risk conditions in relation to three important fall risk factors (FoF, osteoarthritis and problems in kneeling/crouching), and it could be used for targeting, training and studying progress after the use of different treatments.

Relevance to industry: Posturography can be used as an assessment tool to analyse the effects of those treatments aimed at preventing falls. Furthermore, the equations derived from our results can be used along with posturographic variables to assess patient progress.

1. Introduction

Falls and fall-induced injuries are a significant problem among older people due to their frequency and the problems that come from them (Tinetti, 2003; Lockhart et al., 2005). Falls represent a major public health problem in modern societies with ageing populations (Kannus et al., 2005). Thirty percent of people over 65 and 50% of those over 80 fall each year (Stubbs et al., 2014). Injuries reducing mobility and independence and increasing the risk of premature death are sustained by 20%–30% of those who suffer a fall (Freeman et al., 2002). Injuries are, in fact, the fifth leading cause of death in older adults, and most of these fatal injuries are related to falls (Stubbs et al., 2014). Other physical and psychological problems resulting from falls include significant disability, decreased independence, and early admission to nursing homes (Keskin et al., 2008), leading to considerable socioeconomic burdens on both healthcare systems and patients' relatives (Heinrich et al., 2010). Between 20% and 30% of those who suffer a fall sustain moderate to severe injuries, which may be of a physical nature (fractures, head trauma and soft tissue injuries) (Schwenk et al., 2012), psychological (loss of self-confidence, fear of falling (FoF)

Abbreviations: FoF, fear of falling; REO, Romberg test with eyes open; REC, Romberg test with eyes closed; RFEO, Romberg test using a foam rubber mat with eyes open; RFEC, Romberg test using a foam rubber mat with eyes closed; AsIn, assessment index; LS, limits of stability; RDC, rhythmic and directional control.

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and depression), or both (Bloch et al., 2014). Post-fall anxiety syndrome and fear of falling are present in approximately 73% of those who have fallen within the previous year (Fabre et al., 2010). Murphy and Isaacs (1982) described the post-fall syndrome as the development of intense fear and walking disorders after a fall, with FoF being one of the key components of this syndrome. Fear of falling, to some degree, has been reported to occur in 12%–65% of older adults (those in the sixth decade of life or older) who live independently in the community and do not have a history of falling (Lachman et al., 1998). Even previous studies have demonstrated that FoF is common even in middle-aged patients (Martin et al., 2005; Wilson et al., 2005). FoF is an important predictor of falls. Older people who are afraid of falling are more likely to fall, while those who fell in the past have a significantly higher level of fear (Mei and El Fakiri, 2015). Furthermore, FoF is associated with reduced independence, restricted activity, depression, anxiety, a decline in social interactions, poor balance and an increased risk of falling, leading to premature admission into nursing homes (Boyd and Stevens, 2009; Stubbs et al., 2014). Additionally, it is noteworthy that many older adults who have not experienced a fall also experience FoF (Stubbs et al., 2014), with this constituting a risk factor for future falls (Deandrea et al., 2010).

The deterioration of physical functions, especially those connected with walking and activities of daily living, are also common fall risk factors (AGS, 2001). In particular, deterioration in balance in older adults is directly linked to an increased risk of falls, a decreased quality of life and a functional decline in physical and social activities (AGS, 2001; Melzer and Kurz, 2009).

As the aetiology of falls is multi-factorial, a global approach is required for fall assessment and prevention or rehabilitation (Delbaere et al., 2006; Renfro and Fehrer, 2011). Therefore, preventive strategies and those for the management of risk factors, including psychological considerations, are essential to reduce the incidence and consequences of falls. The first step in fall prevention involves the analysis of the risk factors, including an assessment of both the physiological and perceived fall risk. Numerous studies have identified risk factors and have even developed predictive models for screening and intervention programmes (AGS, 2001; Delbaere et al., 2006; Rubenstein, 2006). Preventive strategies are increasingly sought by healthcare systems, and there is less time for patient assessment with policies restricting health expenditure. Consequently, easy-to-use and quantitative tools for the screening of the elderly to identify subjects at risk of a fall or those who have FoF are needed.

One of the most common prevention approaches is to prescribe physical activity programmes that reduce the risk of falls (Shekelle et al., 2003; Rubenstein, 2006). However, the lack of quantitative measurement methods for the assessment and evaluation of the effectiveness of these physical activity programmes makes it difficult to assess their implementation.

Balance training is one of the strategies used in such programmes (AGS, 2001; Rubenstein, 2006; Gschwind et al., 2013). Different balance assessments by means of clinical tests or by instrumental tools have been developed to evaluate human balance ability and identify whether a balance problem exists or not (Raymakers et al., 2005; Duncan et al., 2010). Clinical tests use semi-quantitative scales that are less sensitive to changes when compared to instrumental analysis. In contrast, instrumental measuring systems, such as posturography, provide quantitative and objective data, including information on certain sensory changes that may have occurred in people with balance disorders. Additionally, posturography has been used over the last years to detect balance problems (Chaudhry et al., 2011; Park et al., 2015) and to predict the probability of falling (Buatois et al., 2006; Whitney et al., 2006; Prosperini et al., 2013). Nevertheless, only a few studies have investigated the association between posturography parameters and fall risk factors (Maki et al., 1991; Qiu and Xiong, 2015). This would provide useful information on discriminating between individuals with or without fall risk factors, which could be valuable to target in fall prevention interventions.

This study aimed to analyse the relationship between objective posturography parameters and risk factors associated with falling, including FoF, in a group of community-dwelling older adults. To further investigate these relationships, we studied a cohort of people just entering or at the beginning of old age with a low prevalence of dependency or previous falls.

2. Methods

2.1. Participants

Forty one community-dwelling volunteers (43.9% men and 56.1% women) with a mean age of 63.44 ± 4.1 years participated in the study, and 48.78% of them had historical falls in the past 2 years (19.51% had a single fall and 29.27% had two or more falls). All subjects were functionally independent, physically fit, and had no self-reported limitations in activities of daily living and no history of lower limb trauma, balance irregularities or other disorders associated with balance-related problems. To avoid the possibility of a confounding training effect, the subjects had not undergone any previous posturography tests.

Approval from the ethics committee of the Universitat de València was obtained. Subject participation was voluntary, and all subjects signed a consent form prior to commencement of the study. Data collection took place in the biomechanics laboratory of the Universitat de València.

2.2. Survey

After obtaining consent, the subjects were surveyed on their perception of the degree to which they were affected by potential risk factors associated with falling. The risk factors included in the survey were selected from a previous literature review: personal data (age, gender and any medication being taken), fall history in the past 2 years and the injured body part (history of falls questionnaire) (Qiu and Xiong, 2015), health problems related to falls (arthritis, osteoarthritis, lumbar or cervical spine pain, Parkinson's disease, hearing pathologies, circulatory disease, chronic obstructive pulmonary disease, visual impairments, diabetes, fibromyalgia, osteoporosis and dizziness) (AGS, 2001; Kim and Robinson, 2005; Delbaere et al., 2006; Rubenstein, 2006; Arnold and Faulkner, 2007), functional abilities, which were surveyed using questions regarding frequency of physical activity, and self-reported balance and capacity to perform certain activities or actions (standing, crouching down/kneeling, gait, movement coordination, lower limb strength, trunk and upper limb strength, lower limb range of motion, visual acuity and hearing) (Suzuki et al., 2002; Kempen et al., 2008). To measure the extent of FoF, the following question was asked, “at the present time, are you very fearful, somewhat fearful, or not fearful that you may fall?” (Arfken et al., 1994). Health problems and functional abilities were assessed using closed-ended multiple-choice questions such as, “Do you have difficulty walking/seeing things at a distance/with your balance/ … ?”. Possible answers included: “no problems/with difficulty/unable/ with some help”.

2.3. Posturography

The posturography system used was NedSVE/Dinascan/IBV 3.0 (Instituto de Biomecánica de Valencia, Spain), which assesses