



# A systematic review and meta-analysis of outcome measures to assess postural control in older adults who undertake exergaming



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## ABSTRACT

Exergaming has been shown to be an effective tool to improve postural control (PC) in older community-dwelling individuals. The outcome measures (OMs) used to assess PC are varied and this could limit the estimation of the effectiveness of the intervention. This systematic review and meta-analysis aims to explore the OMs currently used to assess PC in exergaming interventions, for healthy elderly individuals aged over 60 years. The literature search was conducted across five databases (CINAHL, EMBASE, PubMed, ISI, SPORTdiscus and Science Direct) using a range of search terms and combinations relating to exergaming, balance, exercise, falls and elderly. Quality assessment was conducted using the PEDro Scale and a custom-made quality assessment tool. Eleven trials were included in the meta-analysis, with a mean (SD) PEDro score of 5.36 (1.57). Primary and secondary OMs showed small effects in favour of alternative training modes, although these effects were statistically insignificant for all primary OMs. Tertiary OMs could not be included in the meta-analysis due to varying output parameters from different instruments. Heterogeneity remained high across trials and no studies performed long-term follow-up. Exergaming is a potential alternative to PC training, although still in its infancy. Strong and well-designed RCTs are needed, targeting specific populations aged over 60 years. Variability in instrumented OMs prevents generalisation of results. Technological improvements may provide data not currently available from clinical and laboratory-based methods, and may allow PC to be assessed more realistically and specifically in relation to a population's activities of daily living, though this remains a new area of research.

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## 1. Introduction

### 1.1. Background

Falls are associated with ageing and disease, with one third of people aged 65 years and older falling at least once per year [1,2]. In older individuals, a strong predictor of falls is impaired postural control (PC) among other factors [3,4]. Postural control is the ability to maintain, achieve, or restore a state of balance during any posture or activity [5]. Correct PC requires accurately timed vestibular, visual, proprioceptive and somatosensory inputs for adaptive strategies for orientation and balance [6]. Participation in balance-based training is low due to the tedious and monotonous nature of the training [7]. These therapies are repetitive which reduce attention span and impair the effectiveness of the exercises, particularly the large volume of practice associated with chronic neurological and musculoskeletal conditions [7].

A more recent method of PC training is exergaming [7,8]. Exergames are computer games driven by the user's gross physical movements. Due to portability, they facilitate community deployment whereby older individuals have experienced exergaming as a form of PC training [9]. The Nintendo Wii Fit™ had been the most popular exergaming instrument and results have shown beneficial effects on PC [9]. Other exergaming models include X-Box Kinect™, PlayStation Eyetoy™ and Dance Dance Revolution™. The X-Box Kinect™ is revolutionary in its development due to being the first commercial gaming system that does not require a hand held controller or external device, more so it requires the use of infra-red technology to track an individual's movements.

Outcome measures (OMs) used in exergaming interventions, employed for balance evaluation, have been previously categorised as functional assessment (documents balance status and change after intervention), systems assessment (determines the underlying reason for impaired balance control), static posturography (quantify postural sway while a subject remains as still as possible) and dynamic posturography (use of external balance perturbations, changing surface and visual conditions) [10]. The Berg Balance Scale (BBS) [11] and the Tinetti Performance Oriented Mobility Assessment (POMA) [12] quantify functional balance in an ordinal pattern as the participant performs balance and mobility tasks that represent activities of daily living (ADLs). The Functional Reach Test (FRT) [13] uses distance to quantify limits of stability of the centre of mass. The Single Leg Stance (SLS) [14] or the Timed Up and Go (TUG) [15] use the time domain to measure the task being performed via a stop watch. These measures provide information about postural control, likelihood of falling and functional capabilities. Inter-rater reliability has been previously reported excellent for BBS, TUG and FRT as has good intra-rater reliability [16]. Unobtrusive self-report questionnaires such as the Tinetti Falls Efficacy Scale (FES) [17] and

the Activities-specific Balance Confidence Scale (ABC) [18] measure perception of balance confidence and fear of falling of an individual in performing ADLs.

Force platforms quantify the centre of pressure (COP) excursion in mediolateral (ML) and anteroposterior (AP) direction during quiet stance in varying conditions [7]. The COP has previously characterised postural control by evaluating the relative sensitivity of COP based measures to changes in postural steadiness [19] and has been correlated with poor balance and risk of falls [20]. Older adults have previously demonstrated larger areas of COP excursion on a force platform with eyes open, eyes closed or with visual feedback. They displayed longer movement times, longer path lengths of the participant's centre-of-gravity (COG) to different points within their limits-of-stability, and shorter distances of functional reach when compared with younger adults [21]. Miniaturised electronic-based wearables with inertial sensors (e.g. accelerometers and gyroscopes) have objectively and reliably measured postural sway during quiet stance [22–24]. Wearables have been introduced in clinics as an alternative to evaluating PC in the hope to eliminate clinician bias, increase sensitivity to mild impairments (ceiling effects) and improve reliability of measures [25,26]. They have been tested in clinical populations whereby a subset of sensitive, reliable and valid instrumented postural sway characteristics had been formed [27].

It appears necessary to systematically explore OMs used in exergaming interventions in the hope to establish if an influence on intervention effect exists and any individual limitations that OMs may hold.

### 1.2. Objective

The aim of this systematic review and meta-analysis is to explore the outcome measures currently used to assess PC in exergaming interventions for healthy elderly individuals >60 years.

## 2. Methods

### 2.1. Search strategy

This systematic review was reported according to the PRISMA guidelines [28]. The systematic review was beyond the stage of data collection and therefore could not be registered with PROSPERO, however, it did receive an official statement pertaining to its satisfaction of the inclusion criteria. This is available upon request. Electronic databases (CINAHL, EMBASE, PubMed, Web of Science, SPORTdiscus and Science Direct) were searched for publications from January 2000 to April 2016 for interventions performed in clinical and community based settings. The key search terms were merged with Boolean conjunction (OR/AND) and applied on three

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