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Review

Age-related changes in the range and velocity of postural sway

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ABSTRACT

The aim of this analysis was to compare values of centre of pressure (CoP) measures, which describe the ability to maintain static body balance (range of body sway and velocity in antero–posterior and medio–lateral directions), in two age groups on the basis of a systematic review and meta-analysis of available data published worldwide. After a systematic review of publications presenting values of selected CoP measures, a numerical database with means and standard deviations was created. Data were classified by eye condition (open or closed) and by age group (18–35 or ≥56). Allocation to each group was based on the mean value of age of each subgroup in the numerical database. The Mann–Whitney *U* test was used to test the statistical significance of differences between age groups and eyes-open and eyes-closed conditions. This article shows mathematical equations, which quantitatively express increases in body sway and its velocity with age. On the basis of those equations, higher values have been shown for both displacement and velocity measures for the EC vs. the EO conditions and for the elderly vs. the young. The differences between age groups are greater for the velocity measures.

1. Introduction

The need to adapt workstations to elderly workers and to reduce disability associated with age is a major challenge for ageing populations. Ageing is often associated with falls, which can affect health. In the general elderly population, approximately one in three elderly people fall each year (WHO, 2008; Moyer, 2012). A fall is defined as any unexplained event that results in a person inadvertently coming to rest on the floor, ground, or lower level (Venes, 2009). A fall occurs when individuals are unable to maintain their centre of gravity within the base of support provided by their feet.

Falls are caused by either intrinsic or extrinsic factors. Extrinsic factors include, e.g., the environment like the floor, shoes, lighting, and the activity performed (Hignett & Masud, 2006). Intrinsic factors are person-related and may determine impaired postural control. Older age is especially crucial in this respect. The nervous system integrates visual, vestibular and somatosensory information on joint angles and changes in those angles to maintain an upright body posture. Age-related changes in the nervous system and muscles decrease sensitivity of the control of body posture and may contribute to balance problems common with increasing age (Jeong, Park, Choi, Lee, & Kim, 2011; Melzer, Kurz, & Oddsson, 2010).

Balance control is essential for accurate movements and locomotion skills, which are vital for activities of daily living. This is true for both static and dynamic conditions. Static balance is defined as the ability to maintain and control the centre of mass of the body during quiet upright standing exemplified by slow drifts and occasional rapid corrections (Collins & Luca, 1995). Static body balance can be described with measures, which characterize those displacements with the behaviour of a point corresponding to the projection of the centre of gravity on the base (centre of pressure, CoP). Traditional measures of the displacement of the CoP during stationary, upright standing quantify the movement of the CoP trajectory under the assumption that it is a stationary time series (Prieto, Myklebust, Hoffmann, & Lovett, 1996).

Studies showed a relationship between static body balance measures and risk of falls (Kurz et al., 2013; Melzer et al., 2010; Muir, Berg, Chesworth, Klar, & Speechley, 2010). Although good postural control of static balance testing does not mean fewer falls, control of body balance can be useful in assessing the inclination to falls. Because it is necessary to maintain elderly workers' health and to adapt workstations to their needs, it would help to be able to determine quantitatively age-related changes in balance control with key CoP measures, which are related primarily to the capability to maintain a stable body posture.

Pooling the results of several studies and their statistical analysis could provide a basis for establishing a relationship between measures of balance and age. In the process of pooling data, it is quite difficult to compare reports from the literature because basal CoP recordings are analysed in different ways. However, a meta-analysis can be used in a

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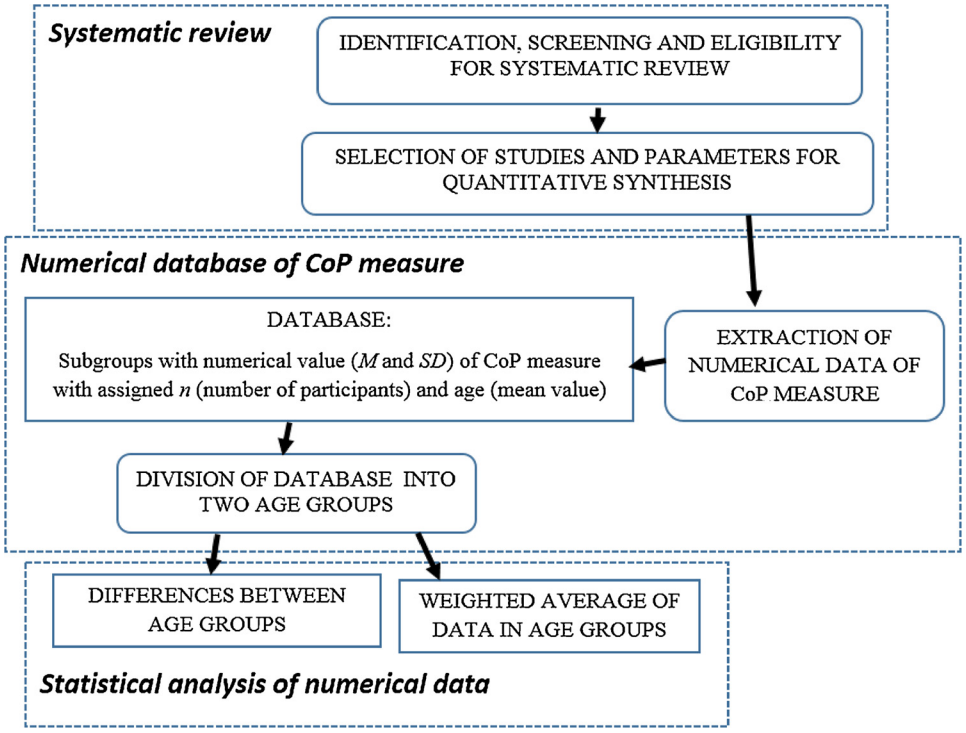

Fig. 1. Steps in the systematic review and meta-analysis of data: a flow chart.

systematic review and summary of studies that do not necessarily use the same measurement methods, but whose quantitative results describe the same types of data (Borenstein, Hedges, & Rothstein, 2007). A meta-analysis determines a common denominator of the results of many studies and submits them to a statistical summary. A meta-analysis of data available in the literature could determine standards on age-related physical changes.

The aim of the analysis presented in this article was to compare values of CoP measures describing the ability to maintain static body balance in different age groups on the basis of a systematic review and a meta-analysis of available data published worldwide.

2. Methods

The aim of the study was achieved in three steps: systematic review; preparation of numerical database of CoP measures; statistical analysis of numerical data (Fig. 1).

2.1. Systematic review

The first step of the systematic review consisted in a search of data sources to select studies. The review of the literature included works published between 1980 and 2016. A comprehensive literature search in PubMed, ScienceDirect, ProQuest, SpringerOpen, Cochrane Library, Web of Science, and Scopus was conducted. The following keywords were used: age; changes in functionality; stability; balance; elderly; aging/ageing; postural sway; body sway; centre of pressure (CoP); falls; posture; postural control; posturography.

A search, which followed a screening of the titles of the studies, identified 431 publications relevant to the topic of this study. Abstracts were screened by one person and later the decision was made by another one. Availability of the values of the analysed variables was the main criterion of acceptance. A screening of the abstracts of potentially relevant articles delivered 56 publications qualified for a full-text review Additionally, the reference lists of all those articles, including review articles, were scanned to identify non-indexed articles that might meet the eligibility criteria. As a result, 6 articles were added.

The next step was to analyse each article and to select for analysis only those fulfilling the following inclusion criteria: healthy adult participants; quiet standing on two legs; force platform measurement; firm surface; measurements done with eyes open and/or closed. Publications which discussed relationships between measures describing balance and age, done on more than one age group, were searched first. However, articles that fulfilled the eligibility criteria, but presented values of the studied parameters for only one group of people of a certain age were accepted, too.

CoP measures estimate a parameter associated with either the displacement of the CoP from the central point, or the velocity of the CoP, also in projection on the coordinates of the anterior–posterior (AP) and medial–lateral (ML) directions. In most studies, CoP measures, which have proven effective as a tool monitoring body posture, were calculated on the basis of Prieto et al.'s (1996) recommendations.

Measures that quantitatively describe the CoP were identified on the basis of the preliminary analysis of the selected publications. Accepted for further numerical data analysis were data extracted from articles that presented displacement measures (rangeAP and rangeML) and velocity measures (velocity CoP, velocityAP, velocityML). RangeAP and rangeML express the distance between the most distant points of CoP displacement in AP or ML directions, respectively. Velocity parameters (velocity CoP, velocityAP, velocityML) are obtained by dividing the total length by the duration of quiet standing. The total length of the path of movement around the CoP is approximated by the sum of the distances between consecutive points on the CoP path (also in ML and AP directions).

Only articles with CoP measures unambiguously described were included. So-called salami publications were excluded. There were two such publications. Also excluded were studies, where it was not clear what parameters were assessed or where there was no precise description of the measurement technique. If an article presented studies with variants which met the inclusion criteria and variants which did not, only the former were considered.

Following a final comprehensive analysis of articles, numerical values of time-domain CoP measures of static balance control were selected. Those values then became the numerical database. Table 1