



Center-of-pressure based postural sway measures: Reliability and ability to distinguish between age, fear of falling and fall history



Hai Qiu, Shuping Xiong*

Ergonomics and Applied Biomechanics Laboratory, Department of Human and Systems Engineering, School of Design and Human Engineering, Ulsan National Institute of Science and Technology (UNIST), UNIST-gil 50, Ulsan 689-798, South Korea

ARTICLE INFO

Article history:

Received 28 August 2014
Received in revised form
27 November 2014
Accepted 15 February 2015
Available online 13 March 2015

Keywords:

Center-of-pressure (CoP)
Postural sway
Reliability
Ageing
Fear of falling
Fall history

ABSTRACT

The purpose of this study was to compare the test-retest reliability of a wide variety of center-of-pressure (CoP) based postural sway measures and their ability to detect the differences between the young and older groups (age comparison), between the older low- and high-fear of falling groups (fear of falling comparison), and between the older non-faller and faller groups (fall history comparison). Forty healthy females (twenty each in both young and older groups) performed three trials of bipedal quiet standing on a force platform, in which eighteen reported CoP based measures were computed from recorded CoP trajectory. Intra-class correlation coefficient (ICC), standard error of measurement (SEM) and %SEM were used to quantify their relative and absolute reliability. Fear of falling and retrospective falls of the older group were recorded using falls efficacy scale-international (FES-I) and the history of falls questionnaire respectively. Experimental results showed that eight measures (RMS distance, RMS distance-AP, mean velocity, mean velocity-AP, mean frequency, mean frequency-AP, phase plane parameter and fractal dimension) had acceptable levels of relative and absolute reliability. Three measures (RMS distance-AP, mean velocity, and phase plane parameter) were sensitive to detect age-group difference and fear of falling under both visual conditions, but no single measure was capable to detect differences between the non-faller and faller groups.

Relevance to industry: The results of this research provide useful information on the selection of appropriate center-of-pressure (CoP) based postural sway measures to assess individual's balance ability for preventing the occupational falls.

© 2015 Elsevier B.V. All rights reserved.

1. Introduction

Falls are frequent occupational accidents involving workers and lead to important social and economic consequences both for the individual and for the employer (Gauchard et al., 2001). Falls represent 20%–25% of occupational accidents for all sectors of industries combined (Health and Safety Executive, 1985) and 10% of fatal accidents in USA (Agnew and Suruda, 1993). The rate reaches 76% of fatalities between 2003 and 2009 for US workers in roofing industry (U.S. Bureau of Labor Statistics, 2012). Furthermore, the fall accidents increase with the age of the workers (Health and Safety Executive, 1985), probably due to the age-related degeneration of balance control system (Borah et al., 2007).

Falls are often caused by several factors. Risk factors can be broadly classified as either intrinsic or extrinsic factors. Intrinsic factors are related to impaired postural control, visual and cognitive problems etc. Extrinsic factors include the environment and the way in which it may encourage or deter accidental falls. Such factors as the type of floor, shoe, lighting, and the activity itself are all important in fall prevention (Hignett and Masud, 2006). Even though extrinsic factors relating to the occupational environment and organization are relatively well identified in workers, intrinsic factors regarding individual's balance ability have not been investigated in studies on occupational falls (Hsiao and Simeonov, 2001).

Different balance assessments 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; Mancini and Horak, 2010). Posturography is a commonly used technique to diagnose human balance problems early and assess the intervention effects on treating these problems (Chaudhry et al., 2011). This technique records displacement of the center-of-pressure (CoP) on

* Corresponding author. Tel.: +82 052 217 2716; fax: +82 052 217 2708.
E-mail address: maverickhkust@unist.ac.kr (S. Xiong).

a force-measuring platform in either static or dynamic conditions and assesses postural sway from the recorded trajectory of CoP (Baloh et al., 1998). Various measures for characterizing the CoP trajectory (Prieto et al., 1996; Raymakers et al., 2005; Mancini and Horak, 2010) have been proposed to assess postural sway; they can be classified into distances, areas, velocities, frequencies, dimensionless quantities and others. Many previous studies (Lafond et al., 2004; Bauer et al., 2008; Pinsault and Vuillerme, 2009) have reported the reliability of their respective CoP based measures using only intra-class correlation coefficients (ICCs) even though it can lead to erroneous conclusions (Santos et al., 2008; Gasq et al., 2014). ICC and the standard error of measurement (SEM) are two related but different reliability coefficients: ICC provides a unitless estimate of the relative reliability of the measurement, while SEM (in the same unit as the original measurement) provides an estimate of the precision and absolute reliability of measurement (Lin et al., 2008). A large ICC can mask poor trial-to-trial consistency (i.e., large within-subject variability) when between-subjects variability is high. Therefore, ICC may not reflect an acceptable measurement if the SEM suggested that the precision of the measurement is not acceptable for the intended purpose, demonstrating an examination of the SEM in conjunction with the ICC is needed (Weir, 2005).

As the balance control system degenerates with the ageing process (Raymakers et al., 2005), older adults over 65 years were confronted with much higher risks of falls (fall rate of 33%) compared with young adults between 18 and 44 years old at fall rate of 2.6% (Adams et al., 2011). Because of this, previous studies proposed some CoP measures for assessing fall risks based on the ability to detect the age-group difference (Prieto et al., 1996; Raymakers et al., 2005). Even though the deterioration of balance control system due to ageing increases fall risks, ageing is only one of the intrinsic factors that lead to falls. Therefore, the age-group related balance change can be regarded as a possible fall-inducing factor, but by itself it is not a sufficient cause. Considering this limitation, recent studies attempted to directly investigate whether the CoP based measures were capable to distinguish the faller and non-faller groups using fall data such as fall history or future fall occurrences. However, results from these studies were conflicted with each other. Laughton et al. (2003) reported that CoP based measures failed to discriminate retrospective fallers and non-fallers during comfortable stance. Melzer et al. (2004) argued that participants standing with narrow stance could be more efficient to identify retrospective fallers compared with standing with comfortable stance. Their studies (Melzer et al., 2004, 2010) found no significant differences in CoP based measures between retrospective fallers and non-fallers during wide base stance, but a significantly increased mediolateral (ML) sway was found in retrospective fallers during narrow base stance. However, Ramdani et al. (2013) indicated even at the comfortable stance, range of ML sway was significantly higher in retrospective fallers. In terms of prospective falls, a literature review conducted by Piirtola and Era (2006) showed that among 9 investigated studies, 5 studies reported that CoP based measures were associated with prospective falls, while in other four studies no association between CoP based measures and falls was found.

The fear of falling has been identified as one of the key symptoms of 'past-fall syndrome' and it has been recognized as a specific health problem among elderly persons (Legters, 2002). 50%–60% of reported fallers experienced fear of falling in several community samples (Powell and Myers, 1995). However, fear of falling was also commonly found among older adults who had not yet experienced a fall (Legters, 2002; Suzuki et al., 2002). Fear of falling may reflect the realistic appraisal of one's own balance capabilities and an accurate estimation of fall risks (Hadjistavropoulos et al., 2007; Park

et al., 2010). Only few studies investigated the association between fear of falling and CoP based measures. Maki et al. (1991) reported that participants who expressed a fear of falling showed significantly poorer performance in spontaneous-sway tests. In their study, the assessment of fear of falling was to directly ask subjects "Are you afraid of falling?". If subjects responded "somewhat" or "very much", they would be assigned to the "fear" group; if subjects responded "not at all", they would be assigned to the "no-fear" group. However, Tinetti et al. (1990) and Legters (2002) had criticized this method of measuring fear of falling, because not only standards used to make judgments varied among subjects but also they may express a general state of anxiety/fear that is not specific to falling. Instead of direct asking individuals whether they were afraid of falling, falls efficacy scale-international (FES-I), which evaluates how much concerns of falls affect activities of daily living, is a commonly used tool measuring the fear of falling (Yardley et al., 2005) and valid measurement of falls (Delbaere et al., 2010; Park et al., 2010). However, to our best knowledge, no study has been conducted to determine whether the CoP based postural sway measures are capable to detect the difference between the older low- and high-fear of falling groups classified by FES-I.

Therefore, the objective of this study was to compare the relative and absolute reliability of a wide variety of center-of-pressure (CoP) based postural sway measures and their ability to detect group differences between age, fear of falling and fall history. It was hypothesized that some CoP based postural sway measures would be more reliable and sensitive in detecting group differences than the others. The outcome of this study is expected to provide some useful information on selecting appropriate CoP measure(s) for effectively discriminating between individuals with low and high risk of falling and assessing the intervention effects on enhancing the individual's abilities to maintain equilibrium and prevent the occupational falls.

2. Methods

2.1. Participants

Forty Korean female volunteers, twenty each in both young group (age: 20.4 ± 1.8 years) and older group (age: 69.4 ± 3.1 years), were accepted as subjects. Only female subjects were enrolled in this test in order to avoid potential gender differences in balance performance (Butler et al., 2009). All subjects were physically fit, functionally independent, and had no self-reported neurological, musculoskeletal deficits or vestibular dysfunction likely to affect balance. They gave their informed consents to participate in the study, which had been previously approved by the university institutional review board (No. 12-005-A).

2.2. Equipment and experimental procedure

A commercially available force platform system, Pro Balance Master[®] from Neurocom[®], Natus[®] Medical Incorporated (USA) was used in this study. It consists of two force plates, two LCD flat panel displays, the safety harness to prevent the fall of the subject and running software to record the experimental data. During a trial, foot forces recorded by the force plates at a sampling frequency of 100 Hz were used to calculate center-of-pressure (CoP), and its displacements were used as an estimation of postural sway. Participants were asked to do barefoot stand (with feet apart) as steady as possible on the stationary force platform, with her arms at the sides in a comfortable position. The foot is positioned by following the standard protocol of Pro Balance Master[®] to minimize its effect on postural sway (Wrisley and Whitney, 2004). The postural sway of participants was measured during the quiet standing under two

Download English Version:

<https://daneshyari.com/en/article/1095968>

Download Persian Version:

<https://daneshyari.com/article/1095968>

[Daneshyari.com](https://daneshyari.com)