Center of Pressure Measurement to Evaluate Fall Risk in the Elderly

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The aim of this article was to develop a center of pressure (COP) measurement device and application to evaluate the fall risk among the elderly. The approach was designed to measure changes in COP in a standing position to assess balance, an important risk factor in falling. The developed approach consisted of both hardware and software; the hardware’s function was to measure the sway in COP while the software controlled the device, displayed the results, and stored the data. Data was transmitted from device to tablet or smartphone via Bluetooth. This approach to COP measurement was configured as a dedicated application, making it easier for the elderly to measure their own COP for evaluating balance and fall risks using the measurement data. In conclusion, this device is easy and convenient for the elderly to use in their daily life and could help with fall management and prevention.

KEYWORDS
Balance, Center of Pressure, Elderly, Falling, Risk

INTRODUCTION
Falling is as an event which results in a person coming to rest unintentionally on the ground or other lower level that is not the result of a major intrinsic event, such as stroke, or overwhelming hazard (Tinetti, Speechley, & Ginter, 1988). Adults older than 65 suffer the greatest number of fatal falls (World Health Organization, 2016). As a consequence of falling, many older adults suffer physical and psychological damage (Jung, 2009; Baranzini et al., 2009; Przybysz, Dawson, & Leeb, 2009). In the elderly, falling is very dangerous and, in the absence of a caregiver, can be even more dangerous since immediate assistance cannot be given when a fall occurs despite the need for it. Monitoring the risk of falling in the elderly could therefore contribute greatly to fall management.

The risk of falling is an important issue in the elderly because it can cause serious injury, and older adults develop many intrinsic associated risk factors through the physical, psychological, and behavioral elements of aging. Many studies have reported such risk factors of falling in the elderly as muscle weakness and disease, as well as changes in balance, range of motion (ROM), sensory function, cognition, and gait (Akyol, 2007; Lamoreux et al., 2008; Oliver, 2007; Rubenstein, & Josephson, 2006).

Among these factors, the most significant is decreasing balance ability (Jakovljevic, 2009; Kim, Kwon, & Lee, 2002; Lee, Yi, & Yoo, 2002), and this is because it is affected by a number of other aspects including muscle weakness, changes in ROM and sensory function, various underlying diseases, taking medication, and the fear of falling. The measurement of balance is therefore key in the prevention of falls. If an elderly person’s balance can be accurately and simply measured, their fall risk can be easily evaluated.
Maintaining balance is controlled by a complex body system. The subsystems that make up the process of postural control include the sensory, central nervous, and musculoskeletal systems (Winter, Patla, & Frank, 1990). The human body sways constantly to keep balance and maintain posture. Thus, even when a person is standing still, the body is moving in the mediolateral and anteroposterior directions to maintain its posture (Winter, 1995). If this system of maintaining balance and posture is impaired in even the slightest way, it can be detected and determined as an abnormality affecting body sway (Nakagawa, Yochida, & Yamada, 2014).

Center of pressure (COP) measures are commonly used as indicators of balance and postural control (Doyle, Hsiao-Wecksler, Ragan, & Rosengren, 2007). The COP is the point location of the vertical ground reaction force vector (Winter, 1995); it is a summary measure representing the movements of all body segments while an individual attempts to remain upright (Doyle et al., 2007). According to Winter (1995), the COP represents a weighted average of all pressures over the surface area in contact with the ground. The position of the COP continuously moves to center the body. COP changes can be brought by postural sway or fluctuations and can be used to indicate a person’s ability to maintain balance. If swaying increases, the body can lose balance and an individual can fall. Therefore, a minimal COP path length indicates good balance (Hong, 2016). Assessment of static standing balance has proved an important source of information in various situations, including fall prediction in older people (Jarnlo, 2003).

Many studies have assessed balance using the COP (Park, 2006; Youm, Park, & Seo, 2008). However, COP measurement and data interpretation are complex processes for older people to adopt. Therefore, measuring devices must be easy to use for the elderly to scientifically measure and quantify their own balance ability. Therefore, this study aims to develop a COP measurement device and application to easily check balance ability for the evaluation of fall risk among the elderly.

RELATED RESEARCH

Scientific Measurement of Falls

Most studies involving the scientific measurement of falls use three-axis acceleration sensors to detect fall occurrence (Bagalà et al., 2012; Kim, Park, Kim, & Kim, 2011). In this type of study, acceleration data are collected during falls using independent tri-axial accelerometers (Igual, Medrano, & Plaza, 2013). The majority of existing research focuses on automatic fall detection (Bagalà et al., 2012).

For example, Kim et al. (2011) developed a portable fall detection system for the elderly using a three-axis acceleration sensor and a two-axis tilt sensor. The device was attached to the subjects and measured both acceleration and the body’s tilt angle during falls and during activities of daily living such as sitting or lying down, standing up, walking, and running. In the study by Park et al. (2013), a three-axis acceleration sensor and a two-axis gyro sensor were also used as a fall recognition system, the device being attached to the upper part of the subjects’ sternum. However, both of these studies used three-axis acceleration sensors to detect falls and not to evaluate the risk of falling.

Some research has used the GAITRite System to assess fall risks and to detect fall occurrences. Rantz et al. (2013) developed a continuous and unobtrusive in-home monitoring system that automatically detected when falls occurred or when there was a higher risk of falling. The system also alerted health care providers and family members so that they could intervene to manage falls. The fall risk assessment data and GAITRite parameters were captured using Microsoft Kinect and pulse-Doppler radar. Relatedly, although a number of current nursing studies have measured the risk of falling with scientific measures, using an assessment tool to check for the presence of fall risk factors, scores were not measured using a scientific device. It can be said that relatively little research has been conducted to quantify and monitor the risk of falls.

As previously outlined, balance is an important factor in falls, and the COP is an important variable in assessing balance (Winter, 1995; Youm et al., 2008; Park, 2006; Goble, Cone, & Fling,
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