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Frailty assessment based on wavelet analysis during quiet standing balance test

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ABSTRACT

Background: A standard phenotype of frailty was independently associated with an increased risk of adverse outcomes including comorbidity, disability and with increased risks of subsequent falls and fractures. Postural control deficit measurement during quiet standing has been often used to assess balance and fall risk in elderly frail population. Real time human motion tracking is an accurate, inexpensive and portable system to obtain kinematic and kinetic measurements. The aim of this study was to examine orientation and acceleration signals from a tri-axial inertial magnetic sensor during quiet standing balance tests using the wavelet transform in a frail, a prefail and a healthy population.
Methods: Fourteen subjects from a frail population (79 ± 4 years), eighteen subjects from a prefrail population (80 ± 3 years) and twenty four subjects from a healthy population (40 ± 3 years) volunteered to participate in this study. All signals were analyzed using time–frequency information based on wavelet decomposition and principal component analysis.
Findings: The absolute sum of the coefficients of the wavelet details corresponding to the high frequencies component of orientation and acceleration signals were associated with frail syndrome.
Interpretation: These parameters could be of great interest in clinical settings and improved rehabilitation therapies and in methods for identifying elderly population with frail syndrome.

1. Introduction

Frail syndrome has been found to be a risk factor for mortality, comorbidity, disability and hospitalization (Fried et al., 2001). The role of falls as a major source of morbidity and mortality in frail syndrome (Tinetti et al., 1988) has prompted a growing interest in postural control deficit measurements during quiet standing (e.g. postural steadiness; Campbell et al., 1989; Izquierdo et al., 1999; Prieto et al., 1993). Traditional postural steadiness evaluation typically includes separate tests with eyes open and eyes closed performed on a force platform and are usually based in the ability of an individual to maintain the position of the body within specific spatial boundaries without moving the base of support (Prieto et al., 1993; Mathie et al., 2004).

Traditional postural control tests on force platforms require a specialized and dedicated laboratory, not being suitable for ambulatory measurement of human body balance. Inertial/magnetic tracking technology opens new perspectives to evaluate postural sway. This measurement system offers a reliable and low-cost alternative to more sophisticated instrumented approaches that are available for measurement of balance during standing and walking (Moe-Nilssen, 1998a). An inertial/magnetic tracking system uses a combination of accelerometers, rate gyros and magnetic sensors (Zhu and Zhou, 2004; Moe-Nilssen, 1998a, 1998b; Sabatini, 2005). The signals obtained from a sacrum-mounted accelerometer can be used to distinguish between different balance conditions (e.g. feet together and apart, and eyes open and eyes closed while standing with feet together; Mayagoitia et al., 1999, Kamen et al., 1998), as well as to distinguish between healthy elderly subjects and idiopathic elderly fallers (Cho and Kamen, 1998; Overstall et al., 1977; Campbell et al., 1989). In a previous study, Martínez-Ramírez et al. (2010) showed complementary relationships between acceleration/gyros and force plates to detect dynamic stability deficits in subjects with chronic ankle instability. Moreover, they found that the accelerometer was more sensitive in some tests of the study. However, to the authors' best knowledge, no studies have examined the relationship between trunk orientation and acceleration signal and frail syndrome in older adults.

The displacements of the center of pressure (COP) and the body center of mass (COM) are notable indicators in postural steadiness

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