Human Movement Science 38 (2014) 319–330

Contents lists available at ScienceDirect

Human Movement Science

journal homepage: www.elsevier.com/locate/humov

Influence of wedges on lower limbs' kinematics and net joint moments during healthy elderly gait using principal component analysis

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ARTICLE INFO

Article history:
Available online 17 November 2014

PsycINFO classification:
3365
2240
2260

Keywords:
Insoles
Joint moments
Range of motion
Senior

ABSTRACT

The elderly are susceptible to many disorders that alter the gait pattern and could lead to falls and reduction of mobility. One of the most applied therapeutical approaches to correct altered gait patterns is the insertion of insoles. Principal Component Analysis (PCA) is a powerful method used to reduce redundant information and it allows the comparison of the complete waveform. The purpose of this study was to verify the influence of wedges on lower limbs' net joint moment and range of motion (ROM) during the gait of healthy elderly participants using PCA. In addition, discrete values of lower limbs' peak net moment and ROM were also evaluated. 20 subjects walked with no wedges (control condition) and wearing six different wedges. The variables analyzed were the Principal Components from joint net moments and ROM in the sagittal plane in the ankle and knee and joint net moments in frontal plane in the knee. The discrete variables were peak joint net moments and ROM in sagittal plane in knee and ankle. The results showed the influence of the wedges to be clearer by analyzing through PCA methods than to use discrete parameters of gait curves, where the differences between conditions could be hidden.
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http://dx.doi.org/10.1016/j.humov.2014.09.007
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1. Introduction

The elderly population is rising in number due to a longer life expectation (Johnson, 2011). The elderly are more susceptible to many disorders (Granacher, Muehlbauer, & Gruber, 2012) that alter the gait pattern and, as a consequence, they are more vulnerable to fall (Kirkwood, de Souza Moreira, et al., 2011; Marcus et al., 2012), which affect their health and independence. In this perspective, the gait analysis of the elderly healthy population seems to be important in order to constitute reference values for understanding the abnormal gait pattern, as well as to assess the influence caused by different interventions on it.

Wedge insoles are often used to correct altered gait pattern. This therapeutic approach has been described as a powerful tool for the compensation of small gait deviations. According to Kerrigan et al. (2002), the use of insoles can influence decisively the quality of walking. Based on the different parameters that constitute an insole (e.g. height, material and density, and its relation with the shoes (e.g. position), it is possible to build insoles adequate to individuals with different diseases (Kerrigan et al., 2002). However, there is no consensus about the influence of different wedge insoles on the typical gait pattern (Van Gheluwe & Dananberg, 2004). Some authors found differences in gait waveforms (Chiu & Shiang, 2007; Erhart, Mündermann, Mündermann, & Andriacchi, 2008; Schmalz, Blumentritt, Drewitz, & Freslier, 2006) while others concluded that these devices did not influence the gait pattern of healthy subjects (Kakihana et al., 2005; MacLean, Davis, & Hamill, 2006).

Most of the recent studies evaluating the gait pattern of elderly subjects presented results of kinematics (Chui & Lusardi, 2010; Kirkwood, Resende, et al., 2011), plantar pressure distribution (Kirkwood, de Souza Moreira, et al., 2011) or, combine kinematic and kinetic parameters (Russell & Hamill, 2011; Trombini-Souza et al., 2011). These results are commonly presented as parameters extracted from discrete points in the kinematic and kinetic curves (called in this study as traditional approach), generating a huge amount of data, that sometimes is difficult to interpret (Chui & Lusardi, 2010). This approach relies on the definition of discrete parameters that are subjective, and it becomes difficult to extract the same values of all temporal waves, especially in the presence of pathologies (Landry, McKean, Hubley-Kozey, Stanish, & Deluzio, 2007). A significant barrier to the clinical use of gait information is the complexity and large amount of data generated in biomechanical evaluations (Chau, 2001).

In the last two decades the interpretation of gait data was improved by different methods of multivariate analysis (Deluzio & Astephen, 2007; Jones, Holt, & Beynon, 2008; Muniz & Nadal, 2009; Olney, Griffin, & McBride, 1998; Sadeghi et al., 2002a). Principal component analysis (PCA) is a powerful method used to reduce redundant information and it allows the comparison of the complete waveform, explaining much of the variance in the data with relatively few factors, or Principal Components (PCs) (Sadeghi et al., 2002a). This approach may bring new insights about changes in gait pattern, to help clinicians to identify gait deviations and then to decide the best intervention for the patients. Therefore, the purpose of this study was to verify the influence of wedges on lower limbs' kinematics and net joint moment during walking of healthy elderly participants using PCA. In addition, the discrete gait parameters were also calculated in order to verify which approach (traditional or PCA) were more successful to determine changes in gait pattern. We hypothesized that using PCA the influence of wedges on lower limbs' kinematics and net joint moment waveforms will be observed. We also hypothesized that PCA approach will be more successful to determine changes in gait pattern compared to the traditional approach of discrete parameters.

2. Methods

This is a repeated measure study with a convenience sample. Ethical approval was granted by the institution in which the research was carried out. All participants freely signed an informed consent agreeing to participate.

2.1. Participants

Considering that the population with no gait dysfunction presents up to 10% of asymmetry for the force parameters between limbs during gait (Herzog, Nigg, Read, & Olsson, 1989), we assumed a

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