Human Movement Science 60 (2018) 115–121

Contents lists available at ScienceDirect

Human Movement Science

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

Full Length Article

The variability of the force produced by the plantar flexor muscles does not associate with postural sway in older adults during upright standing

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ARTICLE INFO

Keywords:
Force control
Calf muscle
Aging
Force variability
Visual feedback

ABSTRACT

The force variability of the plantar flexor muscles (PFM) appears to be directly related to the control of upright standing. Nevertheless, this association is still uncertain in older adults. This study aimed to evaluate the relationship between PFM force variability and postural sway in the upright standing in older women. Forty older women performed submaximal plantar flexion movements measured by force transducers coupled to an experimental chair. They performed this task during three sets of 20 s at 5% and 10% of their maximum voluntary isometric contraction with and without the aid of visual feedback of the force produced. The volunteers then stood barefoot, with eyes closed and feet parallel on a force platform, which allowed the measurement of the center of pressure displacement in the anteroposterior direction. The results did not indicate a significant association between force variability of the PFMs and postural sway in older women. It can be inferred that the force variability of the PFM does not play an important role in controlling the posture in this population, suggesting that other factors may influence the functioning of the postural control system in older adults.

1. Introduction

The force generated by the contraction of skeletal muscles is responsible for movement production (Oshita & Yano, 2012). The force produced during voluntary muscle contractions is not constant and fluctuates around its mean (Christou & Carlton, 2002; Enoka et al., 2003). This force variability is often quantified using the standard deviation of the force produced by the muscles (Hunter & Pereira, 2016) and is most often evidenced during isometric muscle contractions (Carville, Perry, Rutherford, Smith, & Newham, 2007; Tracy, 2007). The variation amplitude is directly conditioned to the motor unit firing behavior (Hunter & Pereira, 2016).

The greater the force variability during muscle contractions, the more difficult it becomes to perform certain daily tasks considered simple, such as handling small objects or even maintaining upright posture (Kornatz, Christou, & Enoka, 2005; Kouzaki & Shinohara, 2010; Oomen & van Dieen, 2017). In fact, the literature reports that the control of upright bipedal posture is directly associated with the control of the plantar flexor muscles (PFM) force variability at low intensities (Kouzaki & Shinohara, 2010; Oshita & Yano, 2012). Although many factors are related to the control of upright bipedal posture, the PFM is not activated with the greatest intensity during this task (Onishi, 2005), using roughly 5–10% of their maximum strength (Cattagni, Scaglioni, Laroche, Gremeaux, &

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https://doi.org/10.1016/j.humov.2018.05.009
Received 17 January 2018; Received in revised form 3 May 2018; Accepted 19 May 2018

Martin, 2016; Kouzaki & Shinohara, 2010; Mello, Magalhaes, & Kohn, 2013; Oshita & Yano, 2012). Kouzaki and Shinohara (2010) showed that the force variability of the PFM produced at an intensity of 5% or less of the maximum voluntary isometric contraction (MVIC) correlated with the postural sway of a combined sample of young and older adults. Corroborating this information, Oshita and Yano (2012) also pointed out this correlation for a sample of young adults, however, at an intensity relating to 10% of the MVIC.

Although these studies point to an association between the magnitude of postural sway and the force variability of PFM at low intensity (Kouzaki & Shinohara, 2010; Oshita & Yano, 2010, 2012), there are still points that need to be clarified. First, both studies provided visual feedback of the force produced by their volunteers during the force variability task, which is different from everyday situations where individuals do not have visual feedback of the force produced by their muscles to control their posture. Second, the results of the previously cited studies (Kouzaki & Shinohara, 2010; Oshita & Yano, 2012) are inconsistent concerning the relative intensity of the force variability that most closely correlates with postural sway (5% or 10% of the MVIC). Moreover, it is not known whether this association between PFM force variability and postural sway magnitude is present when considering only older adults. The analysis of this association specifically in older individuals becomes interesting as aging leads to a series of changes in the body, such as the lower control of PFM force at low intensities (Tracy, 2007) and the increase in postural sway, the latter being a predictor of falls occurrence (Abrahamova & Hlavacka, 2008).

Taking into account the previously mentioned associations, as well as the fact that PFM play a key role in maintaining upright bipedal posture (Heroux, Dakin, Luu, Inglis, & Blouin, 2014), Kouzaki and Shinohara (2010) suggested that the neural mechanisms involved in the PFM control appear to be similar in both maintenance of bipedal upright standing and the control of its force at low intensities. Thus, seeking a better understanding of the factors that interfere with postural control in older adults, this study analyzed the association between the PFM force variability and the postural sway in older adults. Based on the current literature, we hypothesize that this association also occurs in this population.

2. Methods

2.1. Participants

Forty older women (age = 66.3 ± 6.1 years; body mass = 65.1 ± 10.3 kg, height 1.60 ± 0.05 m) participated in this study. The research was approved by the local Research Ethics Committee. All participants signed the consent form before starting the study.

The exclusion criteria were: musculoskeletal injury in the lower limbs in the last six months, vestibular disease or self-reported neuropathy, medical treatment that affects the studied variables, neurological problems or other musculoskeletal problem that may interfere with the study's assessments, and cognitive deficits that could interfere in the understanding of the tasks proposed in the experiments (< 25 points in the Mini-Mental State Examination (Duncan, Schmidt, Giugliani, Duncan, & Giugliani, 2014)).

2.2. Procedures

Initially, the PFM force variability was evaluated. An experimental chair similar to the one used by Oshita and Yano (2011) (Fig. 1) was developed. The volunteers remained seated with knees flexed at 30°, hips flexed at 90°, ankles also flexed at 90°, and feet placed on two metal platforms attached to force transducers (MK, CSAZL model, São Paulo, SP, Brazil) with a capacity of 200 kg of force and data acquisition frequency of 5000 Hz. The participants' upper and lower limbs and trunks were fixed to the chair by belts to avoid compensatory movements (Fig. 1).

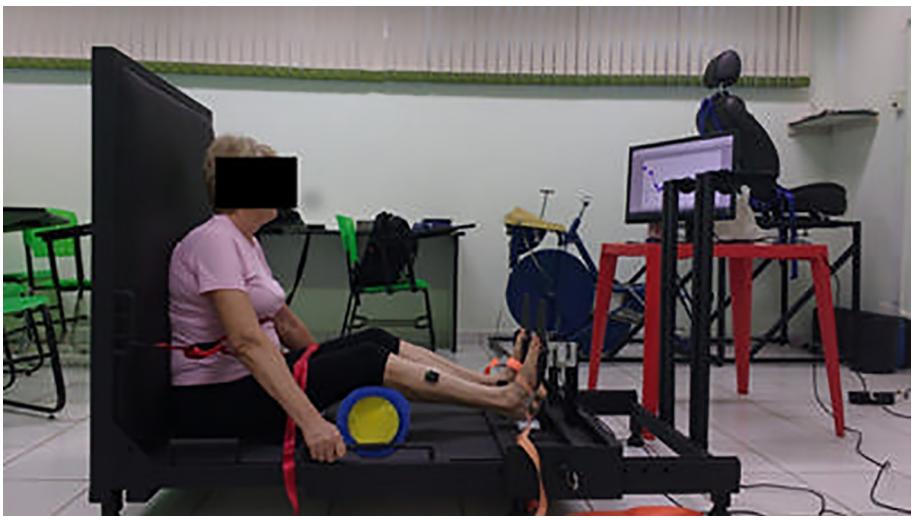

Fig. 1. Picture of the experimental setup of the force task. Note the stripes around the trunk and thigh to avoid compensatory movements of the participant.