Human Movement Science 52 (2017) 108–116

Contents lists available at ScienceDirect

Human Movement Science

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

Full Length Article

Measuring postural control during mini-squat posture in men with early knee osteoarthritis

M. Petrella [a,*], K. Gramani-Say [b], P.R.M.S. Serrão [a], G.C. Lessi [a], J.A. Barela [c], R.P. Carvalho [d], S.M. Mattiello [a]

[a] Department of Physiotherapy, Federal University of Sao Carlos, Rodovia Washington Luís km 235 – SP-310, São Carlos, SP 13565-905, Brazil
[b] Department of Gerontology, Federal University of Sao Carlos, Rodovia Washington Luís km 235 – SP-310, São Carlos, SP 13565-905, Brazil
[c] Institute of Physical Activity and Sport Sciences, Cruzeiro do Sul University, Rua Galvão Bueno, Liberdade, São Paulo, SP 01506-000, Brazil
[d] Department of Human Movement Sciences, Federal University of São Paulo, Av. Ana Costa, 95, Vila Mathias, Santos, SP 11060-001, Brazil

ARTICLE INFO

Article history:
Received 2 May 2016
Revised 17 January 2017
Accepted 23 January 2017
Available online 7 February 2017

Keywords:
Postural stability
Mini-squat
Knee osteoarthritis
Muscle strength WOMAC

ABSTRACT

Studies have suggested a compromised postural control in individuals with knee osteoarthritis (OA) evidenced by larger and faster displacement of center of pressure (COP). However, quantification of postural control in the mini-squat posture performed by patients with early knee OA and its relation to muscle strength and self-reported symptoms have not been investigated. The main aim of this cross-sectional, observational, controlled study was to determine whether postural control in the mini-squat posture differs between individuals with early knee OA and a control group (CG) and verify the relation among knee extensor torque (KET) and self-reported physical function, stiffness and pain. Twenty four individuals with knee OA grades I and II (OAG) (mean age: 52.35 ± 5.00) and twenty subjects without knee injuries (CG) (mean age: 51.40 ± 8.07) participated in this study. Participants were assessed in postural control through a force plate (Bertec Mod. USA), which provided information about the anterior-posterior (AP) and medial-lateral (ML) COP displacement during the mini-squat, in isometric, concentric and eccentric knee extensor torque (KET) (90°/s) through an isokinetic dynamometer (BiodexMulti-Joint System3, Biodex Medical Incorporation, New York, NY, USA), and in self-reported symptoms through the WOMAC questionnaire. The main outcomes measured were the AP and ML COP amplitude and velocity of displacement; isometric, concentric, and eccentric KET and self-reported physical function, stiffness and pain. No significant differences were found between groups for postural control ($p > 0.05$). Significant lower eccentric KET ($p = 0.01$) and higher scores for the WOMAC subscales of pain ($p = <0.001$), stiffness ($p = 0.001$) and physical function ($p < 0.001$) were found for the OAG. Moderate and negative correlations were found between the AP COP amplitude of displacement and physical function ($\rho = -0.40$, $p = 0.02$). Moderate and negative correlations were observed between the AP COP velocity of displacement and physical function ($\rho = 0.47$, $p = 0.01$) and stiffness ($\rho = -0.45$, $p = 0.02$). The findings of the present study emphasize the importance of rehabilitation from the early degrees of knee OA to prevent postural instability and the need to include quadriceps muscle strengthening, especially by eccentric contractions. The relationship between the self-reported symptoms and a lower and slower COP displacement

* Corresponding author.
E-mail addresses: ma.petrella@gmail.com (M. Petrella), kagramanis@yahoo.com.br (K. Gramani-Say), ppregina@yahoo.com.br (P.R.M.S. Serrão), giclessi@gmail.com (G.C. Lessi), jose.barela@cruzeirodosul.edu.br (J.A. Barela), raquelpcarvalho@gmail.com (R.P. Carvalho), stela.mattiello@gmail.com (S.M. Mattiello).

http://dx.doi.org/10.1016/j.humov.2017.01.011
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suggest that the postural control strategy during tasks with a semi-flexed knee should be further investigated.

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1. Introduction

Individuals with knee OA present limitations to perform daily life activities (Wegener, Kisner, & Nichols, 1997). The majority of these activities require a standing posture and the ability to maintain center of mass within a support base. In individuals with knee OA, poor postural control is demonstrated by displacement of the body's center of pressure (COP) during standing (Hassan, Mockett, & Doherty, 2001; Hinman, Bennell, Metcalf, & Crossley, 2002; Masui et al., 2006; Wegener et al., 1997).

Previously recorded postural control impairment in individuals with knee OA has been identified during upright standing tasks. However, there are some daily living tasks and exercises performed in knee OA rehabilitation that require postural stability during a semi-flexed knee posture, such as the mini-squat posture. This is an essential posture performed during tasks of retrieving something from a low table or the floor, using the toilet or performing sitting and standing tasks. Thus, impaired postural control from early knee OA, during the mini-squat posture may compromise the functionality and social participation of these patients. In knee OA rehabilitation protocols, postures involving maintenance of knee flexion are included principally for reasons of quadriceps strengthening, which has been recommended from early knee OA (Bennell, Wrigley, Hunt, Lim, & Hinman, 2013; McAlindon et al., 2014). Since sensorial inputs are necessary for maintaining center of mass within a support base and to avoid falls (Sibley, Straus, Inness, Salbach, & Jaglal, 2013), poor postural control evidenced by an increased and faster center of pressure displacement during the mini-squat posture can compromise functionality and expose individuals to the risk of falls. However, it is unclear if larger and faster displacement of COP is present during the performance of the mini-squat posture in individuals with early knee OA, demonstrating impaired postural control.

The mini-squat may be a challenging posture with regard to muscle strength recruitment, since the muscular system is required for postural control and muscle weakness could lead to impaired postural control (Horlings, van Engelen, Allum, & Bloem, 2008). For mini squat performance, eccentric quadriceps contractions are required to achieve posture, isometric quadriceps contractions for posture maintenance and concentric quadriceps contractions to return to the upright standing posture.

Quadriceps weakness have been observed in individuals with knee OA, even in the early stages of the disease stages (Palmieri-Smith, Thomas, Karvonen-Gutierrez, & Sowers, 2010), especially during eccentric knee extensor torque assessment (Hortobágyi, Garry, Holbert, & Devita, 2004; Serrão et al., 2014). However, it is uncertain whether knee extensor torque assessed in different types of contractions is related to postural stability during the mini-squat posture in individuals with early knee OA.

The literature demonstrates that tasks involving knee flexion are among those in which symptoms of knee OA become more evident (Marsh, Rejeski, Lang, Miller, & Messier, 2003). Hence, postural control in performing the mini-squat posture can also correlate with worse knee OA symptoms, such as physical dysfunction, stiffness and pain.

Considering the above, the aim of this study was to compare postural stability during the mini-squat posture (anterior-posterior and medial-lateral amplitude and velocity of COP displacement) and verify the correlation between these variables of postural stability, knee extensor torque (isometric, concentric and eccentric) and self-reported symptoms, in individuals with early knee OA. This study will support the performance of this task with regard to maintenance of postural control.

This study hypothesized that those with early knee OA would have poor postural stability during the bipedal mini-squat posture, demonstrated by larger and faster displacement of COP. A negative correlation was expected among the variables related to postural stability and extensor peak torques. In addition, it was hypothesized that with larger and faster displacement of COP, physical function, stiffness and pain would worsen.

2. Methods

2.1. Patients

The *a priori* sample size was calculated (G*Power 3.1.3 software) based on the anterior-posterior amplitude of COP displacement data from a pilot study with five subjects per group (two groups) (power = 0.8; alpha = 5%; effect size = 0.45). The minimum sample size required for the study was determined by the highest value obtained, which was sixteen subjects per group. Fifty-nine sedentary male volunteers aged 40–65 were recruited for the present study. After the initial assessment, 19 volunteers did not meet all the inclusion criteria. Thus, 40 sedentary male subjects participated in this study, divided into two groups, matched by age, height, weight and body mass index (BMI): the control group (CG) consisting of 20 volunteers with no joint disease and the osteoarthritis group (OAG) consisting of 20 volunteers diagnosed with knee OA grade I or II. Table 1 presents the anthropometric information for each group (Kellgren & Lawrence, 1957). Only men were included in

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