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Ankle strength impairments associated with knee osteoarthritis☆

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ABSTRACT

Background: Knee Osteoarthritis seems to negatively impact ankle biomechanics. However, the effect of knee osteoarthritis on ankle muscle strength has not been clearly established. This study aimed to evaluate the ankle strength of the plantar flexors and dorsiflexors of patients with knee osteoarthritis in different degrees of severity.
Methods: Thirty-seven patients with knee osteoarthritis and 15 controls, subjected to clinical and radiographic analysis, were divided into three groups: control, mild, and moderate knee osteoarthritis. Participants answered a self-reported questionnaire and accomplished a muscle torque assessment of the ankle using the Biodex dynamometer in isometric, concentric and eccentric modes.
Findings: The mild osteoarthritis group (peak torque = 26.85(SD 3.58)) was significantly weaker than the control (peak torque = 41.75(SD 4.42)) in concentric plantar flexion ($P < 0.05$). The control and mild osteoarthritis groups were not significantly different from the moderate osteoarthritis group (peak torque = 36.12(SD 4.61)) in concentric plantar flexion. There were no significant differences for dorsiflexion among the groups; however the control and moderate osteoarthritis groups presented large and medium standardized mean differences. The mild osteoarthritis group was significantly lower than the control and moderate osteoarthritis groups in the concentric plantar flexion by concentric dorsiflexion torque ratio.
Interpretation: Ankle function exhibited impairments in patients with knee osteoarthritis, especially in the plantar flexion torque, in which the mild osteoarthritis group was weaker than the control. Interestingly, patients with moderate knee osteoarthritis showed results similar to the control group in plantar flexion torque. The results raise the possibility of a compensatory mechanism of the plantar flexors developed by patients in more advanced degrees to balance other muscle failures.

1. Introduction

Knee osteoarthritis (OA) is a very common form of arthritis with prevalence rising over the course of age (Cross et al., 2014). The musculature around this joint performs an important role in the management of this disease. The negative impacts of OA on muscle function have been described, particularly concerning the quadriceps femoris muscle (Hinman et al., 2002; Hortobagyi et al., 2004; Liikavainio et al., 2010; Pietrosimone et al., 2011). The reasons for muscle implications in the course of knee OA are reported to be caused by arthrogenic inhibition (Hurley and Newham, 1993; Hurley et al., 1997; Shakespeare et al., 1985), atrophy due to disuse (Felson et al., 2000), or muscle compensations to cope with the recognized impairments of the quadriceps muscle that may occur (Igawa and Katsuhira, 2014). Nonetheless, conclusions have not been found concerning the role of the ankle muscles or ankle muscle strength in patients with knee OA, although these muscles play important roles in lower limb function in most daily activities (Kepple et al., 1997; Sutherland et al., 1980).

The ankle plantar flexors are associated with stability of the ankle and knee during gait (Sutherland et al., 1980; Winby et al., 2009). In the presence of induced deficiency of the plantar flexor muscles, the activity of the quadriceps muscle is extended to compensate for the absence of the ankle plantar flexors contribution to knee stability (Sutherland et al., 1980). The gastrocnemius muscles together with the quadriceps resist the knee adduction moment in the frontal plane during the stance phase of gait and thus prevent increased weight

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bearing on the medial knee joint, contributing to knee stability (Shelburne et al., 2006). Plantar flexor muscles are also associated with the push-off or forward propulsion phase of gait (Kepple et al., 1997; Winter, 1983). This muscle group transfers the energy generated by itself to the trunk in order to provide support and forward progression and also contribute to swing initiation (Meinders et al., 1998; Neptune et al., 2001; Winter, 1983). Ankle dorsiflexion also plays a role in stability. While descending stairs, the dorsiflexion of the support limb moves the center of mass anteriorly and provides stability for this activity (Koyama et al., 2015), whereas the contralateral ankle plantar flexor muscles develop an important eccentric role slowing the downward movement of the center of gravity during stair descent (Igawa and Katsuhira, 2014).

In patients with knee OA, some results concerning the ankle muscles have been verified. The activity of the medial gastrocnemius in patients with severe knee OA was lower than asymptomatic and moderate knee OA groups during the late stance cycle (Rutherford et al., 2011). Decreases in gastrocnemius activity were also seen during the propulsive phase in a severe knee OA group (Hubley-Kozey et al., 2008). Kinematic alterations have been reported as the greater ankle dorsiflexion found in OA patients at a late stance during gait, compared to a control group, were justified as a compensatory response in order to promote sufficient power generation at the ankle during propulsion (Levinger et al., 2013a). Patients with mild knee OA demonstrated greater plantar flexion than the controls at toe-off and swing phases (Gonçalves et al., 2017). Changes in muscle strength were also found in these patients, such as lower peak force of the gastrocnemius muscles during gait (Harding et al., 2015), and low plantar flexor torques in patients with severe knee OA (Hubley-Kozey et al., 2008), when compared with asymptomatic and moderate knee OA patients (Hubley-Kozey et al., 2006), in isometric contraction assessments.

Therefore, it seems that plantar flexion and dorsiflexion muscles suffer alterations in the presence of knee OA. Despite this, it is not well established if the appointed decrements in gastrocnemius muscle activity and gastrocnemius muscle force during gait, and the reported deficits in dorsiflexion kinematics, represent real changes in ankle strength, since the analysis of the aforementioned studies did not include a direct measure of muscle strength. Identifying possible changes in ankle muscle strength in this population would contribute to the development of appropriate treatment strategies. In addition, studies have often focused on the most severe grades of the disease, when joint damage and muscle deficits are settled, and are therefore less likely to benefit from a rehabilitation program.

The purpose of this investigation was to evaluate the ankle muscle strength of the plantar flexors and dorsiflexors between patients with mild and moderate knee OA and control individuals without knee OA. We hypothesized that the plantar flexor muscle strength would be significantly decreased in subjects with knee OA when compared to those without knee OA and that the greater the severity of OA the lower the muscular strength. We also believed that the dorsiflexor muscles' strength will be increased to compensate the strength loss in the plantar flexor muscles.

2. Methods

A cross-sectional case-control study was undertaken at the Physiotherapy Department of the Federal University of São Carlos (UFSCar), Brazil.

2.1. Participants

People from the general community were invited to participate in the study through the university website, local radio news, and magazine and newspaper advertisements. Individuals of both sexes, aged between 40 and 65 years and with radiographic signs of knee OA, unilateral or bilateral, and clinical signs according to the American College Rheumatology criteria (ACR) (Altman, 1991) were eligible for the study. Potential participants were excluded if they had: a body mass index (BMI) > 35 kg/m^2; undergone physical therapy treatment for the knee in the previous six months; the presence of systemic arthritic conditions; a previous history of trauma in the lower limb and ligament and meniscus injuries of the knee; previous surgery of the knee or hip; a diagnosis of hip OA; the use of corticosteroid infiltration at the knees in the previous six months; the presence of pain predominantly in another region of the body, and any medical condition which precluded participation in the proposed assessments (cardiovascular, respiratory, neurological, and/or musculoskeletal).

One hundred and forty two participants contacted the research laboratory by phone. Of this total, 113 appeared for the first interview. Seventy-six were excluded based on the exclusion criteria, or did not have an x-ray for the diagnosis of OA, or failed to return for the subsequent assessments. Of the remaining 37, 20 were males and 17 were females. Asymptomatic individuals with no radiographic signs of knee OA and who did not meet the exclusion criteria were matched by age and sex with knee OA groups to compose the control group.

Radiographic examination was performed on both knees during weight-bearing and in the anteroposterior, axial, and lateral positions (Hortobagyi et al., 2004). The presence of OA at the tibiofemoral and patellofemoral joints was classified according to the Kellgren and Lawrence criteria (KL) (Kellgren and Lawrence, 1957) by two specialists.

The local Human Research Ethics Committee approved the study and all participants provided written informed consent.

2.2. Procedures

Individuals were grouped into three groups: a control Group, composed of healthy individuals or with knee OA grade 0 or 1 of the KL; a mild OA Group, composed of patients with knee OA grade II KL; and a moderate OA Group, grade III KL. In case of bilateral knee OA, the knee with the greater KL score was used for the assessments in the study.

For the current study, all the participants completed a self-reported questionnaire and accomplished muscle strength assessments of the ankle.

2.2.1. Self-reported measure

For the assessment of knee disability the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) was used (Bellamy et al., 1988). The WOMAC is a self-report questionnaire for patients with knee OA. This questionnaire provides information regarding pain, stiffness, and physical function levels linked to knee OA during activities of daily living. In the WOMAC, higher scores indicate worse symptoms.

2.2.2. Ankle strength

Muscle torque tests of the ankle joint were determined using the Biodex System isokinetic dynamometer (Biodex Medical Systems 3 Pro, Shirley, New York, USA) and recorded with a sampling frequency of 100 Hz. The dynamometer calibration was checked before every evaluation session. Concentric, eccentric, and isometric contraction modes were conducted to evaluate plantar flexion and dorsiflexion muscular torque. The individuals were positioned according to the manufacturer's instructions: semi-reclined with knee in 30° of flexion and with the back of the seat tilted back at an angle of 70° from the seat line. A pad was fixed under the thigh for stabilization. The flexed-knee protocol allowed full range of motion at the ankle and prevented the hip and knee muscles from contributing (Hartmann et al., 2009). The individuals were stabilized with a seat belt around the hips, two shoulder straps that crossed the participant's chest, a strap across the thigh of the tested leg, and straps across the top of the forefoot and midfoot. The foot was positioned in a bracket such that the axis of

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