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The Knee



Kinematic alterations of the lower limbs and pelvis during an ascending stairs task are associated with the degree of knee osteoarthritis severity☆

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ABSTRACT

Background: Individuals with knee osteoarthritis (OA) generally demonstrate great difficulty in ascending stairs. The strategies and compensations used by these individuals in stair activities have not been fully established. The purpose of this study was to investigate the joint kinematics of the pelvis, hip, knee and ankle throughout the gait cycle, in the sagittal and frontal planes, in individuals with mild and moderate knee OA, during an ascending stairs task.

Methods: Thirty-one individuals with knee OA and 19 controls were subjected to clinical and radiographic analysis, divided into three groups: control, mild knee OA, and moderate knee OA. Participants answered a self-reported questionnaire, carried out performance-based tests, and their kinematic data were recorded during an ascending stairs task using an eight-camera Qualisys 3D-Motion analysis system.

Results: The individuals with moderate degrees of knee OA demonstrated kinematic alterations in the pelvis, hip, knee, and ankle in the sagittal plane. The individuals with mild degrees of knee OA demonstrated kinematic alterations of the hip in the frontal plane, and kinematic alterations of the ankle in the sagittal plane.

Conclusions: The ascending stairs task allowed verification of meaningful information regarding gait strategies used by individuals with mild and moderate knee OA. The strategies of these two groups of individuals are different for this task, although more pronounced in individuals with moderate knee OA. The findings should be taken into account in the development of rehabilitation programs.

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1. Introduction

Individuals with knee osteoarthritis (OA) generally demonstrate difficulty in ascending and descending stairs [1–4]. As stair negotiation is a more demanding motor task than walking, higher overload of the musculoskeletal system occurs [5–10]. Stair ascent requires important motor requests and previous studies have reported that this movement necessitates a higher external knee adduction moment and higher knee moments compared to the stair descent and walking in healthy subjects, [6,11], reaching joint moments close to the maximum limits of ankle moment capability [12].

Taking into account individuals with knee OA and their difficulty in stairs negotiation, some studies have directed their analysis to the lower extremities during stair ascent of these patients and found kinematic alterations [13–16]. The results reported

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predominantly focus on the knee joint [13–16]. Hicks-Little et al. [13] found smaller peak knee flexion during support, swing and foot strike in a group of individuals with mild to moderate OA in comparison with controls. Conversely, other studies on stair ascent did not observe differences in knee flexion angles between knee OA groups and controls [14–16]. Regarding the hip joint, one study reported greater flexion in individuals with knee OA [16], whereas other studies found no differences for hip flexion while ascending stairs [13,14]. However a greater hip abduction angle was verified at foot strike in individuals with knee OA [13]. In the ankle joint, studies on knee OA found no differences in the kinematic results during ascent [13,14,16]. Only one study regarding knee OA investigated the pelvic joint in stair ascent, reporting differences in pelvic tilt between individuals with knee OA and controls [16].

The discordant findings regarding the lower limbs and kinematics could be a result of different study methods. Kaufman et al. [15] only considered the maximum angle of knee flexion found during the entire gait cycle. Fok et al. [16] evaluated the kinematics of the trunk, pelvis, hip, knee and ankle only at the time of contralateral toe-off. Asay, Mündermann and Andriacchi [14] were concerned with the sagittal plane kinematics of the hip, knee, and ankle at the point of foot contact with the first step. Hicks-Little et al. [13] analyzed the kinematics of the lower limbs in the frontal and sagittal planes; however the pelvis joint was not verified. Therefore, the absence of clarification regarding some joints of the lower limbs, the pelvis, and some phases of the gait while ascending stairs does not allow definitive conclusions about this routine task. In addition, studies on stair ascent have not investigated the different degrees of severity of knee OA [13,15]; the majority included all degrees of severity in the OA groups [13,15]. One study included individuals with grade < 2 in the Kellgren and Lawrence classification of knee OA in the less severe group [14], a degree that is not considered knee OA according to the American College of Rheumatology criteria (ACR), and another study divided the groups regarding the concurrent presence of patellofemoral and tibiofemoral OA or patellofemoral OA in isolation [16].

Based on the above, greater elucidation on the limitations and strategies of the lower limbs while ascending stairs in this population is necessary. Due to the good responsiveness in detecting alterations in individuals with knee OA [17], climbing stairs is one of the most highly recommended tests to assess physical function [18]. Thus, the purpose of this study was to investigate the joint kinematics of the lower limbs at different moments of the gait cycle, both in the sagittal and frontal planes, in individuals with mild to moderate OA of the knee, during an ascending stairs task.

We hypothesized that the individuals with knee OA would present kinematic alterations in the pelvis, hip, knee and ankle due to the presence of symptoms and radiological signs of knee OA. Given the demands of the task, we also believed that compensatory strategies and limitations of this population might be highlighted while ascending stairs. And, lastly, we hypothesized that individuals with mild knee OA and moderate knee OA were likely to present different kinematic behavior. Besides contributing to the understanding of physical dysfunctions caused by knee OA, the results may provide new information to aid the design of interventions aimed at improving daily activities and quality of life in these subjects.

2. Methods

2.1. Participants

People from the general community were invited to participate in the study through the Federal University of São Carlos (UFSCar) website, local radio news, and magazine and newspaper advertisements. Individuals were eligible for the study if they were aged between 40 and 65 years with radiographic signs of knee OA, unilateral or bilateral, and clinical signs according to the American College Rheumatology criteria (ACR) [19]. The following exclusion criteria were applied: body mass index (BMI) > 35 kg/m²; physical therapy treatment for the knee in the previous six months; the presence of systemic inflammatory arthritis; a previous history of trauma in a lower limb or ligament and meniscus injuries of the knee; previous surgery in 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; any medical condition which precluded participation in the proposed assessments (cardiovascular, respiratory, neurological, and/or musculoskeletal); and an inability to walk and climb stairs without aid.

One hundred and fifty five individuals contacted the research group by telephone, of which 29 were excluded as they were older than 65 or younger than 40 years old, or presented systemic inflammatory arthritis. Thus, 126 were invited for clinical assessment in our research laboratory. Of these, 90 were excluded based on the criteria, or did not perform a radiography exam for the diagnosis of OA, or failed to return for the following assessments, leaving 36 participants.

Anterior–posterior and lateral radiographs during weight-bearing, and skyline radiographs were taken of both knees [20]. The tibiofemoral and patellofemoral joints were classified according to the Kellgren and Lawrence criteria (KL) [21] by two specialists. This scale is comprised of four levels of severity: Grade 0 presenting no radiographic signs; Grade 1 indicating doubtful narrowing of joint space and possible osteophytic lipping; Grade 2, definite osteophytes and possible joint space narrowing; Grade 3, moderate multiple osteophytes, definite joint space narrowing, some sclerosis, and possible deformity of bone ends; and Grade 4, large osteophytes, marked joint space narrowing, severe sclerosis, and definite deformity of bone ends. Asymptomatic individuals with radiographic signs graded as 0 or I (KL) who did not meet the exclusion criteria were matched for age and gender with the knee OA groups to compose the control group. The local Human Research Ethics Committee approved the research and all participants provided written informed consent.

2.2. Procedures

Participants were divided into three groups: control Group, composed of healthy individuals or with knee OA grade 0 or 1 on the KL; mild Group, composed of individuals with knee OA grade II on the KL; and moderate Group, grade III on the KL. For

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