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KINEMATIC AND KINETIC PARAMETERS DURING STAIR ASCENT AND DESCENT IN PEOPLE WITH EARLY-STAGE KNEE-JOINT OSTEOARTHRITIS

[1] Lynsey D Duffell, [2]Dominic FL Southgate, [1]Vivek Gulati and [1]Alison H McGregor
[1]MSK lab, Imperial College London, UK.
[2]Bioengineering Department, Imperial College London, UK

SUMMARY
End-stage osteoarthritis (OA) usually requires joint replacement surgery as there is no other available treatment for the condition. However, since the cartilage is a metabolic tissue, which can repair itself after minor damage, understanding the mechanisms involved with early OA is extremely important to delay or prevent the disease process. Twenty subjects with early knee OA and 20 matched controls were recruited and asked to ascend and descend a set of instrumented steps while motion data was recorded. Subjects with early OA showed small but significant differences in forces generated and range of motion at the knee joint in both their affected and unaffected sides. Minor adaptations can be detected in people with early OA, which may assist with early diagnosis and intervention.

INTRODUCTION
There is a growing interest in the mechanisms underlying degenerative diseases that affect ageing populations. Osteoarthritis (OA) is the commonest rheumatic disease and the knee (tibiofemoral) joint is the most susceptible joint [1], affecting as many as 12% of the population over the age of 60 years [2]. End-stage OA is usually treated with joint replacement, as there are no other known treatments however joint replacements have a limited life-span. Therefore understanding the mechanisms involved with early OA is extremely important to delay or prevent the disease process with a view to delaying the need for surgery and promoting cartilage regeneration.

Patients with advanced knee OA frequently display compensation patterns when performing activities of daily living (ADLs), such as altered knee kinetics in gait [3] and altered kinematic parameters during more challenging tasks such as stair ascent [4]. It is thought that the biomechanical adaptations that occur with OA are different for people with early and end-stage disease [5], and the current literature is focused on subjects with end-stage OA. One study that investigated stair descent in people with early knee OA noted no functional adaptations in the sagittal plane [6]. However, adaptations in mechanical loading in the coronal plane have long been implicated in the disease process [7], but are underexplored. Improving our understanding of the alterations associated with early OA may help design early interventions, with a target to prevent or delay the disease process in these patients.

METHODS
Twenty subjects diagnosed with unilateral early medial compartment knee OA from x-ray and MRI after presenting in the clinic with knee pain, and 20 sex and age (±7 years) matched control subjects, were recruited. This study had ethical approval from the South West London Research Ethics Committee and all subjects provided written informed consent.

A novel set of stairs, based around the use of a Kistler portable force plate (Kistler Type 9286B, Kistler Instrumented AG, Winterthur, Switzerland), was used to measure the forces at the feet. A custom frame was made consisting of three steps and handle bars, and the force plate could be supported on any of the three steps; for the present study it was positioned on the first step. A 10-camera Vicon motion capture system was used to capture the position of 35 markers attached to the subject (Vicon Motion Systems Ltd, Oxford, UK). The signals from the force plates were recorded at 1000Hz and synchronised with the motion capture data, recorded at 100Hz. Each subject was asked to ascend and descend the stairs three times leading with their left leg, and three times leading with their right. They were asked to do this at a normal and comfortable speed, without using the handle bars if possible.

Data was separated into gait cycles and time normalised, providing three gait cycles per subject, for each leg. Joint angles and moments were calculated using a custom made model written in Body Builder software (Vicon Motion Systems Ltd, Oxford, UK) [8]. The model used clusters on the thigh, shank and foot to calculate kinematic parameters, and force plate data were combined with this data to calculate kinetics, for the stance phase only.

Peak vertical ground reaction forces (GRF-Z) and peak angles and moments at the knee in the sagittal and coronal planes were measured, as well as knee range of motion (ROM). Statistical comparisons (SigmaStat) were made between OA and matched control subjects, using the student's paired t-test and the Wilcoxon test. Significance was set at $p < 0.05$.

RESULTS AND DISCUSSION

All subjects were able to ascend and descend the stairs without using the handle bars and reported no pain during the task. OA subjects had significantly reduced peak GRF-Z in their affected knee during stair ascent and their unaffected knee during stair descent (Figure 1). OA subjects also showed reduced knee ROM in the sagittal plane during stair descent in both their affected knee and unaffected knees (Figure 2). There were no significant differences in the kinematics measured in the coronal plane or moments measured in both the sagittal and coronal planes.

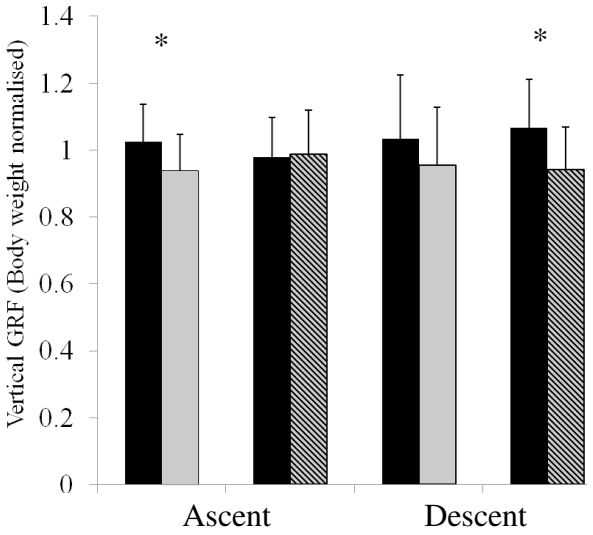

Figure 1: Mean (SD) vertical ground reaction force (GRF) for control (black) and osteoarthritis (grey) subjects' affected (solid) and unaffected (hatched) sides. *denotes significant difference between groups ($p < 0.05$).

We have noted small but significant differences in kinetic and kinematic parameters when comparing people with early knee OA and control subjects. The differences in the GRF-Z and sagittal plane knee ROM are in contrast with a previous study that identified no differences in these parameters when comparing similar groups [6]. However, reduced ROM at the knee joint has been reported previously during gait in people with moderate knee OA [9], which has been proposed to be associated with co-contraction of the quadriceps and hamstring muscles in an attempt to stabilize the knee joint [10]. Our results indicate that this adaptation can be detected earlier in the disease process during a challenging task such as stair descent.

Alterations in the coronal plane in people with early knee OA were not identified in the current study. Such adaptations may occur later in the disease process, associated with structural changes occurring at the knee joint [5, 11].

These data are important as detection of early adaptations associated with OA may assist us in early diagnosis as well as therapeutic interventions to delay or prevent the disease process. Since cartilage is a metabolic tissue, which is able to repair itself, such interventions also have the potential to promote cartilage regeneration in the very early stages of cartilage damage and OA development.

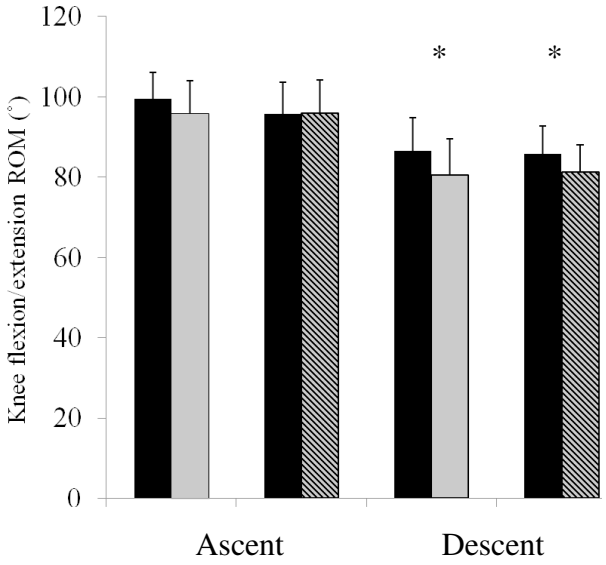

Figure 2: Mean (SD) knee range of motion (ROM) in the sagittal plane for control (black) and osteoarthritis (grey) subjects' affected (solid) and unaffected (hatched) sides. *denotes significant difference between groups ($p < 0.05$).

CONCLUSIONS

Stair ascent and descent are challenging activities of daily living. We have noted small biomechanical adaptations during these tasks in people with early knee osteoarthritis. This may be useful in the early diagnosis of knee OA, and in the design of early interventions.

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