



Balance and gait adaptations in patients with early knee osteoarthritis



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ABSTRACT

Gait adaptations in people with severe knee osteoarthritis (OA) have been well documented, with increased knee adduction moments (KAM) the most commonly reported parameter. Neuromuscular adaptations have also been reported, including reduced postural control. However these adaptations may be the result of morphological changes in the joint, rather than the cause. This study aimed to determine if people with early OA have altered gait parameters and neuromuscular adaptations. Gait and postural tasks were performed by 18 people with early medial knee OA and 18 age and gender-matched control subjects. Parameters measured were kinematics and kinetics during gait and postural tasks, and centre of pressure and electromyographic activity during postural tasks. OA subjects showed no differences in the gait parameters measured, however they demonstrated postural deficits during one-leg standing on both their affected and unaffected sides and altered hip adduction moments compared with controls. Increased activity of the gluteus medius of both sides ($p < 0.05$), and quadriceps and hamstrings of the affected side ($p < 0.05$) during one-leg standing compared with controls were also noted. This study has demonstrated that gait adaptations commonly associated with OA do not occur in the early stages, while neuromuscular adaptations are evident. These results may be relevant for early interventions to delay or prevent osteoarthritis in its early stages.

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1. Introduction

Despite knee osteoarthritis (OA) being the most common joint disorder in the UK, the pathogenesis of the disease is not fully understood. Mechanical adaptations in loading are thought to be a key factor in OA development and progression [1], and there is a body of evidence reporting kinematic gait adaptations in people with knee OA including reduced walking speeds, reduced knee flexion during weight acceptance and reduced overall range of motion at the knee joint [2–4]. Hip motion in the frontal plane has also been implicated in knee OA development, and one study reported that a greater hip abduction moment during gait protected against ipsilateral medial OA progression [5].

In terms of kinetics, the knee adduction moment (KAM), thought to represent loading on the medial compartment of the

joint, is the most commonly reported parameter in medial knee OA. It is thought that an increased ground reaction force (GRF), combined with an increased lever arm distance between the knee joint centre and the GRF vector, due to malalignment, results in higher KAMs in OA subjects. Previous studies have reported an increased KAM during gait in people with medial knee OA [3,6,7], and this parameter has also been correlated with an increase in OA severity [4,8,9]. However, whether or not increased KAM is involved in the initiation of OA remains a topic of debate. Indeed some studies report no difference in KAM between OA and control subjects [10] and increased KAM has been correlated with a reduction in pain [11], indicating that higher KAMs are a consequence of pain reduction induced by pain relief medication.

Most studies to date have focussed on people during the latter stages of the condition and there is less evidence characterising gait adaptations early in the disease process. We recently reported that people with early OA show asymmetrical weight distribution during the sit-to-stand task in that they place more load through their unaffected side; in addition knee flexion and adduction moments in the affected side were not significantly different compared with control subjects [12]. Two recent review articles also concluded that there was limited evidence to suggest an involvement of KAM in early OA [2,9]. While there is evidence to suggest that increased KAM may be involved in the progression of

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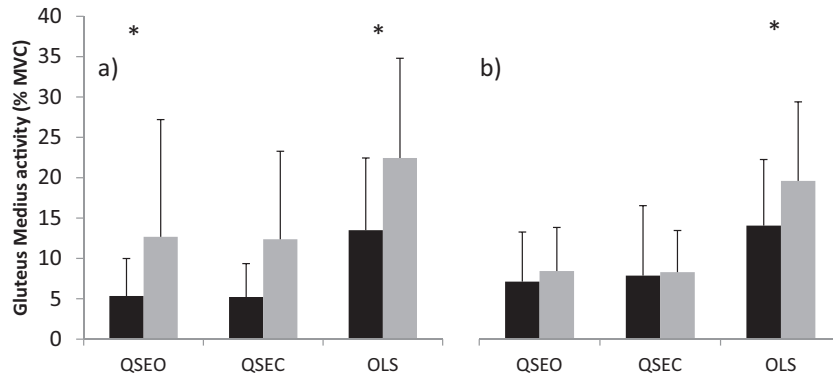


Fig. 3. Mean (SD) activity of the gluteus medius muscle for controls (black) and early OA subjects (grey) of the (a) left (controls) or unaffected (OA) side and (b) right (controls) or affected (OA) side for quiet standing with eyes open (QSEO) and eyes closed (QSEC) and one leg standing (OLS). * denotes significant difference between groups ($p < 0.05$).

additional neuromuscular deficits and a higher incidence of falls [15] and greater postural sway [16] has been noted in people with OA compared with control subjects of similar age. There is limited work investigating neuromuscular deficits in the early stages of OA development; our data indicate that alterations in muscle activation patterns and postural sway do occur in these subjects when compared with age- and gender-matched control subjects. Specifically, OA subjects had increased postural sway when standing on one-leg on both their affected and unaffected sides. They also demonstrated increased activation of the quadriceps and hamstrings muscles when standing on their affected side only, and increased gluteus medius activity, a hip abductor muscle, during quiet standing and one-leg standing on both their affected and unaffected sides. Kinetic outputs during OLS indicated that there were differences between control and OA subjects. The increased external hip adduction moment on the unaffected side of OA compared with control subjects may explain the concurrent increased gluteus medius activity during that task. This seems unlikely however because, on their affected side, OA subjects had lower HAM compared with controls but the gluteus medius activity was again increased. It is interesting to note that control subjects had significantly higher HAMs on their right compared with left sides. This indicates the leg dominance may be relevant, and therefore this factor should be considered in future studies.

It has been proposed that pain causes reduced postural control, since experimentally induced pain impairs postural stability in healthy individuals [29]. However, this does not explain our data since the subjects reported no pain in their affected side (on the day of testing) and reduced postural control was also noted when subjects were standing on their unaffected limb. Muscle weakness and reduced proprioception have also been related to alterations in postural stability [30]. While these parameters were beyond the scope of the present study, previous studies have indicated that both quadriceps strength [19] and proprioceptive accuracy [20] are similar in people with early OA compared with control subjects. It is possible that the altered muscle activity observed in this study, notably in the gluteus medius muscle on both the affected and unaffected sides, is related to the reduction in postural control, either as a causative or compensatory factor.

The increased activation of the vastus lateralis, vastus medialis and biceps femoris muscles during one-leg standing on the affected side of subjects with early OA is similar to that commonly reported in OA subjects during the stance phase of gait [17,18], and also previously noted in people with early OA [18]. This may be a protective mechanism over the knee joint, which occurs early in the disease process or may be a risk factor for knee OA.

It should be acknowledged that the groups in this study were not matched in terms of body mass and the OA subjects were significantly heavier compared with controls; all force data were

therefore body-weight normalised. Subjects were also not matched for other factors associated with the development of knee OA; while this would be ideal, it is unrealistic to control for such a wide range of factors. Our data indicate that few gait adaptations can be noted in people with early knee OA, however neuromuscular alterations are evident. Thus, in terms of understanding the causes of OA, more attention should be given to neuromuscular adaptations that occur early in the disease process and these should be measured longitudinally in people at high risk of OA development. Since neuromuscular adaptations are easily targeted by therapy, and it has been suggested that early cartilage defects are reversible [22], such therapeutic interventions require further attention to prevent OA or to delay or reverse OA progression.

In conclusion, we have noted no differences in commonly reported kinematic and kinetic variables measured during gait in people with early OA. People with early medial knee joint OA did however have reduced postural stability on both their affected and unaffected limbs and altered muscle activation patterns, specifically related to gluteus medius and the quadriceps and hamstrings. Further work is required investigating the neuromuscular adaptations associated with early OA to improve our understanding of the causative factors in OA development and to inform early rehabilitation strategies.

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Conflicts of interest statement: The authors declare no conflicts of interest.

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