Altering foot orientation changes knee loading in people with and without knee osteoarthritis during three daily activities

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INTRODUCTION

Knee osteoarthritis (KOA) is a highly prevalent joint disease and a leading cause of disability, especially in the elderly population. Pathological changes such as bone spurs, cartilage loss and joint space narrowing generally occur in the medial compartment of the knee [1], where loading magnitude is commonly represented by knee adduction moment (KAM) [2]. Additionally, KAM impulse accounts for both the magnitude and duration of loading, which can provide insights into long-term wear. Foot orientation modifications have been found to reduce knee loading [3], although previous research has only examined KAM during walking and it remains unknown if KAM is similarly reduced during stair climbing and sit-to-stand activities. This study aimed to compare foot orientation modifications on knee loading in KOA and healthy participants, across several different daily activities.

METHODS

Twenty-seven KOA patients (67% female, 57 ± 5 years, 168 ± 10 cm, 78 ± 13 kg) and twenty-nine healthy participants (59% female, 56 ± 5 years, 170 ± 8 cm, 74 ± 14 kg) performed overground walking, sit-to-stand and stair ascent activities on force plates embedded in the ground or two-step stairs. Participants moved at their preferred speed during three, foot progression angle (FPA) conditions; 10˚ toe-in (I), 10˚ toe-out (O) and 0˚ neutral (N), with each condition repeated five times. Three-dimensional kinematic (200Hz) and kinetic data (1000 Hz) were recorded and processed to identify FPA using the frontal angle of the foot, and knee moments (normalised to body mass) using inverse dynamics (Visual 3D). Statistical analysis was performed using general linear mixed effect modelling (MATLAB) on FPA and 1st peak KAM.

RESULTS AND DISCUSSION

During all three activities, toe-in FPA led to a lower peak KAM in both KOA and healthy groups (Fig 1, $P < 0.001$). As FPA became more toe-in, there was a greater reduction in peak KAM for the healthy group, compared to the KOA group across all three activities ($P \leq 0.001$), despite the KOA group having a higher overall KAM. Toe-in FPA significantly reduced KAM impulse during stair ascent and sit-to-stand, in both healthy and KOA populations ($P < 0.05$), but was not significantly altered during walking ($P = 0.560$). Reducing KAM impulse, indicates less cumulative loading on the knee, which may slow the disease progression and reduce the rate of developing KOA in higher risk populations.

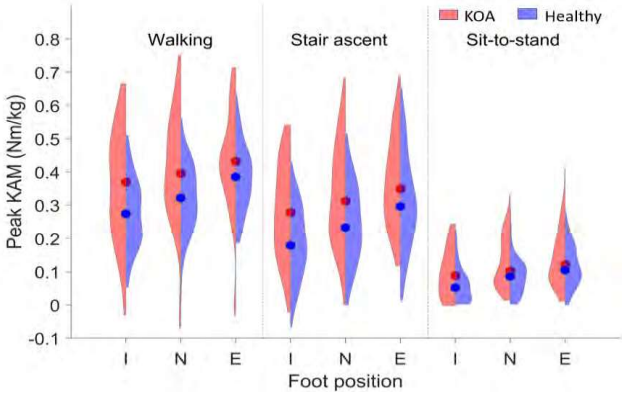

Figure 1 Violin plots of median peak KAM (range) during walking, stair ascent and sit-to-stand during toe-in, neutral and toe-out conditions for KOA and healthy population. I = toe-in, N = neutral, E = toe-out.

Toe-in FPA reduced KAM moment arm length, thus reducing the overall magnitude of KAM. This is consistent with previous literature that toe-in FPA can potentially migrate ground reaction force vector closer to the knee joint centre. In addition, toe-in FPA appeared to increase step width, which is an important factor to reduce knee loading.

All results showed a significant decrease in knee loading with toe-in FPA, indicating that toe-in gait can not only reduce knee loading during walking, but also in stair climbing and sit-to-stand, for both KOA and healthy populations. The results of this study suggest that gait modifications could assist in early clinical intervention and gait rehabilitation to slow the disease progression in KOA population, and could also be used as a preventive exercise strategy for people who are at increased risk of KOA. Future studies should consider the efficacy of long-term personalised gait retraining in patients with KOA, to assist with knee joint unloading and pain relief.

CONCLUSIONS

These results demonstrate the effectiveness of gait modification for clinical rehabilitation, which may also have substantial impact in preventive applications.

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