THE EFFECT OF FOOT ORIENTATION MODIFICATIONS ON KNEE JOINT BIOMECHANICS DURING DIFFERENT ACTIVITIES

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Introduction

Foot position during daily activities can influence the magnitude and rate of knee joint loading [1]. Over time, increased loading can cause cumulative damage to the articulating surfaces of the knee joint, especially in people with existing knee osteoarthritis [2]. Knee joint loading is difficult to measure in vivo as the majority of knee loading is distributed on the medial compartment of the knee joint, therefore, knee adduction moment (KAM) is commonly used as a surrogate measure for knee joint loading [3].

Foot orientation is believed to have an impact on knee loading during daily activities such as walking and standing from a chair, altering the direction of the ground reaction force vector to reduce the adduction moment arm, relative to the knee joint [4]. However, limited studies have systematically explored the effect of foot orientation on KAM in activities other than walking, which is crucial for improving functional mobility and quality of life in this population beyond the lab. Therefore, this study aims to evaluate the effect of different foot orientations (toe-in, parallel and toe-out) on knee loading across several daily activities (walking, sit-to-stand, and stair climbing).

Methods

Twenty-nine participants (56 ± 5 years, 170 ± 8 cm, 74 ± 14 kg) performed over-ground walking, stair climbing and sit-to-stand movements at their preferred constant speed under three foot conditions, 10° toe-in, 10° toe-out, neutral (0°). Participants performed walking and sit-to-stand on overground force plates, and stair climbing on a portable force plate embedded within the stairs. Each condition within each activity was repeated until five successful trials were obtained.

Three-dimensional kinematic (200 Hz) and kinetic data (1000 Hz) were recorded to obtain knee joint moments and foot progression angles. Foot progression angle was identified using the frontal angle of foot (defined as a 6DOF rigid body) to the global coordinate system (QTM). KAM was computed using inverse dynamics (Visual 3D) and normalised to body mass. Mean within-participant values were calculated for statistical analysis, with repeated measures ANOVA and Bonferroni post-hoc analysis used to compare the KAMs of three foot orientations across all activities.

Results

KAMs during toe-in foot position were significantly lower than those under neutral foot position during walking (P = 0.011), stair climbing and sit-to-stand (P < 0.001), while the KAMs during neutral foot position were significantly lower than those in toe-out foot position across all activities (P < 0.001) (Fig 1).

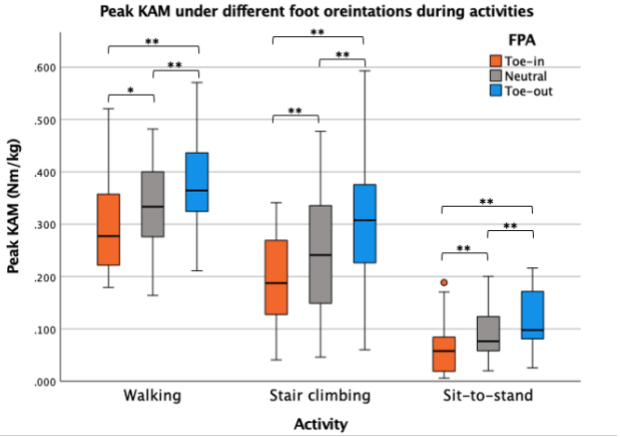

Figure 1: Median and interquartile, peak KAM for toe-out, toe-in and neutral foot position conditions during walking, stair climbing and sit-to-stand.

Discussion

All results showed a significant decrease in peak KAM during the toe-in foot position condition compared to toe-out and neutral foot positions, which is consistent with previous gait studies. The results of this study indicate that toe-in gait can reduce knee joint loading not only during walking, but also in stair climbing and sit-to-stand activities.

The results of this study will be of help in gait retraining programme in clinics and rehabilitation aimed at minimising knee loading and joint pain to slow the progression of the disease. They may provide a range of clinical guidance for injury prevention in a healthy older population under the common contexts of stair climbing and sit-to-stand, taking the technique outside the lab. Future studies should explore the effectiveness of altered foot orientation modifications on knee loading and pain reduction, in a patient population such as knee osteoarthritis.

References

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