KNEE OSTEOARTHRITIS SUBJECTS ACTIVATE MUSCLES TO UNLOAD MEDIAL CONDYLE

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INTRODUCTION

Subjects with knee osteoarthritis (OA) exhibit altered mechanical loading and neuromuscular control patterns in the lower limb during gait [1]. Hubley-Kozey et al. [1] suggested that increased activation of vastus lateralis and biceps femoris, and inhibition of medial gastrocnemius that is observed in OA subjects may be employed to reduce the compressive load on the diseased medial knee compartment. However, such efforts may not be captured by the resultant joint moments typically used as surrogate loading measures, and it is unknown if individuals could successfully reduce knee contact loading through selective changes in muscle activations.

Therefore, the purpose of this study was to test whether selective activation of lateral knee muscles can effectively unload the medial knee compartment during gait.

METHODS

Unilateral lower limb segment trajectories and ground reaction forces were collected for eight subjects with moderate knee osteoarthritis walking at self-selected speeds. Electromyographical (EMG) data were obtained from seven muscles spanning the knee: medial and lateral gastrocnemii, medial and lateral vasti, rectus femoris, biceps femoris, and semimembranosus.

A detailed lower-limb musculoskeletal model [2], including 35 muscles, was scaled to each subject. Inverse kinematics, inverse dynamics, and muscle moment arms about each joint were computed using OpenSim (NCSRR, Palo Alto, CA). Joint kinematics and dynamics were identical for both “Optimal” and “OA” conditions. Muscle forces were estimated in Matlab (The Mathworks, Natick, MA) to minimize a weighted sum of squares of muscle stress at each instant in the gait cycle. Muscle forces were constrained to be positive, and to balance the hip flexion, hip adduction, knee flexion, and ankle flexion moments. This set of baseline muscle forces was called the “Optimal” condition.

To test the effect of selective lateral activation on knee contact forces, muscle forces were perturbed to inhibit medial gastrocnemius (MG), and increase vastus lateralis (VL) and biceps femoris (LH) activations. Perturbation magnitudes were equal to the mean difference in normalized EMG principal component patterns between control and moderate OA subjects [1]. A complete set of perturbed “OA” muscle forces was then optimized in Matlab subject to the additional constraint that the three perturbed muscles (MG, VL, and LH) must maintain their prescribed patterns of activation. For both “Optimal” and perturbed “OA” conditions, axial tibial contact forces were computed using a frontal-plane moment balance at tibial-fixed medial and lateral contact locations.

RESULTS

Selective lateral activation resulted in a 0.3 times bodyweight (BW) increase in peak lateral contact force during early stance ($p < 0.01$) due to antagonistic co-contraction, but did not significantly change the total contact force (Figure 1). During late stance, there was a 0.4 BW decrease in peak medial contact force ($p < 0.01$) and a corresponding 0.3 BW decrease in total contact force ($p = 0.02$). Knee contact impulse was decreased for the medial condyle ($p = 0.03$), but increased for the lateral condyle ($p < 0.01$).

DISCUSSION & CONCLUSIONS

When the optimization model was perturbed to incorporate “OA” patterns of selective lateral activation, there was a significant decrease in medial contact load and a significant increase in lateral contact load. These changes are independent of external kinematics or dynamics, but are similar in magnitude to in vivo changes in contact loads detected during medial thrust and walking pole gait [3]. Results suggest that future knee osteoarthritis research should consider changes not only in external loading (i.e. knee adduction moment) but also in neuromuscular coordination.

REFERENCES


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