LATERAL MUSCLE CO-CONTRACTION IS NOT RELATED TO KNEE ADDUCTION MOMENTS IN PATIENTS WITH MEDIAL COMPARTMENT KNEE OSTEOARTHRITIS

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Introduction
Medial compartment knee osteoarthritis (OA) is highly prevalent and marked by an increased external knee adduction moment during gait. The increased adduction moment is positively correlated with medial joint space narrowing and medial joint loading, suggesting that the adduction moment can be used as a marker for the progression of medial knee OA. The increased adduction moment is thought to be accompanied by lateral femoral liploff concentrating the load on the medial compartment. This increased load may be minimized by greater activity in the lateral knee muscles to redistribute the joint’s reaction force back to the lateral compartment. Patients with medial knee OA have medial joint laxity and instability and may be unable to shift the load off of the medial compartment because they need large amounts of muscular co-contraction on both sides of the joint to restore dynamic stability. This muscle co-contraction could further exacerbate the breakdown of medial compartment articular cartilage. The purpose of this study was to determine the relationship between muscle co-contraction and knee adduction moment in patients with medial knee OA and genu varum.

Methods
Subjects
Twelve patients (6 female, 6 male) with medial compartment knee OA and genu varum (OA group), and twelve (6 female, 6 male) healthy age-matched control subjects (Control group) with neutral alignment gave informed consent approved by the IRB of the University of Delaware. Skeletal alignment was measured from weight-bearing radiographs of the lower extremity from the hip joints down to the feet. The body mass index of the OA group was 29.5 ± 4.1 kg/m², and the control group was 28.6 ± 5.7 kg/m². The OA group was 50.3 ± 7.4 years old, and the Control group was 49.5 ± 6.1 years old.

Measurement of Joint Laxity
Joint laxity was measured through stress radiographs, using a TELOS device. A varus stress was applied to measure the lateral joint space opening, and a valgus stress was used to measure medial joint space. Joint space measurements were made at the narrowest location between the femur and tibia in both the medial and lateral compartments. The medial laxity was calculated as the medial joint space during a varus stress minus the medial joint space during a varus stress. Lateral laxity was calculated as the lateral joint space during a varus stress minus the lateral joint space during a valgus stress.

Motion Analysis
All subjects underwent 3-dimensional lower extremity gait analysis. Kinematic data were collected at 120 Hz using a passive 6-camera system (VICON) and kinetic data were collected at 1920 Hz with a Bertec force platform. Data were analyzed using MOVE3D (NIH Biomechanics lab) to calculate the motions and moments of the hip, knee, and ankle using rigid body analysis. Muscle activity was recorded concurrently at 1920 Hz, using active surface electrodes (Motion Lab Systems) placed over the medial and lateral hamstrings (MH and LH), medial and lateral quadriceps (VM and VL), and medial and lateral gastrocnemius (MG and LG). A linear envelope of the muscle activity was created and a co-contraction index was calculated for the following antagonistic muscle groups: VM-MH, VM-LH, VL-LH, VL-LG. Co-contraction is defined as the simultaneous activation of antagonist muscles and was calculated according to the following equation:

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\text{Cocontraction index} = \frac{\sum_{i=1}^{n} \text{lower EMG}_{i} \times \text{higher EMG}_{i}}{\text{lower EMG}_{i} + \text{higher EMG}_{i}}
\]

A ratio of lateral to medial co-contraction was calculated (i.e. VLLG/VLLH and VMMG/VMMH) to determine the relationship between the muscle activity and knee adduction moments.

Statistics
Joint laxity and co-contraction indices were compared using independent samples t-tests. As walking velocity influences gait parameters, velocity was used as a covariate in one way ANCOVA to test group differences in knee adduction moment. A linear regression analysis was used to determine the presence of a relationship between muscle co-contraction and the adduction moment. Significance was set at α = 0.05

Results
The mean knee adduction moment of the OA group was 0.445±0.076 Nmm/kg•m which was significantly greater than the control group whose adduction moment was 0.364±0.103 Nmm/kg•m (p = 0.021). No difference was found between the groups in lateral joint laxity (p = 0.239), although the OA group’s medial laxity of 5.1±1.5mm was significantly greater than the control group’s laxity of 3.2±1.0 mm (p = 0.001). On the medial side of the joint, the OA subjects had a significantly greater VMMG co-contraction index (17.2 ± 7.3) compared to the control subjects, which was 10.9±7.2 (p = 0.043). No difference was observed between groups for the VMMH co-contraction indices (p = 0.908) or on the lateral side of the joint for the VLLH (p = 0.184) or the VLLG muscle groups (p = 0.370). The ratios between medial and lateral muscle co-contraction were not statistically different between the groups. The regression analysis was significant for the healthy control group (R² = 0.693, p = 0.005), however when the same regression was performed on the OA group, no significant relationship was observed (R² = 0.097, p = 0.664) (see Figure 1).

Discussion
These data support the hypothesis that the greater lateral/medial co-contraction ratios are strongly related to larger knee adduction moments in healthy individuals but not in the OA group. The lateral/medial co-contraction ratios in the control group may be assisting with the distribution of forces off of the medial compartment, reducing medial joint loading. The lack of relationship between the lateral/medial co-contraction ratios in the OA group suggests that individuals with knee OA do not increase lateral co-contraction to any great extent when large adduction moments are present. In fact, the individuals with knee OA could be using increased medial co-contraction, to reduce knee instability that results from increased medial joint laxity which was present. Indeed increased VMMG co-contraction was observed in the OA group. Greater medial co-contraction would not only fail to oppose a large and damaging knee adduction moment, it could also promote greater medial joint compression that would contribute to ongoing degeneration of the medial compartment of the knee. The results of this study suggest that patients with medial knee OA, genu varum and knee instability appear to use higher co-contraction between the medial knee muscles and fail to use greater lateral muscle co-contraction that could compensate for the large damaging adduction moments that can exacerbate OA. Further study is required to determine the relationship between muscle activation and the progression of knee joint instability and OA in the knee joint.

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