AN EMG DRIVEN MUSCULOSKELETAL MODELING APPROACH FOR ESTIMATING ARTICULAR LOADING AT THE KNEE

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INTRODUCTION

The knee adduction moment has long been used as an indicator of knee joint loading. The magnitude of the moment has been shown to correlate with the severity and progression of knee osteoarthritis (OA) [1], and as such has become an outcome measure of great interest to those studying gait mechanics. The relationship between the knee moment and joint loading is not straightforward, particularly when agonist/antagonist muscle groups are co-activated. Co-activation is believed to be a neuromuscular strategy to help stabilize the joint and is used by individuals with knee OA [2]. Computational methods which account for subject specific neuromuscular activation patterns are important when studying articular loading. In this paper we present results of an EMG-driven modeling approach to predict articular loading for patients with different muscle activation patterns and frontal plane knee moments.

METHODS

An EMG-driven musculoskeletal model was used to compute muscle forces at the knee during the stance phase of gait [3]. The muscle forces were used as inputs to a moment balancing algorithm to compute the contact forces necessary to balance the internal and external forces at the knee. Three adult male subjects participated in this study: one healthy, one with medial knee OA and one with lateral OA. Gait kinematics and ground reaction forces were sampled using traditional methods (ie., video cameras and force platform). Visual3D was used to compute the net joint moments at the knee. In addition, muscle activity was recorded from 3 of the 4 quadriceps, all 4 hamstrings and both gastrocnemii. Kinematic data were sampled at 120 Hz and EMG at 1080 Hz.

RESULTS AND DISCUSSION

The subject with medial OA had the largest adductor moment while the individual with lateral OA had the smallest (Figure 1, top panel). Both subjects with OA exhibited similar peak medial loading during early stance while loading of the lateral condyles was dramatically different during late stance (Figure 1, bottom panels). Negative loading for the subject with medial OA indicates lateral compartment unloading during late stance involving lateral soft tissue restraints (ie., ligament & capsule) to balance the external moment.

Loading profiles for the healthy subject in our study were similar to patterns reported for an elderly subject fitted with an instrumented knee implant [4]. Both subjects had a two-peak pattern of loading for the medial condyle with the first peak larger than the second. Lateral compartment loading for both subjects was less than noted on the medial side. The lateral compartment for our subject never became unloaded, consistent with findings reported by Fernandez et al. [4].

CONCLUSIONS

The EMG-driven musculoskeletal model predicted differential loading between the subjects with medial and lateral OA. Assuming joint moments of comparable magnitude, smaller loading implies a greater proportion of the frontal plane moment was supported by the muscles. Quadriceps strength has been implicated as an important predictor of function in patients with medial compartment OA [5]. The subject with medial OA appears to have used more of a muscle balancing strategy compared to the individual with lateral OA. Additional work is underway to evaluate the efficacy of this modeling approach for investigating healthy and pathological gait.

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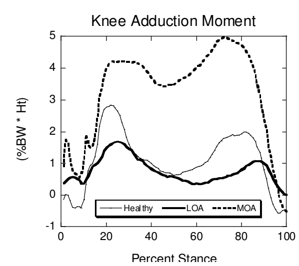
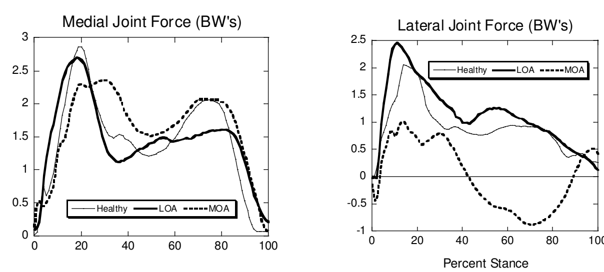
Figure 1: (top panel) representative knee adduction moment for each subject. MOA = medial OA, LOA = lateral OA. (bottom panels) Articular loading for the medial condyle (MC) and lateral condyle (LC).





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