

A POTENTIAL MECHANICAL PATHWAY FOR THE INITIATION OF OSTEOARTHRITIS IN THE OBESE POPULATION

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INTRODUCTION

Obesity has been identified as a major risk factor for knee OA. Yet, the precise mechanism describing the basis for obesity as a cause of knee OA remains unknown. Recent results (Andriacchi et al. 2004) have indicated that healthy and osteoarthritic cartilage thickness is related to the knee adduction moment during walking. A relationship between cartilage morphology and loading during gait for overweight and obese subjects without osteoarthritis similar to that in patients with knee OA would suggest a mechanical pathway of the initiation of OA in this population. Other mechanical factors may also play a critical role in the initiation of knee OA. For instance, knee hyperextension at heel-strike during walking has been observed in overweight and obese subjects (Messier et al. 2005). The purpose of this study was to test the hypotheses that (a) the ratio of medial to lateral articular cartilage thickness is correlated with the magnitude of the knee adduction moment during walking and (b) the ratio of anterior to posterior articular cartilage thickness in both medial and lateral compartments is correlated with the degree of hyperextension of the knee at heel-strike in overweight and obese subjects and age and gender matched control subjects.

METHODS

Six overweight and obese subjects (3 male; age 48.5 ± 7.7 yrs; mass 84.7 ± 15.1 kg; height 1.70 ± 0.15 m; body mass index 29.2

± 0.3 kg/m²) and six age and gender matched normal-weight control subjects (46.5 ± 10.2 yrs; 66.6 ± 6.3 kg; 1.73 ± 0.05 m; 22.3 ± 1.1 kg/m²) underwent magnetic resonance imaging (MRI) of their knees (fat suppressed 3D spoiled gradient echo sequence) (Koo et al. 2005). Cartilage was segmented in MR images, and three-dimensional thickness models were created. Average cartilage thickness was calculated for anterior, middle, and posterior regions of the medial and lateral femur condyles and anterior and posterior regions of the medial and lateral tibia plateau. Medial/lateral and anterior/posterior cartilage thickness ratios were computed. Then, a six marker link model, optoelectronic system, and force plate were used to collect kinematic and kinetic data for three walking trials at self-selected speed. The knee flexion angle at heel-strike and the first peak knee adduction moment were determined (Schipplein, Andriacchi, 1991). Paired Student's t-tests were used to compare subject characteristics, cartilage thickness, and average gait variables between groups ($\alpha=0.05$). Linear regression analyses were used to relate cartilage thickness ratios to gait variables within each group ($\alpha=0.05$).

RESULTS AND DISCUSSION

Overweight and obese subjects had a negative correlation between the medial/lateral cartilage thickness ratio for the tibia and the first peak knee adduction moment whereas the control subjects had a positive correlation (Figure 1). This result

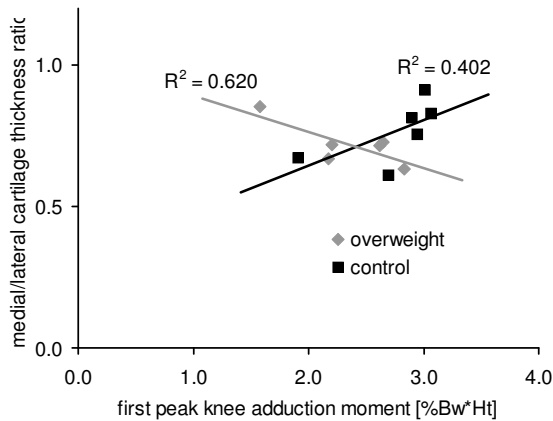


Figure 1: Relationship between medial/lateral cartilage thickness ratio for the anterior cartilage region and the first peak knee adduction moment.

indicates that the cartilage thickness at the knee joint in overweight and obese subjects responds to loading during gait in a manner similar to patients with OA as previously reported (Andriacchi et al. 2004). These findings suggest the possibility that increased weight initiates a pathway of cartilage degeneration prior to the emergence of OA symptoms. This result and the previous finding that patients with more severe knee OA have a higher knee adduction moment compared to healthy subjects (Mündermann et al. 2004) supports the interpretation that a higher knee adduction moment may not be the cause of OA but the result of morphological changes associated with the disease. The results of the current study suggest that cartilage of overweight and obese subjects is sensitive to the load distribution at the knee during walking and reacts similarly to higher loads as osteoarthritic cartilage even though the load magnitude is in a healthy range.

Another important finding of this study was that the negative correlation between medial/lateral thickness ratio and adduction moment was more pronounced in the anterior than the posterior tibia region ($P = 0.032$). The anterior/posterior cartilage

thickness ratio for the lateral tibia plateau was higher for the overweight and obese subjects than for the normal-weight subjects (+25.6%; $P = 0.011$). Three of the six overweight and obese subjects had knee hyperextension at heel-strike that would be considered pathological (knee flexion angle $< -5.0^\circ$). The anterior/posterior cartilage thickness ratio showed a strong relationship with knee hyperextension at heel-strike (overweight and obese subjects: $R^2=0.637$; $P = 0.028$) suggesting that knee hyperextension at heel-strike may be critical. Thus, it is possible that in subjects with greater knee hyperextension, the femur is in contact with the tibia more anteriorly at heel-strike during walking and that cartilage adapts to these differences in loading area.

This study represents a first step in evaluating a proposed mechanism that involves testing the relationship between variations in *in vivo* functional mechanics and variations in cartilage thickness in an obese population, and thus a potential mechanical pathway for the initiation of OA in the obese population. In addition, these findings suggest the potential benefits of the earlier introduction of a load modifying intervention in this population.

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