GAIT CHARACTERISTICS OF PATIENTS WITH KNEE OSTEOARTHRITIS

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INTRODUCTION Osteoarthritis (OA) is the most prevalent form of arthritis in the elderly. It is estimated that 9% of men and 18% of women over age 65 have knee osteoarthritis[2]. Individuals with OA experience pain, stiffness, and decreased range of motion of the joints, which may significantly limit an individual's ability to rise from a chair, stand comfortably, walk, or climb stairs. The purpose of this study was to analyze the gait characteristics of subjects with knee osteoarthritis. We hypothesized that these patients will compensate to minimize joint loading and resultant pain.

METHODS This study was performed on 139 adults (47 males and 92 females) diagnosed with knee OA ($\geq$ Grade II). The subjects had a mean age of 57±12.5 years (range 30-82), mean weight of 85 (±17) kg and mean height of 167 cm (±9.7). All subjects had symptoms greater than six months. Subjects were not included if they had inflammatory arthritis or previous major lower extremity surgery. As a basis for comparison, 16 normal, healthy subjects (7 males and 9 females) were also studied for comparison with the patients. The normal subjects had a mean age of 31 ± 8 (range 20-42), mean weight of 73(± 15) kg and mean height of 172 (± 11)cm.

The walking conditions studied were those most commonly encountered during activities of daily living[6], namely: level walking, ascending stairs, and descending stairs.. Kinematic parameters were acquired with a computerized motion analysis system utilizing six video cameras (Expertvision-Motion Analysis Corporation, Santa Rosa, CA). A set of 21 reflective markers was placed on the body of each subject as described by Kadaba et al.[4]. One set of data corresponding to the standing position (static data) was recorded in order to calculate the location of the joint centers. Ground reaction force data and video data were collected at a sampling rate of 60 Hz. The level walking was performed on a 12 meter walkway. The stairs were a flight of four, 18-cm high stairs with a 25 cm run. OrthoTrak 4.0 (Motion Analysis Corp., Santa Rosa, CA) was used, to calculate the joint kinematics and kinetics. The knee joint moments were normalized to body weight and body height and were expressed as net internal moments. Results were averaged from three trials for each gait condition. The gait parameters for the involved leg of each subject were used. For subjects with bilateral involvement, the mean of the gait parameters from both limbs was used. A two-tail, unpaired Student t-test was used for determining significant differences when there was no difference in walking velocity. If there was a significant difference in a walking velocity, an Analysis of Covariance was used to control for differences in gait velocity. Statistical differences were defined as significant at the $\alpha = 0.05$ level.

RESULTS The subjects with OA walked slower than the normal subjects. These differences in walking velocity were statistically significant for stair ascent and descent. However, on level ground the difference was not significant. The knee flexion angle on stairs was greater than on level ground. The maximum flexion angle for the patients with OA did not differ significantly from the flexion angle for healthy subjects during stair walking ($p>0.42$). During level walking the patients with OA had 5 degrees less peak knee motion than normal subjects (54 ± 7 vs. 59 ± 4, $p<0.01$). There was no significant difference in the time of maximum knee flexion for all three walking conditions ($p\geq0.15$). The peak knee extension moment was significantly less for the patients with OA than the normal subjects ($p<0.04$)(Figure 1). During stair ascent, the timing of the maximum knee extension moment was significantly delayed in the patients with OA ($p<0.01$). The peak knee extension moment occurred at 32 percent (±23) gait cycle for the patients with OA compared to 19 percent (±8) gait cycle for the normal subjects. However, the knee flexion angle was not significantly different ($p=0.06$). Gender differences were identified in the patients with OA. The female subjects walked faster on level ground, but slower during stair ascent and descent. The difference in gait velocity was statistically significant for level ground only. The female subjects had a greater peak knee flexion (Figure 2a) while there was no significant difference in the time of peak knee flexion. The difference in peak knee flexion is most likely due to a significant difference ($p=0.001$) in height between the female and male subjects, 162 ± 6cm vs. 177 ± 8 cm respectively. The female subjects generated greater peak

knee extension moments (Figure 2b). These differences were statistically significant for both stair ascent and descent.

DISCUSSION This study demonstrated that subjects with OA attempted to minimize their pain by reducing the knee extensor moment. The contact forces in the knee joint are proportional to the net external moment. A large internal moment, needed to balance a large external moment, will produce a large contact force. The results of this study agree with other studies that show the demands of stair walking produce larger external moments [1,5,8] and a 12 to 25 % increase in knee loading[7]. However, these other studies have all been performed on normal, healthy individuals, whereas the current was performed on subjects with OA. The patients with OA did not demonstrate a reduction in knee range-of-motion during either stair ascent or stair descent. This may be due to the early stage of OA studied. The peak knee moment during stair ascent and descent occurred at a flexion angle of about 50 degrees whereas during level walking the largest moment occurred when the knee was near full extension (~20°). Female gender is a significant risk factor for OA. A longitudinal study of knee OA showed that women have a 1.8 times greater risk of developing OA than men[3]. Among those over age 65 years, the prevalence of symptomatic knee arthritis in women is twice the rate in men[2]. The exact etiology for this difference in prevalence is unknown. The female subjects with OA had greater knee extension moments than their male counterparts. This increased knee loading may be partially responsible for the increased prevalence of OA in females.

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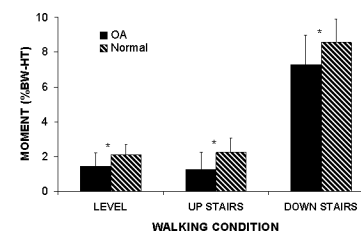8. Yu, B., et al., Clin Biomech 12(5):286-293, 1997.

Figure 1. Maximum knee internal extension moment during level walking, stair ascent and stair descent. The patients with osteoarthritis had a significantly lower moment for all walking conditions ($p<0.04$).
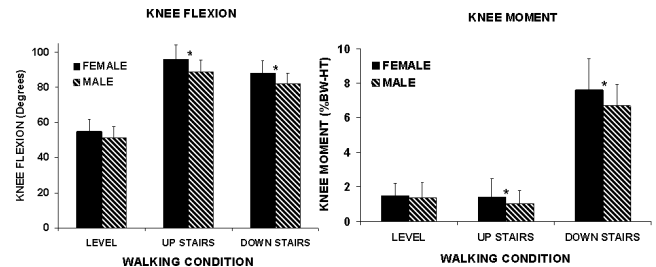

Figure 2. Gender differences in knee mechanics during gait. The female subjects had greater knee flexion and greater knee moments for all walking conditions.

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