Patients with Knee Osteoarthritis Adopt Stair Climbing Patterns to Reduce Quadriceps Demand

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Introduction: Loss of quadriceps function associated with osteoarthritis (OA) of the knee is a common clinical finding (Slemenda et al. 1997). In fact, there are therapies directed at improving quadriceps function in patients with knee OA (Miakesky et al. 2006). While the cause for the loss of quadriceps function is likely the result of several conditions, it is possible that patients may adopt patterns of movement during stair climbing to compensate for the loss of quadriceps functions. Compensatory mechanisms have been reported for patients with compromised quadriceps function following total knee replacements (TKR) (Andriacchi 1982), and it has been suggested that these patients lean their trunk forward to compensate for weakness in their quadriceps muscle (Andriacchi et al. 1985). Thus, as the severity of knee OA increases, it is likely that patients adopt compensatory strategies that are associated with a forward trunk lean. Identifying this compensatory mechanism would provide a useful method to evaluate quadriceps function without the need of tests requiring the exertion of maximum effort. The purpose of this study was to test the hypothesis that patients with knee OA of varying severity adopt a compensatory mechanism to reduce knee flexion moment by exhibiting a greater trunk flexion angle while ascending stairs.

Materials and Methods: Twenty-two patients with radiographically diagnosed knee OA (14 female, 8 male; age: 63.3 ± 7.3 yrs; height: 167.9 ± 8.6 cm; mass: 71.5 ± 13.9 kg) and 16 physically active adults (7 female, 9 male; age: 59.9 ± 6.2 yrs; height: 172.7 ± 8.9 cm; mass: 72.9 ± 12.5 kg) participated in this study. The physically active control subjects had no musculoskeletal involvement. OA patients were divided into severity based on their Kellgren-Lawrence grade (KL): less severe (KL ≤ 2, n = 11) and more severe (KL ≥ 3, n = 11) (Kellgren & Lawrence 1963). Each subject was asked to perform three stair ascending trials on each leg. The stairs consisted of two steps with force plate on the first step (height first step: 20.5 cm; height difference between first and second step: 22 cm). The more severe knee for OA patients was included in the analysis. Lower limb kinematics and kinetics were calculated as previously reported (Schipplein & Andriacchi 1991). The maximum knee external flexion moment during stance of the first step was calculated. The position of the trunk was defined by the midpoints of the lines connecting the iliac crest and shoulder markers. The trunk flexion angle was calculated as the angle of the upper trunk segment relative to the global vertical axis (Fig. 1). Values were averaged for the three trials. Analyses of variance (ANOVA; α = 0.05) with Tukey post-hoc tests were used to detect differences in kinematic and kinetic variables between less and more severe patients and control subjects.

Results: Subjects with more severe OA showed 37.2% lower knee flexion moments compared to control subjects (P = 0.002). More severe OA subjects also had a 6° greater trunk flexion while ascending stairs compared to the control subjects (P = 0.012). The less severe OA subjects did not have significant differences in knee flexion moment and trunk flexion angle when compared to controls (P = 0.286 and P = 0.229, respectively). No significant differences in knee and hip flexion angles between the OA subjects and control subjects were observed (P = 0.185 and P = 0.065, respectively).

Discussion: The results of this study support the presence of a compensatory mechanism to reduce the quadriceps demand during stair climbing in patients with more severe knee OA. Unlike previous results (Kaufman et al. 2001), this mechanism was not observed in patients with less severe knee OA. The reduction or avoidance of quadriceps used to balance the external knee flexion moment could potentially cause previously reported reductions in quadriceps strength in patients with knee OA (Slemenda et al. 1997). The OA patients in this study are not as disabled as patients that receive a TKR, yet they presented with kinematic and kinetic patterns similar to those found post-operatively in TKR subjects (Andriacchi et al. 1985). Thus, it is likely that patients with knee OA develop these kinetic patterns before surgery and continue the patterns after surgical intervention due to continued quadriceps weakness and altered joint loading. Assessing flexion moments during stair climbing may be a useful method for evaluating quadriceps function. The results of this study may have important implications for the treatment of patients with knee OA and for rehabilitation regimens post TKR surgery. It is speculated that pain thresholds may play an important role in a body's ability to adopt gait patterns to reduce joint loads during activities of daily living.


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