Knee Kinematics and Kinetics during Step up and down in Patients with Knee Osteoarthritis

INTRODUCTION:
Knee osteoarthritis (OA) is a degenerative disease. Biomechanical studies have revealed a characteristic of knee motion during gait in OA patients, particularly in severe cases. We previously examined the difference of the knee motion between early and severe OA. Our results suggested that knee abduction and tibial rotation were different due to OA severity. We here aimed to investigate whether knee kinematics would be different between early and severe OA during step up/down motion. This is one of the most important movements in daily life. Patients with knee OA complain the knee pain not only during gait but also during step up/down motion like stairs. We therefore hypothesized that knee movements during step up/down motion are different due to OA severity.

METHODS:
Thirteen patients with knee OA were recruited. All subjects were examined while stationary in the standing position and performed box step up/down that simulated the stair up/down. The box height was 30cm. Subjects with a history of serious musculoskeletal injuries, musculoskeletal injuries in the past 6 months, and injuries influencing gait were excluded. Before starting of this study, subjects had an X-ray and were evaluated by the orthopedic surgeon. All subjects provided a written informed consent; the study was performed in accordance to the guidelines approved by the Ethics Committee of National Rehabilitation Center for Persons with Disabilities, Japan.

Twenty-eight reflective markers were secured using a Helen Hayes configuration for full body analysis. Three-dimensional movements were recorded using an 8-camera high-speed motion analysis system (Hawk: Motion Analysis Corp., CA, USA) in each trial. To determine foot contact patterns, ground reaction forces were recorded using a force plate (9287A; Kistler Japan Co. Ltd., Tokyo, Japan). The motion and force data were recorded at 100 Hz and 1000 Hz, respectively.

Knee kinematics and kinetics were calculated using Kintools software (Motion analysis Corp., CA, USA). In each trial, we calculated the angular displacements and joint external moment in flexion/extension and abduction/adduction. We calculated peak value of each variable during stance phase. The subjects were required to perform at least 3 successful trials of step up/down motion, respectively.

Subjects were instructed step up and down motion with barefoot at their own self-selected speed. We determine the step up phase as between the moment of toe off in affected limb from the floor and the moment of knee full extension in the other limb on the box. Step down phase was determined as between from the beginning of knee flexion in accepted limb and the moment of foot contact in the same limb on the floor. Toe off and foot contact were decided by vertical reaction force.

Student's t-test was used to determine the difference in knee joint kinematics and kinetics and the other gait variables between early OA and severe OA. OA severities of 26 knees were graded using the Kellgren–Lawrence grade: grade 0, 1 and 2 indicated early OA (n=19), and grade 3 and 4 indicated severe OA (n=7). The alpha level was set at p<0.05.

RESULTS:
There were no significant difference in step up and step down time between the groups (p>0.05).

Figure 1 shows the mean time-course comparison across OA severities for knee flexion/extension and knee abduction/adduction during step up. The peak knee flexion angle in the severe OA (mean(SD)=82.5° (5.0)) was significantly greater than that in early OA (77.3° (4.2)) (p<0.05). The abdution angle during step up were not significantly different between groups (p>0.05). The knee abduction angle in severe OA (-0.44 Nm/kg (0.10)) was significantly greater than that in early OA (-0.34 Nm/kg (0.08)) (p<0.05), although there was no significant difference in knee flexion moment between severe OA (0.54 Nm/kg (0.11) and early OA (0.5 Nm/kg (0.33)) (p>0.05).

Figure 2 shows the mean time-course comparison across OA severities for knee flexion/extension and knee abduction/adduction during step down. The peak knee flexion angle in the severe OA (mean(SD)=91.5° (6.3)) was significantly greater than that in early OA (81.3° (6.2)) (p<0.05). The knee flexion angle in step down was greater than step up (p<0.05). The abduction angle during ascending were not different significantly between groups (p>0.05). The knee flexion and abduction moments in severe OA (0.69 Nm/kg (0.24), and -0.37 Nm/kg (0.14)) were not significantly different than that in early OA (0.66 Nm/kg (0.32) and -0.38Nm/kg (0.09)).

DISCUSSION:
The results of this study revealed different characteristics of knee kinematics and kinetics variables during step up/down motion due to OA severities. In this study, knee abduction moment in severe OA was greater than early OA. This would be associated with changing joint alignment and joint deformity. With OA progression, joint space would be decreased, and joint stability would be decreased. Our previous study suggested that instability of knee abduction due to joint OA progression was in the progressed OA patients.

In conclusion, present study suggested that step up/down motion like stairs, which is painful activity in OA patients, is more risky movement in the progressed OA patients.

REFERENCES: