Compensatory mechanisms used by patients with hip osteoarthritis during walking and turning

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INTRODUCTION

Patients with hip OA suffer from pain, limited joint range of motion and muscle weakness for long periods. Previously, kinematic and kinetic adaptations during straight walking have been studied in patients with hip OA and compared with those of healthy individuals; the patients commonly show decreased gait speed, stride length, hip joint motion and hip muscle moments [1-4,6].

A change the direction of travel while walking is essential for functional mobility and is a common occurrence in activities of daily living. Gait compensations of the patients with hip OA may become more obvious while they turn because turning during walking requires more complex control of hip joint than during a straight walk. However, no studies have examined the compensatory mechanisms used while turning in patients with hip OA. The purpose of this study was to identify the compensatory strategies used by patients with hip OA while walking and turning.

METHODS

Fourteen female patients with hip OA (age, 59.3 ± 5.3 years) and 13 female age-matched controls (age, 62.6 ± 4.4 years) were recruited for this study. The Harris Hip Score of the patients with hip OA was 61.1 ± 10.5 points. Patients were excluded from the study if they had a musculoskeletal condition other than hip OA, or if they had been diagnosed with neurological disorders. All of the control participants were free from orthopedic and neurological abnormalities. All participants provided informed consent, and the protocol was approved by the local Ethics Committee.

Kinematic and kinetic measurements were recorded using a 7-camera Vicon motion system (Vicon Nexus; Vicon Motion Systems Ltd.) at a sampling rate of 200 Hz and a low-pass filter with a 6 Hz cutoff and using 4 force plates (Kistler Japan Co., Ltd.) at a sampling rate of 1000 Hz, and a low-pass filter (20 Hz). Reflective markers were attached to the body according to the Vicon Plug-in-gait marker placement protocol.

In each experimental trial, participants were asked to walk straight, and to walk straight and make a turn of 45° to the right or the left; the patients were asked to use the affected leg and the controls were asked to use the non-dominant leg and perform step and crossover turns (Fig. 1).

Patients were asked to walk at a self-selected speed. Control participants were asked to walk at both a self-selected speed and at an adjusted slow speed to compensate for the differences in walking speed between the groups. Experimental conditions of the turns were presented in random order and 3 successful trials were recorded for subsequent analysis. The following dependent measures were analyzed: walking speed; foot progression angle; peak joint angle at the hip, knee, and ankle; and peak internal joint moment at the hip, knee, and ankle. For the ankle plantarflexion moment, each peak value for the first half and the second half of the stance phase was calculated. Joint moments were normalized by body weight and leg length. AN unpaired *t*-test was used to determine whether there were significant differences in the dependent measures between the patients group and the control group for each walking condition. The level of significance was set at 0.05.

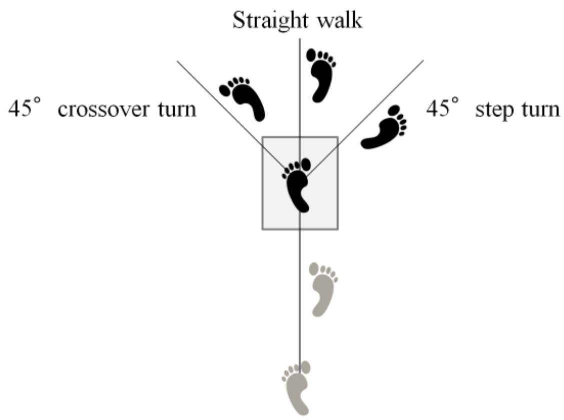

Figure 1: Schematic representation of crossover turn and step turn at an angle of 45°. Participants walked straight forward until they reached the turning zone (force plate) at which they turned into the designated path and kept walking at least 3m.

RESULTS AND DISCUSSION

The patients with hip OA walked at significantly slower speed than the control participants during the straight walk, though there was no significant difference in walking speed between the groups during step and crossover turns. When walking at slow speed of 2 control participants were adopted for analysis, no significant difference was seen in walking speed between groups. Consequently, we could compare the kinematic and kinetic data between 2 groups.

In straight walking, the patients with hip OA showed decreased hip flexion, extension, and adduction angle and knee flexion angle. The patients also showed smaller hip flexion and extension moment and knee flexion moment than the controls (Fig. 2). There was no significant difference in the angle and moment of the ankle joint. During the step turn, hip flexion, extension, and abduction angle, hip flexion moment, and knee flexion moment decreased in the patients (Fig. 2). Although not statistically significant, it should be noted that ankle plantarflexion moment during the first half of the stance phase tended to be increased in the patients with hip OA ($p = 0.07$; Fig. 2). During the crossover turn, patients had decreased hip flexion, extension, and adduction angle, knee flexion angle, hip abduction moment, and knee extension moment (Fig. 2). Furthermore, ankle plantarflexion moment during the first half of the stance phase was increased by about 25% in patients than in the control participants (Fig. 2). Patients showed a greater foot progression angle with more toe-out foot placement during straight walking and crossover turn. The change of the foot progression angle during the stance phase also significantly increased in the patients during the crossover turn.

The results of our straight walking test were consistent with those of previous studies regarding decreased hip motion and less hip moment while walking in patients with hip OA [1-4,6]. On the basis of the turn data, patients with hip OA showed greater ankle plantarflexion moment during the first half of the stance phase along with the hip dysfunction. Our previous study [5] confirmed that patients with total hip arthroplasty resulting from hip OA exerted more ankle plantarflexors power while walking; this was related to the decreased hip flexor muscle function during late stance. Patients with hip OA rely on ankle plantarflexors to compensate for the dysfunction of the hip muscles. The compensatory strategy was more apparent while turning than while walking straight. Moreover, the finding that the change in the foot progression angle during the stance phase was increased in the patients (especially in the crossover turn) suggests that the patients used the crossover turn in combination with a pivot turn, where rotation occurs on the ball of the foot. Motion analysis of the turns coupled with a straight walk would contribute to the understanding of the compensatory mechanisms used by patients with hip dysfunction.

CONCLUSIONS

Patients with hip OA rely primarily on the ankle plantarflexors to compensate for hip dysfunction while turning. Understanding the mechanisms of turning will provide an insight into directing physical therapy to preserve hip joint and increase locomotor function in patients with hip OA.

ACKNOWLEDGEMENTS

This study was supported by a Grant-in-Aid for young Scientists (B) from the Ministry of Education, Culture, Sports, Science and Technology.

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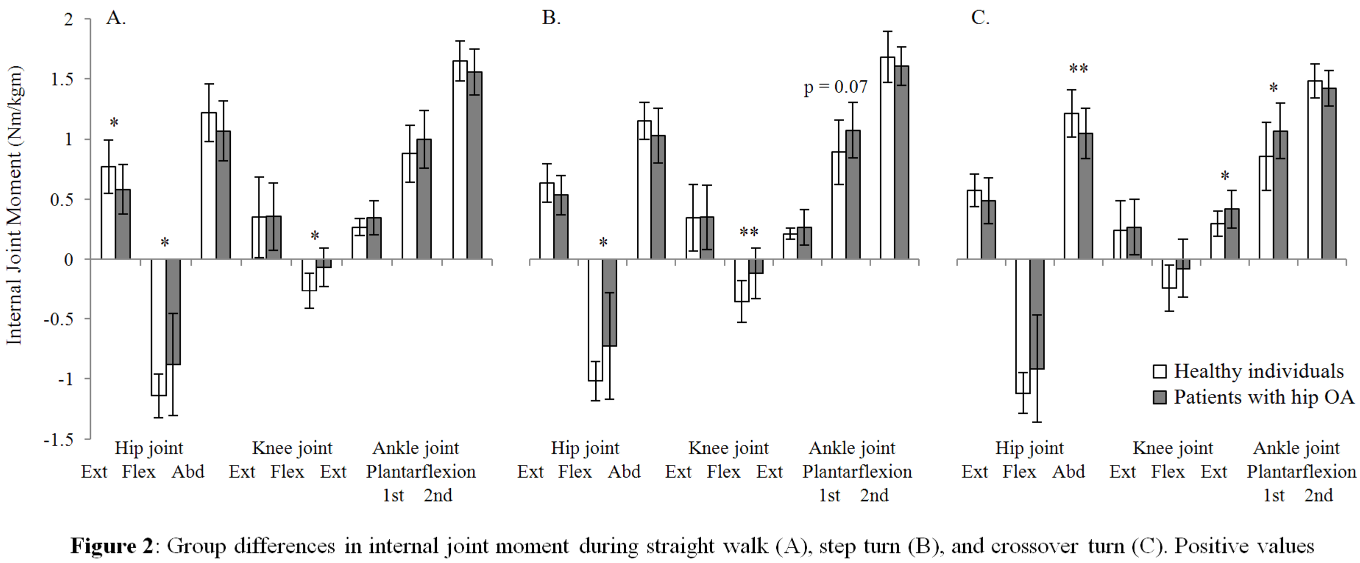

Figure 2: Group differences in internal joint moment during straight walk (A), step turn (B), and crossover turn (C). Positive values correspond to moment of hip extension and abduction, knee extension , and ankle plantarflexion. * $p < 0.05$, ** $p < 0.01$