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Age- and Speed-Related Changes in Gait Parameters of Adult Women with Osteoarthritis of the Hip

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We conducted this cross-sectional study to elucidate age- and speed-related changes in gait parameters of adult women with osteoarthritis (OA) of the hip using simple timed normal and maximum walking tests on a 10 m walkway. The study included 42 women, who were divided into four age groups: G 40 (35–44 years, n = 9), G 50 (45–54 years, n = 18), G 60 (55–64 years, n = 10), and G 70 (65–74 years, n = 5). Test-retest reliability coefficient for three gait parameters (speed, step length, and cadence (step frequency)) during normal and maximum walking was shown to be excellent (all r > 0.85, Pearson's correlation). We found a steep decline in normal and maximum walking speeds from G 60 to G 70 at a 6.3% and 8.5% per decade, respectively, which were much smaller than previously reported for normal adults by others and were considered due to slower speeds in G 40 to G 60. From normal to maximum walking, a percent increase in cadence was significantly greater than that in step length for G 40 and G 50, suggesting an altered strategy to increase walking speed in the presence of the limited hip rotation as primary joint impairment. These results suggest that hip OA affects gait parameters significantly in middle aged subjects.

Key Words
Walking speed,
Gait parameter,
Osteoarthritis.

Introduction

In Japan, osteoarthritis (OA) of the hip is mostly secondary to developmental dislocation or dysplasia[1]. It causes exacerbating pain, limited motion, and stiffness and may lead to profound mobility-related disability. There is currently no medical cure for hip OA and salvage surgery such as femoral or pelvic osteotomy is usually indicated for relatively young and active patients with an early or middle disease stage[2].

Previous studies have consistently shown an age-related decline in walking speed and step length of the general population[3-5]. Elble et al. have further demonstrated that an increase in step length from normal to fast walking is produced almost entirely by an increase in hip rotation[6]. In contrast, patients with hip OA were shown to walk slower with less hip rotation than normal subjects[7, 8]. However, gait characteristics of patients with hip OA remain unclear with respect to age-related and speed-dependent changes.

The purpose of this study was to elucidate age- and speed-related changes in gait parameters of female patients with

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hip OA using simple timed walking tests.

Subjects and Methods

Subjects

The patient population was composed of 42 women recruited from an outpatients clinic at a university hospital. The participants were limited to women because of their great predominance in the clinic. The inclusion criteria of the study were adult women who had OA with or without past salvage surgery in either or both hips. Radiographic evidence of joint space narrowing and associated bony changes confirmed the presence of OA. None of them underwent joint replacement surgery. They gave oral informed consent after understanding the purpose of the study. Patients were considered ineligible if they had self-reported pain in other weight-bearing joints and chronic diseases which possibly affect mobility such as coronary heart disease.

The 42 participants were divided into four groups by age range: G 40 (35–44 years), G 50 (45–54 years), G 60 (55–64 years), and G 70 (65–74 years).

Hip Function

Overall function of the hip involved was assessed using the Harris hip score, which was originally developed to assess functional status of the hip[9] and has been widely used as an outcome measurement after hip surgery. A total score possibly ranges from 0 to 100 points (low–high).

Normal and Maximum Walking, and Associated Gait Parameters

Normal walking speed (NWS) and then maximum walking speed (MWS), the fastest possible speed a person is able to achieve, were measured according to the method previously described by Suzuki et al. with some modifications[10]. For NWS, the subjects were instructed to walk at a normal and comfortable speed on a 10 m straight walkway with start and finish lines drawn at both ends. For MWS, they were instructed to walk as fast as possible but safely on the same walkway. They were provided with several meters both before the start line for acceleration and after the finish line for deceleration. The time taken to cross the two lines was measured with a stopwatch. The use of walking aids (canes or crutches) was permitted if required. After one practice, the test was repeated twice for both NWS and MWS. An average time of the two NWS trials was converted to speed expressed as cm/second for NWS and the shorter time of the two MWS trials was converted to speed expressed as cm/second for MWS.

As speed is a product of step length and cadence (step frequency), we also measured these gait parameters. To do this, the number of steps taken to cross the two lines was counted with a hand-tally. An average number of steps taken of the two NWS trials and the smaller number of steps taken of the two MWS trials were converted to step length expressed as cm. Cadence was calculated as the number of steps divided by the time for NWS and MWS and was expressed as steps/min.

Subject Characteristics

Characteristics of each age group and the overall participants are shown in Table 1. There were no significant differences between age groups for physical parameters and the Harris hip score

Table 1. Characteristics of age groups and the overall participants of women with hip OA

characteristic	G40(35-44y) n=9	G50(45-54y) n=18	G60(55-64y) n=10	G70(65-74y) n=5	Overall n=42
age, years, mean (SD)	38.2(3.5)	49.2(2.6)	58.7(3.4)	69.6(1.7)	51.5(10.1)
height, cm, mean (SD)	155.7(5.1)	155.6(5.9)	152.3(3.4)	152.0(2.6)	154.4(5.1)
weight, kg, mean (SD)	54.3(12.5)	51.7(6.0)	53.0(6.4)	46.4(8.5)	51.9(8.4)
bmi, kg/m^2, mean (SD)	22.3(4.6)	21.4(2.4)	22.9(2.8)	20.1(4.3)	21.8(3.3)
Harris score, points, mean (SD)	77.2(12.2)	78.6(13.8)	72.5(14.9)	68.4(12.9)	75.6(13.6)
hip involvement, uni vs bil, number	5 : 4	9 : 9	4 : 6	5 : 0	23 : 19
past surgery, yes vs no, number	7 : 2	10 : 8	4 : 6	2 : 3	23 : 19

There were no significant differences between age groups in physical parameters, hip involvement, and past surgery.

(analysis of variance), hip involvement, and past surgery (chi square test). Overall, age was on average 51.5 years (SD, 10.1), body height, 154.4 cm (SD, 5.1), body mass, 51.9 kg (SD, 8.4), body mass index (body mass per square of body height), 21.8 kg/m^2 (SD, 3.3), and the Harris hip score, 75.6 points (SD, 13.6). Of the 42 subjects, 23 (55%) had unilateral hip involvement and 19 (45%), bilateral hip involvement. Twenty-three subjects (55%) underwent past surgery and 19 (45%), no past surgery.

Statistics

To determine the degree of the reliability for normal and maximum walking tests, Pearson's correlation coefficient between the two repeated trials was calculated for speed, step length, and cadence.

The Kruskal-Wallis test was used to evaluate differences between age groups for gait parameters.

For each age group, the mean and SD of a percent increase in speed from normal walking to maximum walking were calculated. To determine which parameter contributes more to the increase in speed, a difference between a percent increase in step length and cadence was assessed for each age group using the Wilcoxon signed-ranks test.

Significance was set at $P<0.05$ for all analyses.

Results

Test-retest reliability was estimated by calculating Pearson's correlation coefficient for normal and maximum walking tests. All gait parameters of these tests had high reliability coefficient: in normal walking, NWS (0.93), step length (0.90), and cadence (0.90) and in maximum walking, MWS (0.91), step length (0.87), and cadence (0.89) (all $P<0.001$).

Figures 1 A and 1 B depicted the mean values of speed, step length, and cadence during normal and maximum walking for each age group to evaluate age-related changes in gait kinematics. NWS (Figure 1 A) declined at an average of 1.6% (G 40 to G 50), 5.4% (G 50 to G 60), and 6.3% (G 60 to G 70) decrease per decade and MWS (Figure 1 B)

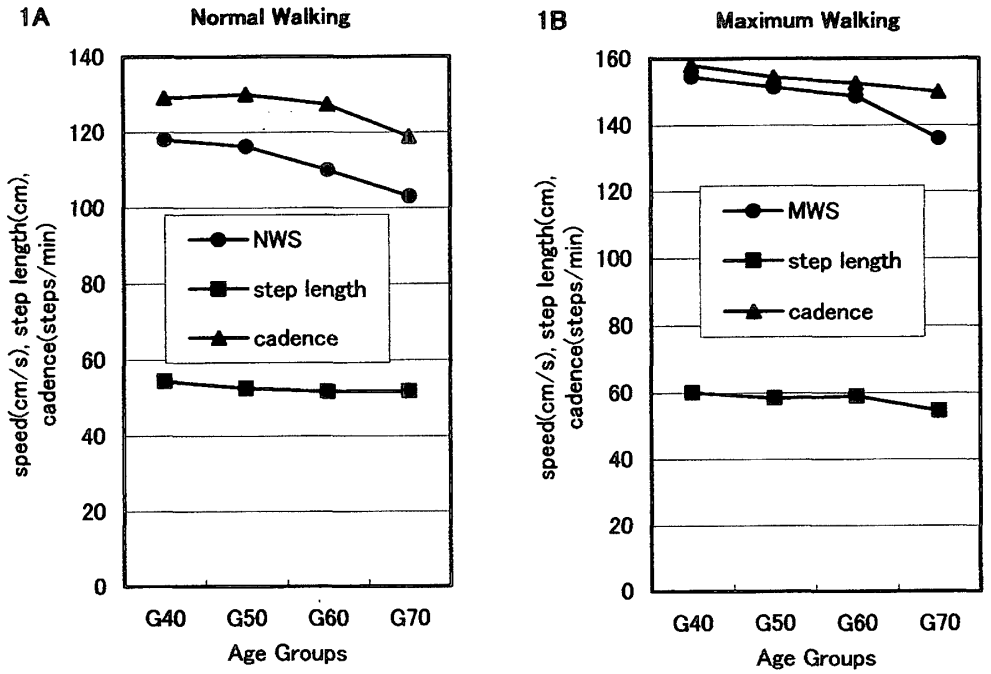


Figure 1 A and 1 B. Age-related changes in gait parameters during normal (Figure 1 A) and maximum walking (Figure 1 B)
Means of speed, step length, and cadence were plotted for each age group.
Age groups: G 40 (35–44 years), G 50 (45–54 years), G 60 (55–64 years), and G 70 (65–74 years).

did at an average of 2.1% (G 40 to G 50), 1.8% (G 50 to G 60), and 8.5% (G 60 to G 70) decrease per decade. The greater decrease in NWS and MWS from G 60 to G 70 was associated with an average of 6.7% decrease in cadence and 7.5% decrease in step length, respectively. However, among changes in these gait parameters from G 60 to G 70, only cadence in normal walking was significant at $P<0.05$.

To see speed-related changes, the percent increase in speed, step length, and cadence from normal to maximum walking was shown in Table 2 for each age group. We found no significant differences in these gait variables among the age groups. However, the percent increase in cadence was significantly greater than that in step length for G 40 and G 50 (both $P<.05$, Wilcoxon signed-ranks test). For G 60 and G 70, differences were not significant ($P = 0.33$ and 0.07, respectively). Overall, the percent increase in cadence was significantly greater than that in step length ($P<0.001$).

Discussion

In the present study, first we assessed the age-related changes in gait parameters among the patients. In contrast to the small decrease in NWS and MWS (1 -2% per decade) from G 40 to G 50, there was the greater decline in NWS and MWS (6.7% and 7.5% per decade) from G 60 to G 70, which was almost entirely attributable to the decrease in cadence and step length, respectively. Given no literature on this particular issue of OA patients, the reason for this slow-down in the older patients is unclear. In the female population, Himann et al. have shown an accelerated decline of

Table 2. Percent increase in speed from normal to maximum walking and associated changes in step length and cadence according to age groups.

gait parameter	G40	G50	G60	G70	Overall
speed, mean (SD)	32.1(16.3)	31.5(18.5)	35.7(16.6)	41.5(23.2)	33.6(17.6)
step length, quartiles[a]	3.0, 10.0, 15.2	6.8, 10.0, 13.8	5.8, 12.2, 22.1	3.4, 5.9, 14.0	5.9, 10.0, 15.7
cadence, quartiles[a]	13.2, 24.4, 32.9*	11.1, 16.5, 22.3*	14.2, 18.5, 30.0	13.1, 35.7, 44.8	12.3, 19.4, 29.4**

Values in each cell indicate %increase from normal to maximum walking.
a : Values of step length and cadence represent 25 th percentile, 50 th percentile (median), and 75 th percentile.
A difference between step length and cadence was assessed for each age group using Wilcoxon signed-ranks test (* $P<0.05$, ** $P<0.001$).

12.4% per decade after 63 years of age[3], which is greater than our results. Similarly, Kaneko et al. have observed nearly 30% decline after 60 years for normal and fast walking speeds in Japanese older women[11]. Compared with their normal data, there is a 13–20% reduction in speed of the present subjects in G 50 and G 60 (no G 40 subjects in their study)–i.e. NWS, 145 vs 116 cm/s in G 50, 138 vs 110 cm/s in G 60 ; MWS, 182 vs 151 cm/s in G 60, 171 vs 149 cm/s in G 60. Our results of G 70 are, however, comparable to their data. These may suggest that the disease affects walking speed greater in middle age but to a lesser degree afterward in the present sample. The sample included the small number (n = 5) of subjects in G 70, who were unlikely to exemplify this age group of patients. Most old patients are generally in worse functional conditions and require joint replacement surgery.

Normal young subjects were shown to have a greater increase in step length during fast walking than old subjects, which was caused by an increase in hip rotation[6]. In contrast, we found that the increase in speed during maximum walking is attributable at the greater degree to cadence than step length for G 40 and G 50, as is almost the same for G 70. Previous gait analysis have shown that patients with hip OA walk slower by taking shorter steps, which is caused mainly by less hip rotation (particularly hip extension at the stance phase of an involved limb)[7, 8]. Murray et al. speculated that the limitation of extension is pain-avoidance maneuver to reduce the force applied on the hip because there was a lack of the relationship between flexion contracture and extension loss during walking[7]. The greater role of cadence to increase speed in the present younger patients could be a strategy compensatory for the limitation of extension to increase step length.

In addition to the small sample size, the main limitation of our study was that we had to use the simple timed walking test without modern gait analysis system and were therefore unable to measure steps taken beyond a decimal point. This apparently created a certain degree of errors in step length and cadence, which is roughly estimated to be a maximum of 9 –12% for normal walking and 10–13% for maximum walking based on the value of individual's step counting. However, with simplicity and high test-retest reliability, as was also confirmed in the present study, the timed walking test is a good assessment tool for people with gait disorders[12].

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