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Ambulatory Physical Activity is Associated with Walking Speed in Adult Women with Hip Disorders

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Walking speed is important for safe ambulation in the community and provides useful information on health-related outcomes. The objective of this study was to determine whether ambulatory physical activity is associated with normal walking-speed (NWS) and maximum walking speed (MWS) in adult women with hip disorders. One hundred and fourteen adult women including 64 who had osteoarthritis (OA) of the hip and 50 following total hip arthroplasty (THA) were recruited from an outpatients clinic. Daily ambulatory physical activity was measured using pedometer over 7 days. Multiple linear regression analysis determined that ambulatory physical activity (step counts) was associated independently with NWS and MWS in the THA group and with MWS in the OA group, after controlling for age, height, body mass index, and hip score. Further studies are needed to determine whether interventions to increase ambulatory physical activity can lead to an improvement in walking speed among adult women with hip disorders.

Key Words
Physical activity,
Walking speed,
Hip joint.

INTRODUCTION

Osteoarthritis (OA) is a common, chronic arthritis which frequently affects the knee and hip and is a leading cause of mobility-related disability in older adults[1,2]. However, there is currently no medical cure for OA. Although joint replacement surgery provides significant functional improvement for end-stage OA, it has been suggested that patients following hip replacement surgery may still have hip disorders including pain, limited range of joint motion, and muscle weakness compared to normal controls[3,4].

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Walking speed is crucial to safe ambulation in the community-i.e. crossing the street in signaled intersections, and provides useful information on health-related outcomes. It serves as an indicator of locomotor function for people with gait disorders[5] and a predictor of functional dependence and self-rated health in older adults[6,7]. Thus, it is important to know the determinants of walking speed. Previous studies have shown that variables including age[8-10], height[8,10,11], muscle strength[13], and physical activity[11,12] are associated with normal walking speed (NWS), the speed a person normally and comfortably walk at, in older adults. In contrast, maximum walking speed (MWS), the fastest possible speed a person is able to achieve, has been shown to correlate more significantly with age and muscle strength than NWS in the general population[13]. However, there is a substantial lack of knowledge as to the determinants of NWS and MWS in patients

with joint disorders.

Despite arthritis-related benefits from physical activity[14, 15], several studies have recently suggested that a significant proportion of adults with arthritis do not meet public health recommendations for physical activity[16, 17]. Given the association between physical activity and lower extremity function in older adults[18, 19], the purpose of the present study was to verify whether ambulatory physical activity is associated with NWS and MWS in adult women with hip disorders. The study sample included patients who had hip OA and those following THA to assess the associations of ambulatory physical activity with NWS and MWS in relation to the OA and THA groups.

SUBJECTS AND METHODS

Subjects. The patient population comprised 114 adult women recruited from an outpatients clinic. 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 either of the following conditions in one or both hips: OA with or without past salvage surgery such as femoral osteotomy; THA for pre-existing OA. All surgeries had been performed at least 6 months before the study entry so that functional changes, which usually occur more rapidly 6 months postoperatively, could be minimized during the 7-day measurement of daily physical activity (described below). They gave oral informed consent after understanding the purpose of the study. Patients were considered ineligible if they had symptoms in other weight-bearing joints or chronic diseases which possibly affect mobility.

Methods. *Normal Walking Speed (NWS) and Maximum Walking Speed (MWS).* Normal walking speed (NWS) and maximum walking speed (MWS) were measured according to the method as reported previously[20].

Daily Ambulatory Physical Activity. Daily ambulatory physical activity was measured using a digital-pedometer over 7 days. Patients were asked to wear a pedometer with memory functions (Lifecorder, Suzuken Co. Ltd., Nagoya, Japan) at the waist, which converts the vertical acceleration of the trunk into the number of steps taken continuously. After the measurement period, the pedometer was sent back in a cushioned envelop by mail. The data of ambulatory physical activity was then downloaded to a personal computer to perform calculations. Activity was evaluated as the average number of steps taken per day over 7 days.

Hip Function. Overall function of the hip involved was assessed at study entry using the Harris hip score, which was originally developed to assess functional status of the hip[21] and has been widely used as an outcome measurement after hip surgery.

OA stage. Radiographs were assessed for each hip using the Kellgren-Lawrence scale[22]: stage 1, pre-OA; stage 2, early OA; stage 3, advanced OA; stage 4, end-stage OA.

Statistics. The OA and THA groups were compared using Student's t-test for continuous variables. Fisher's exact test was used for a categorical variable (hip involvement).

Pearson's correlations were calculated separately for the OA and THA groups to examine the linear associations of NWS and MWS with age, height, BMI, hip score, and step counts.

To further examine the effect of ambu-

latory physical activity on walking speed, multiple linear regression analysis was performed on NWS and MWS (dependent variables) among the OA and THA groups separately. Step counts was included as independent variable in the regression. The purpose of the analysis was to assess the relationship of the independent variable of interest (step counts) with NWS and MWS, while controlling for age, height, body mass index (BMI), and hip score. A total of five independent variables were included at once in the analysis.

Computer software (JMP version 5.0, SAS Institute Japan Inc. Tokyo, Japan) was used for all analyses. Significance was set at $P < .05$ in all analyses.

RESULTS

Demographics by hip category.

Table 1 shows the results of demographic variables by hip category. Compared to those in the THA group, patients in the OA group were older, had greater height and body mass index (BMI), and walked at higher NWS and higher MWS. There was no significant group-difference in the proportion of unilateral hip involvement. About two thirds (65.6%) of the OA group had advanced or end-stage OA. The OA group

Table 1. Demographics according to hip category

Demographics	Total (n=114)	OA (n=64)	THA (n=50)	p-value
Basic characteristics				
Age, mean (SD) years	57.3 (13.2)	49.2 (10.3)	67.6 (8.3)	<.0001
Body height, mean(SD) cm	153.4 (5.4)	154.6 (5.3)	151.8 (5.2)	.005
Body mass, mean (SD) kg	52.4 (7.7)	51.5 (7.6)	53.7 (7.8)	.121
Body mass index,mean (SD) kg/m^2	222.3 (3.3)	21.5 (3.1)	23.3 (3.4)	.004
Functional status				
Hip score,mean (SD) points	79.2 (13.3)	77.9 (13.2)	80.8 (13.4)	.242
Normal walking speed,mean (SD) m/sec	1.09 (0.19)	1.15 (0.15)	1.01 (0.22)	<.0001
Maximum walking speed, mean (SD) m/sec	1.42 (0.28)	1.53 (0.21)	1.29 (0.29)	<.0001
Hip involvement				
Unilateral, number (%)	71 (62.3)	38 (59.4)	33 (66.0)	.56
OA stage, number (%)				
stage 1 (pre)		6 (9.4)		ND
stage 2 (early)		16 (25.0)		ND
stage 3 (advanced)		19 (29.7)		ND
tage 4 (end-stage)		23 (35.9)		ND
Ambulation				
Step counts (steps/day)	5935 (2305)	6680 (2360)	4983 (1854)	<.0001

The OA and THA groups were compared using Student's t-test for continuous variables and Fisher's exact test for a categorical variable (hip involvement). ND, not determined.

took an average of 6680 ± 2360 steps per day, while the THA group did an average of 4983 ± 1854 steps per day (p <.0001).

Correlation analysis.

Pearson's correlations of NWS and MWS with age, height, mass, BMI, hip score, and step counts are presented in Table 2 for the OA group and in Table 3 for the THA group. In OA, NWS and MWS showed a similar correlation pattern: both correlated weakly but significantly with age and step counts and did moderately with hip score. In THA, NWS and MWS showed a different correlation pattern from that in OA: both correlated significantly with height as well as age, hip score, and step counts.

Table 2. Pearson's correlation between walking speeds and demographics in OA

	Age	Height	BMI	Hip score	Steps
NWS	−.328**	.032	−.210	.625***	.302*
MWS	−.353**	.038	−.070	.538***	.390**

NWS: normal walking speed, MWS: maximum walking speed, *P<.05, **P<.01, ***P<.001

Table 3. Pearson's correlation between walking speeds and demographics in THA

	Age	Height	BMI	Hip score	Steps
NWS	−.417**	.351*	−.069	.617***	.443**
MWS	−.434**	.424**	−.085	.601***	.446**

NWS: normal walking speed, MWS: maximum walking speed, *P<.05, **P<.01, ***<.001

Regression analysis.

Tables 4 shows the independent association of ambulatory physical activity (step counts) with NWS and MWS in the OA group, controlling for age, height, BMI, and hip score. Step counts just reached significance for MWS (p=.049) but not for NWS (p=.289). An increase in step counts by 1000 steps per day is associated independently with an estimated increase in MWS (dependent variable) by 2.00 cm/sec.

Table 4. Multiple linear regression analysis showing associations of ambulatory physical activity with normal walking speed (NWS) and maximum walking speed (MWS) in OA

Dependent variable	Independent variable	Estimate (SE)	t-value	*p*-value
Normal walking speed	Age (/year)	−.21 (.16)	−1.30	.199
	Height (/cm)	−.36 (.29)	−1.25	.217
	Body mass index (/kg/m^2)	−.43 (.52)	−.82	.414
	Hip score (/point)	.67 (.13)	5.30	<.0001
	Step counts (/1000 steps)	.71 (.67)	1.07	.289
	R^2			.447
Maximum walking speed	Age (/year)	−.31 (.24)	−1.28	.205
	Height (/cm)	−.38 (.43)	−.89	.377
	Body mass index (/kg/m^2)	−.15 (.73)	−.21	.836
	Hip score (/point)	.71 (.18)	3.90	.0002
	Step counts (/1000 steps)	2.00 (1.00)	2.00	.049
	R^2			.376

The analysis was performed separately for normal and maximum walking speeds. SE: standard error

Table 5 shows the independent association of ambulatory physical activity (step counts) with NWS and MWS in the THA group, controlling for age, height, BMI, and hip score. Unlike in the OA group, step counts were significantly associated with both speeds (NWS, p=.047, and MWS, p=.038) in the THA group.

An increase in step counts by 1000 steps per day is associated independently with an estimated increase in NWS (dependent variable) by 2.91 cm/sec and in MWS (dependent variable) by 3.90 cm/sec.

Table 5. Multiple linear regression analysis showing associations of ambulatory physical activity with normal walking speed (NWS) and maximum walking speed (MWS) in THA

Dependent variable	Independent variable	Estimate (SE)	t-value	p-value
Normal walking speed	Age (/year)	-.38 (.32)	-1.18	.243
	Height (/cm)	.85 (.51)	1.66	.104
	Body mass index (/kg/m^2)	.64 (.77)	0.83	.412
	Hip score (/point)	.70 (.19)	3.67	.0007
	Step counts (/1000 steps)	2.91 (1.43)	2.04	.047
R^2				.514
Maximum walking speed	Age (/year)	-.51 (.41)	-1.25	.217
	Height (/cm)	1.52 (.63)	2.40	.021
	Body mass index (/kg/m^2)	.60 (.93)	.65	.521
	Hip score (/point)	.93 (.24)	3.81	.0004
	Step counts (/1000 steps)	3.90 (1.81)	2.14	.038
R^2				.539

The analysis was performed separately for normal and maximum walking speeds. SE : standard error

DISCUSSION

Many clinical trials have suggested that regular physical activity is beneficial for functional improvement in adult with OA [14, 15]. The American College of Rheumatology and the US Arthritis Foundation indeed emphasize the importance of moderate-intensity exercise. In the present study, we examined the relationship between ambulatory physical activity and walking speed in adult women with hip disorders including OA and post-THA. The regression analysis determined that ambulatory physical activity was associated independently with both NWS and MWS in the THA group and with MWS in the OA group, after controlling for age, height, BMI, and hip score. These results support the positive relationship between daily ambulatory physical activity and walking speed in this population.

Several studies from the national surveys of the US and Canada have suggested that physical inactivity is pervasive among adults with arthritis[16, 17]. In our study, OA patients (mean age, 49.2 years) took an average of 6680 steps per day, while THA patients (mean age, 67.6 years) did 4983 steps per day. In contrast, the national survey of Japan have shown that women aged 40 s averaged 8198 steps per day and those aged 60 s did 6876 steps per day[23]. Our results may suggest that a significant proportion of patients in both groups were physically inactive. Inactivity in the OA group might have been explained by the avoidance model of activity, as suggested by others, where fear of pain during activity leads to avoidance of activity[24]. Similar to this explanation, inactivity in the THA group might have been due to the avoidance model, where fear of THA problems related to activity such as implant failure leads to avoidance of activity.

We conclude that, although the present study was cross-sectional and therefore unable to infer causation, daily ambulatory physical activity is associated with walking speed in adult women with hip disorders. Further studies are needed to determine whether interventions to increase ambulatory physical activity can lead to improvement in walking speed.

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