mechanisms linking physical activity and sedentary behavior with metabolic risk between Japan and Western countries, where previous studies have been conducted. Further research using objective behavioral measures is warranted to explore such differences.

In this study, significant associations between combined PA/ST categories and likelihood of being overweight or obese were found in men but not in women. This pattern of sex difference diverges from the findings of studies conducted in Australia [18], Europe [19], and the United States [20], which have shown stronger associations between sedentary behavior and metabolic health risks in women. One possible explanation is that the prevalence of overweight or obesity is very low among women in this sample. It was 12.5%, which is even lower than the national prevalence for women reported in the Japanese National Health and Nutrition Survey (20%) [21]. It is possible that women in this sample, particularly those who are not very active, may pay close attention to diet so as to control their weight. Future studies should examine diet so as better to understand obesity risks among Japanese women.

Several limitations need to be considered. First, the study used a cross-sectional design; thus it is not possible to make causal inferences. Second, the utilization of IPAQ-SV may cause the overestimation of PA time due to recall bias [22,23]. Third, ST was not measured separately by weekday and weekend, which may contribute to an inaccurate estimation of ST. Fourth, as discussed above, potentially confounding behaviors such as light-intensity activity and diet were not assessed in the study. Finally, the study sample was extracted from the list held by an Internet survey company. Previous studies have indicated that respondents to Internet-based surveys are generally younger, better educated, have higher income and may have greater access to the Internet than respondents to traditional surveys [24,25]. Thus the findings obtained from our sample may not be representative for the entire adult population of Japan.

Regardless of the limitations, our findings suggest the importance of addressing both aspects of physical inactivity (insufficient PA and high ST) to reduce overweight and obesity at the population level. Future health promotion strategies addressing obesity in Japan should focus not only on increasing PA but also on reducing sedentary time, especially in men.

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Authors' contributions
YL contributed to analysis and interpretation of data and drafted and revised the paper. KH participated in the study design, contributed to analysis and interpretation of data, and revised the paper. AS, KI, KO, SI conceived the study, participated in its design and coordination, and helped in drafting the manuscript. TSU, YN, TSH performed the sequence alignment and helped in drafting the manuscript. All the authors have read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

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Sociodemographic Determinants of Pedometer-Determined Physical Activity Among Japanese Adults

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Background: Although previous studies have reported physical activity and its sociodemographic determinants using self-report measures, there have been few studies using pedometers.

Purpose: To ascertain pedometer-determined physical activity and its sociodemographic determinants among community residents living in four Japanese cities.

Methods: A cross-sectional mail survey was conducted from February 2007 to January 2008 with a sample of 4000 residents (aged 20–69 years and 50% male) who were randomly selected from the registry of residential addresses. Complete responses for both questionnaire and pedometer were obtained from 790 residents (48.3±13.7 years, 46.7% male). Associations of 11 sociodemographic variables with steps per day were examined using multiple logistic regression analyses. Data were analyzed in 2010.

Results: Men averaged 8763±3497 steps/day and women averaged 8242±3277 steps/day. Further, 29.0% of men and 27.8% of women walked ≥10,000 steps/day. City of residence, good self-rated health, low educational attainment, and not owning a car were associated with taking ≥10,000 steps/day in men, whereas employed status and dog ownership were associated with walking ≥10,000 steps/day in women.

Conclusions: The results contribute to understanding of step-defined physical activity and its sociodemographic determinants. A diversity of step counts by sociodemographic variables clarifies specific populations among Japanese who are in need of intervention to promote physical activity.
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Introduction

Physical activity promotion is one of the priorities for chronic disease prevention.[1,2] To develop effective intervention strategies, solid evidence of physical activity patterns among specific population groups is needed. Previous studies have reported the association between sociodemographic variables and physical activity.[3–7] However, most of these studies (1) were conducted in Western countries and (2) used self-reported physical activity, with a few exceptions.[8,9] Thus, the generalizability of findings to countries of a different culture, such as Japan, is unclear.

Further, there remains the potential for information bias from self-reported physical activity.[10] Step-counting devices provide an objective output and are becoming widespread as intervention tools.[11,12] Therefore, data related to step-defined physical activity are increasingly important.

Thus, the objectives of the present study are to (1) report step-defined physical activity levels and (2) examine sociodemographic characteristics of people who achieve ≥10,000 steps/day[13] using a randomly selected community sample from four Japanese cities.

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Methods

Participants and Data Collection

This cross-sectional study was a part of larger project[14] to investigate physical activity environment. Data were collected from February to March 2007 and from December 2007 to January 2008.

Four thousand residents (aged 20–69 years, 50% male) living in four Japanese cities (Koganei, Tsukuba, Shizuoka, and Kagoshima) were randomly selected from the registry of residential addresses, stratified by gender, age, and city of residence. Locations, areas, and population sizes of four cities are indicated in Appendix A (available online at www.ajpm-online.net). Koganei lies approximately at the center of Tokyo. Tsukuba is located 50 km northeast of Tokyo within commuting distance from Tokyo. Shizuoka and Kagoshima are the prefectural capitals in mid- and west Japan.

The study was conducted by mail. At first, participants were asked about sociodemographic characteristics and subsequently invited to wear an accelerometer. If participants consented to join, the accelerometer was mailed out. Of the targeted 4000 residents, 1508 responded to the questionnaire (37.7%). Of these, 886 offered to wear the accelerometer, but valid accelerometer data were obtained from 790 participants (overall response rate: 19.8%). All participants provided signed informed consent. The current study received prior approval from the Tokyo Medical University Ethics Committee. Further details of the survey were reported in a previous article.[14]

Assessment of Step Counts

Participants were asked to wear an accelerometer (Suzuken Lifecorder Ex 4 second version, Nagoya, Japan) for 7 consecutive days. This device has a step-counting function with a 35-day memory. Acceleration signals were used only for calculation of device use (wearing and nonwearing time). Previous studies[15,16] have validated the step-counting feature of this device. The step data were systematically processed according to the following rules: (1) nonwear time was defined as no acceleration signal for ≥30 consecutive minutes; (2) a recorded day was deemed valid if it was worn at least 10 hours that day[17,18]; and (3) to be included in the analysis the participant had to have 3 or more valid days of data.[18] Finally, mean steps/day were calculated based on steps of valid days.

Sociodemographic Variables

Gender, age, and city of residence were obtained from the registry of residential addresses. Information on height, weight, self-rated health, education, employment, marital status, child (defined as junior high school students or younger; aged ≤15 years) in household, household motor vehicle, and dog ownership were obtained by questionnaire. BMI was calculated from self-reported weight and height.

Statistical Analyses

Multiple logistic regression analyses were conducted to examine the relationships between sociodemographic variables and steps/day. Steps/day were recoded into three categories, sedentary to low active (Se/LA), <7500 steps/day; somewhat active (SA), 7500–9999 steps/day; and active to highly active (A/HA), ≥10,000 steps/day.[13] All 11 sociodemographic variables were included in the model. Cities of residence were included in the model as dummy variables. Following the analyses of the overall sample, stratified analyses by gender were conducted. The odds of higher step counts (SA and A/HA) compared with Se/LA by 11 sociodemographic attributes were calculated. Significance was considered to be $p<0.05$. Analyses were conducted in 2010 using SPSS, version 17.0.

Results

Men accounted for 46.7% of participants. Mean age was 48.3±13.7 years overall. Mean steps/day were 8763±3497 steps/day in men and 8242±3277 steps/day in women. The prevalence of taking ≥10,000 steps/day was 29.0% in men and 27.8% in women. Further information about participants' characteristics is shown in Appendix B (available online at www.ajpm-online.net).

In multivariate analyses (Table 1), city of residence (Tsukuba or Koganei); good self-rated health; being employed; not having a household motor vehicle; and dog ownership were related to either SA or A/AH or both SA and A/AH. ORs (95% CI) of A/HA, that is, engaging in ≥10,000 steps/day (vs Se/LA) were 1.80 (1.04, 3.12) for Tsukuba residents and 2.03 (1.17, 3.52) for Koganei residents compared with Kagoshima residents; 1.70 (1.18, 2.43) for people with good self-rated health; 1.67 (1.06, 2.63) for employed; 2.40 (1.28, 4.49) for nonowners of motor vehicles; and 1.77 (1.13, 2.76) for dog owners. According to stratified analyses by gender; city of residence (Tsukuba, Koganei, or Shizuoka); good self-rated health; lower educational attainment; and having no household motor vehicle were associated with more steps/day in men. High step-defined activity was associated with good self-rated health, being employed, and dog ownership in women.

Discussion

The present study showed the step-defined physical activity level of residents in four Japanese cities and its association with sociodemographic variables. Most previous studies conducted in Western countries have been based on self-report. Thus, the findings of the current study add new evidence from two perspectives. First, the present study was conducted in Japan and therefore extends understanding of physical activity determinants to include a distinct culture. Second, objective step data were collected. Step-defined physical activity is relevant to health promotion applications because of the potential of step counter to be widely used as an intervention tool.

Participants in the current study appear to be more active compared with national surveys in Japan[19] and the U.S.[20] Japanese survey[19] in 2007 reported that men and women took 7321 steps/day and 6267 steps/day, respectively. Differences in sampling and response rates may explain some of this discrepancy. The current sample did not include older adults (aged ≥70 years) and was primarily living in urban settings. In the 2005–2006 National Health and Nutrition Examination Survey[20] of the U.S., accelerometer-determined physical activity data treated to approximate pedome-

Table 1. ORs for active people, as determined by pedometer, by sociodemographic variables

	Overall (N=790)				Men (n=369)	
	SA (vs Se/LA)		A/HA (vs Se/LA)		SA (vs Se/LA)	
	7500–9999 (vs <7499)		≥10,000 (vs <7499)		7500–9999 (vs <7499)	
	OR (95% CI)	p-value[a]	OR (95% CI)	p-value[a]	OR (95% CI)	p-value[a]
Gender	—	—	—	—	—	—
Men	1.10 (0.77, 1.59)	0.595	1.07 (0.73, 1.55)	0.741	—	—
Women	1.00	—	1.00	—	1.00	—
Age (years)	—	—	—	—	—	—
20–39	1.46 (0.81, 2.63)	0.205	1.24 (0.69, 2.24)	0.474	2.31 (0.88, 6.10)	0.090
40–59	1.58 (0.96, 2.58)	0.069	1.14 (0.70, 1.85)	0.599	1.69 (0.80, 3.57)	0.172
60–69	1.00	—	1.00	—	1.00	—
City of residence	—	—	—	—	—	—
Tsukuba	1.40 (0.84, 2.34)	0.194	1.80 (1.04, 3.12)	0.035	2.69 (1.27, 5.71)	0.010
Koganei	1.59 (0.95, 2.67)	0.079	2.03 (1.17, 3.52)	0.012	2.16 (0.96, 4.87)	0.062
Shizuoka	0.98 (0.58, 1.63)	0.927	1.43 (0.84, 2.45)	0.187	1.20 (0.55, 2.63)	0.649
Kagoshima	1.00	—	1.00	—	1.00	—
BMI	—	—	—	—	—	—
<25	0.93 (0.60, 1.44)	0.737	1.08 (0.68, 1.72)	0.732	0.77 (0.43, 1.36)	0.362
≥25	1.00	—	1.00	—	1.00	—
Self-rated health	—	—	—	—	—	—
Good	1.52 (1.07, 2.16)	0.018	1.70 (1.18, 2.43)	0.004	1.38 (0.82, 2.34)	0.228
Fair or poor	1.00	—	1.00	—	1.00	—
Education (years)	—	—	—	—	—	—
≥13	1.04 (0.71, 1.51)	0.857	0.73 (0.50, 1.07)	0.103	0.95 (0.52, 1.71)	0.853
≤12	1.00	—	1.00	—	1.00	—
Employment status	—	—	—	—	—	—
Employed	1.55 (0.99, 2.43)	0.053	1.67 (1.06, 2.63)	0.028	2.15 (0.85, 5.48)	0.108
Not employed	1.00	—	1.00	—	1.00	—
Marital status	—	—	—	—	—	—
Married	1.53 (0.93, 2.52)	0.094	1.56 (0.94, 2.59)	0.089	1.94 (0.83, 4.55)	0.128
Not married	1.00	—	1.00	—	1.00	—
Child in household	—	—	—	—	—	—
Yes	0.91 (0.60, 1.38)	0.669	0.65 (0.41, 1.01)	0.056	1.04 (0.54, 1.98)	0.911
No	1.00	—	1.00	—	1.00	—
Household motor vehicle (no.)	—	—	—	—	—	—
0	1.88 (1.00, 3.56)	0.052	2.40 (1.28, 4.49)	0.006	4.24 (1.38, 13.01)	0.012
≥1	1.00	—	1.00	—	1.00	—
Dog ownership	—	—	—	—	—	—
Yes	1.65 (1.06, 2.55)	0.026	1.77 (1.13, 2.76)	0.012	1.40 (0.74, 2.67)	0.301
No	1.00	—	1.00	—	1.00	—

(continued on next page)

[a]p-values were calculated by multiple logistic regression analyses adjusted for all other sociodemographic variables listed in the table.
A/HA, active and high active; SA, somewhat active; Se/LA, sedentary and low active

Table 1. *(continued)*

		Women (*n*=421)			
A/HA (vs Se/LA)		SA (vs Se/LA)		A/HA (vs Se/LA)	
≥10,000 (vs <7499)		7500–9999 (vs <7499)		≥10,000 (vs <7499)	
OR (95% CI)	*p*-value[a]	OR (95% CI)	*p*-value[a]	OR (95% CI)	*p*-value[a]
—	—	—	—	—	—
—	—	—	—	—	—
—	—	—	—	—	—
—	—	—	—	—	—
2.52 (0.94, 6.78)	0.067	1.02 (0.47, 2.23)	0.952	0.83 (0.38, 1.83)	0.649
1.37 (0.64, 2.89)	0.416	1.29 (0.65, 2.57)	0.468	1.03 (0.52, 2.03)	0.942
1.00	—	1.00	—	1.00	—
—	—	—	—	—	—
2.90 (1.26, 6.68)	0.013	0.77 (0.37, 1.60)	0.477	1.31 (0.62, 2.78)	0.481
3.22 (1.34, 7.73)	0.009	1.28 (0.63, 2.58)	0.493	1.70 (0.81, 3.55)	0.160
2.37 (1.06, 5.32)	0.036	0.85 (0.42, 1.71)	0.649	1.02 (0.49, 2.14)	0.960
1.00	—	1.00	—	1.00	—
—	—	—	—	—	—
1.06 (0.57, 1.98)	0.859	1.39 (0.65, 2.96)	0.397	1.01 (0.50, 2.04)	0.983
1.00	—	1.00	—	1.00	—
—	—	—	—	—	—
2.46 (1.41, 4.29)	0.001	1.81 (1.11, 2.94)	0.018	1.30 (0.80, 2.12)	0.294
1.00	—	1.00	—	1.00	—
—	—	—	—	—	—
0.46 (0.25, 0.84)	0.011	1.16 (0.69, 1.93)	0.582	1.00 (0.59, 1.68)	0.990
1.00	—	1.00	—	1.00	—
—	—	—	—	—	—
1.15 (0.49, 2.66)	0.749	1.43 (0.83, 2.45)	0.198	1.92 (1.09, 3.40)	0.024
1.00	—	1.00	—	1.00	—
—	—	—	—	—	—
2.15 (0.88, 5.24)	0.093	1.44 (0.75, 2.76)	0.272	1.48 (0.77, 2.86)	0.239
1.00	—	1.00	—	1.00	—
—	—	—	—	—	—
0.77 (0.38, 1.57)	0.475	0.78 (0.44, 1.37)	0.385	0.60 (0.34, 1.09)	0.092
1.00	—	1.00	—	1.00	—
—	—	—	—	—	—
5.47 (1.81, 16.51)	0.003	1.17 (0.52, 2.65)	0.706	1.47 (0.66, 3.29)	0.347
1.00	—	1.00	—	1.00	—
—	—	—	—	—	—
1.39 (0.71, 2.72)	0.341	1.78 (0.96, 3.29)	0.065	2.17 (1.18, 4.00)	0.013
1.00	—	1.00	—	1.00	—

ter-determined scaling indicated that American men took 7431 steps/day and women took 5756 steps/day. Although the differences of sampling strategy and of device should be considered, participants in the current study appear to be more active.

Gender and age were not significantly related to steps/day in multivariate analyses. In previous studies,[3,4] men and younger adults were more active than women and older adults. In the present study, multivariate analyses included a wide range of sociodemographic variables. Thus, after adjustment for these variables, the effect of gender and age alone appears to be lessened. People in Tsukuba and Koganei were more active than those in Kagoshima. Both Tsukuba and Koganei are in the Greater Tokyo Area.

According to the Nationwide Person Trip Survey in Japan,[21] 22.2% of commuters drive in metropolitan areas (including Koganei); 31.6% in suburban cities of metropolitan areas (including Tsukuba); and 63.0% in core local cities (including Shizuoka and Kagoshima). The differences among cities might be related to existing public transport networks. Koganei also has high walkability, characterized by high density and land use mix.[22,23] Thus, the importance of environmental features was suggested.

Sociodemographic variables associated with steps/day differed by gender. High education level was related to lower steps/day in men. This is inconsistent with previous findings.[3,4,6,7] However, many previous studies have focused on leisure-time physical activity. It is likely that the sociodemographic determinants of total physical activity are different. Physically demanding jobs among less-educated men may be one possible reason for this result. Employment status was an important factor for women. Women without jobs outside the home might have fewer opportunities to walk for transport. Association of motor vehicle ownership and steps/day suggested a car-reliant lifestyle among men. In contrast, women may feel an obligation to walk their dog and increase their activity as a result.

There were some limitations in the current study. First, the response rate might be considered low. If participants were reactive to wearing the accelerometer, they might have been active regardless of their sociodemographic characteristics, leading to an underestimation of the association between sociodemographic variables and steps/day. Second, the study setting was relatively urban because of the original purpose of this survey. Research including rural areas is also needed in the future.

In spite of these limitations, the present study contributes to understanding of step-defined physical activity and its sociodemographic determinants. A diversity of steps/day by sociodemographic variables clarifies specific populations in need of intervention to promote physical activity.

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Appendix

Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.amepre.2010.12.023.

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Differences in Association of Walking for Recreation and for Transport With Maximum Walking Speed in an Elderly Japanese Community Population

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Background: Physical activity contributes to maintaining functional ability later in life. Specific relationships between walking for particular purposes (eg, recreation or transport) and functional ability are not clear. It is useful for planning health promotion strategies to clarify whether walking time for recreation, or walking time for transport has the stronger relationship with maximum walking speed (MWS), a determinant of functional ability later in life in the elderly. ***Methods:*** A cross-sectional survey was conducted in 2007 using a sample of 372 community-dwelling elderly people aged 60 to 87 years in Mitoya Town, Unnan City, rural Japan. Associations with MWS were examined for self-reported weekly times of walking for recreation and for transport using multiple linear regression analyses. ***Results:*** Both in men and women, walking time for recreation was significantly associated with MWS after controlling for age, height, weight, hip and knee pain, and a number of chronic diseases (men: $\beta = 0.18$, $P = .024$; women: $\beta = 0.17$, $P < .01$). However, walking time for transport was not significantly associated with MWS (men: $\beta = -0.094$, $P = .24$; women: $\beta = -0.040$, $P = .50$). ***Conclusions:*** Walking for recreation may contribute to maintaining functional abilities such as MWS in the elderly.

Keywords: physical activity, physical fitness, public health, older adults, epidemiology

Physical activity plays a role in maintaining functional ability later in life.[1–4] Walking is the most common physical activity behavior of adults and the elderly.[5–7] Previous studies have shown the health benefit of walking behaviors.[1,3,4,8,9] However, there has been little study of the differences in the purposes of walking (eg, recreational vs. nonrecreational). If the intensities of walking for recreation and for transport are different, effects of those behaviors on health outcomes should be different, and taking such differences into account could be useful, in health education and the promotion of walking behaviors. Differences between specific associations of walking for recreation or for transport with health benefits, such as functional ability, have not been clearly identified.[10]

Maximum walking speed (MWS) is a good predictor of bone health[11] and functional dependence[12] in the elderly and believed to be susceptible to walking behavior.[13] The purpose of this study was to clarify specific relationships between walking for particular purposes and maximum walking speed in the elderly. We hypothesized that walking for recreation may have a greater influence on functional ability, such as maximum walking speed,[11] because this type of walking is assumed to be conducted with higher levels of intensity compared with walking for transport.

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Methods

Study Location and Subjects

A cross-sectional survey was conducted in community-dwelling elderly in Mitoya Town (population 8241, area 82.7km²), Unnan City, Shimane Prefecture, in western rural Japan in October 2007. This study was a part of a Shimane study[14] conducted concomitantly with an annual health examination. All adults aged 20 years and above then living in Mitoya were invited to participate in the study by direct mail, local public broadcasts, cable television, circulars called *kairanban*, and city newsletters. Figure 1 shows the flowchart of the recruitment. The following inclusion criteria were used for each subject: aged 60 years and over, community-dwelling, and a participant in a Shimane study conducted concomitantly with the subject's annual health examination. Exclusion criteria applied were those individuals in assisted living facilities, those requiring nursing care, and those who walked

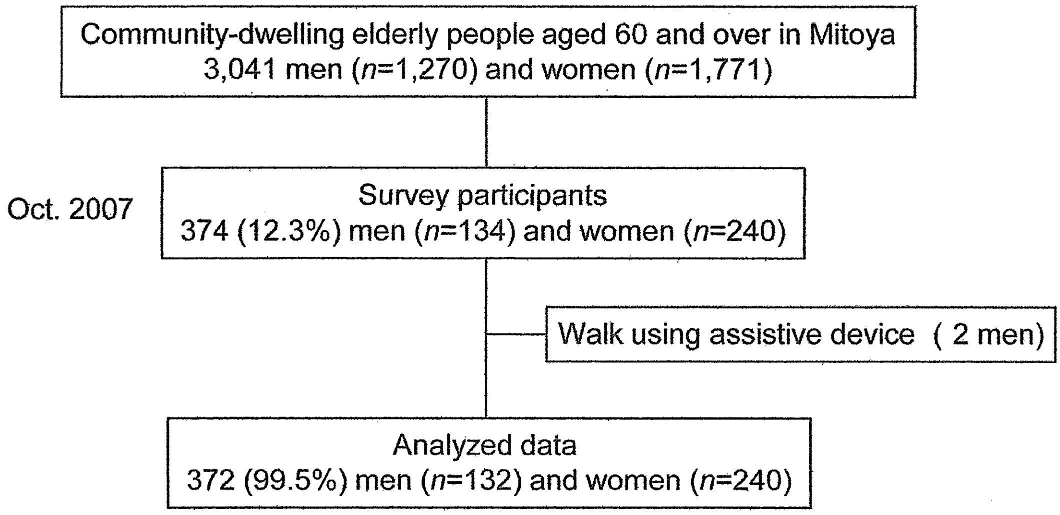

Figure 1 — Subject recruitment.

using an assistive device. Data on 372 elderly people who qualified as subjects (132 men and 240 women) aged 60 to 87 years (70.5 ± 5.8) were used in the analyses.

Walking Behavior

We investigated average walking time for recreation (including for both exercise and leisure) and for transport (to or from work, shopping, to access public transportation, etc.) over a typical 7-day period (min/w), using a self-administered questionnaire and a face-to-face interview for confirmation. Subjects were asked to address only their walking activities lasting for at least 10 minutes at a time. This questionnaire and interview confirmation method had an acceptable 1-week test-retest reliability (Spearman's $\rho = 0.79$, $P < .01$) in 43 elderly people (22 men and 21 women) aged 75.7 ± 4.6 years in Kisuki Town, adjacent to Mitoya, in Unnan City. A validity test with a 1-week walking diary was also conducted in Kisuki with another group of 44 elderly people (12 men and 32 women) aged 72.7 ± 5.2 years. These subjects were provided with walking diaries and were asked to make daily records of their start and finish times and purpose of all walking activities continuing for at least 10 minutes. This validity test showed acceptable results of walking times for recreation (Spearman's $\rho = 0.49$, $P < .01$) and for transport (Spearman's $\rho = 0.38$, $P = .013$). Results of a validity test for total walking time with average daily step counts recorded by a uniaxial accelerometer (Lifecorder, Suzuken Co. Ltd., Nagoya, Japan)[15,16] were also acceptable (Spearman's $\rho = 0.41$, $P < .01$) in 93 elderly people (35 men and 58 women) aged 73.7 ± 5.0 years in Kisuki. The questionnaire used in this study is originally in Japanese and available online.[17]

Maximum Walking Speed (MWS)

Walking speed was measured once by trained examiners using digital stopwatches and a 10-m course set between the 2- and 12-m marks of a 14-m straight, flat, indoor walkway. We asked subjects to walk as fast as they safely could without running on the walkway course. The high reliability of walking (gait) speed measurements have been reported previously.[13]

Other Measurements

Subjects underwent anthropometric measurements and questionnaires with face-to-face interviews covering chronic musculoskeletal pain in the hip and knee,[18,19] and chronic diseases (cerebrovascular disorder, diabetes, heart disease, liver disease, lung disease, hypertension).[2,20]

Data and Statistical Analyses

Differences by gender were examined by t test for variables with normal distributions and Mann-Whitney test for variables with nonnormal distributions. Correlations with MWS were calculated by Pearson correlation for age, height, weight, and body mass index and Spearman's ρ for musculoskeletal pain, a number of chronic diseases, walking time for recreation, and walking time for transport with nonnormal distributions. The correlations between walking times for recreation and for transport were calculated by Spearman's ρ. Multiple linear regression models were used with MWS as the dependent variable and walking times for recreation and for transport as the independent variables separately by gender. Adjustments were made for selected variables whose P values were 0.10 and under in univariate analyses with

MWS based on age, height, weight, hip and knee pain, and/or a number of chronic diseases for model 1 and by all these potential confounding factors for model 2. Data on walking for recreation and for transport were simultaneously analyzed in multiple linear regression analyses. Significance was set at a level of $P < .05$. Analyses were conducted using SPSS 14.0J for Windows (SPSS Japan Inc., Tokyo, Japan, 2006)

This study was approved by the research ethics committee of the Physical Education and Medicine Research Center UNNAN. All the subjects took part in the study after signing informed consent forms.

Results

Subject characteristics are shown in Table 1. The mean values of MWS were 2.2 ± 0.4 m/s in men and 2.0 ± 0.4 m/s in women. The mean walking times for recreation and for transport were 66 ± 101 min/w and 26 ± 51 min/w, respectively, in men, and 47 ± 87 min/w and 35 ± 70 min/w, respectively, in women. The median values of walking times for recreation and for transport were 0 min/w for both men and women. About 40% of the subjects engaged in walking for both recreation and transport, while 37.9% of the subjects engaged in neither. Although a direct comparison cannot be made, the prevalence of recreational walkers in our study was similar to national data of annual participation rates of walking for recreation in Japanese elderly (47.2% for 60–69 year-olds; 35.6% for 70+ year-olds).[21] Women were more likely to be younger, have smaller height and weight, have hip and knee pain, and have lower MWS, compared with men.

MWS was significantly correlated with age and walking time for transport in men and with age, height, hip and knee pain, number of chronic diseases, and walking time for recreation in women (Table 2). The correlation between walking times for recreation and for transport was not significant (men: Spearman's ρ = –0.048, P = .59; women: Spearman's ρ = 0.038, P = .56, not shown in tables).

Table 3 shows the results of multiple linear regression analyses. Both in men and women, walking time for recreation was positively and significantly associated with MWS after controlling for potential confounding factors. However, walking time for transport was not significantly associated with MWS. Each model explained 22% of the variance of MWS in men and 25% in women. Results did not change much and the model R^2 values decreased somewhat when walking times were analyzed as categorical variables divided into nearly 3 equal parts

Table 1 Subject Characteristics (Shimane, Japan, 2007)

	Men (n = 132)	Women (n = 240)	
	Mean ± SD or Number (%)	Mean ± SD or Number (%)	P^a
Age (years)	71.7 ± 5.8	69.8 ± 5.7	<0.01
60–64	17 (12.9)	48 (20.0)	
65–69	30 (22.7)	73 (30.4)	
70–74	41 (31.1)	69 (28.8)	
75–79	33 (25.0)	35 (14.6)	
80+	11 (8.3)	15 (6.3)	
Height (cm)	161.1 ± 5.8	148.9 ± 5.2	<0.01
Weight (kg)	58.3 ± 8.6	50.1 ± 7.0	<0.01
Body mass index (kg/m²)	22.4 ± 2.8	22.6 ± 2.9	0.60
Hip and knee pain	63 (47.7)	154 (64.2)	<0.01
Number of chronic diseases[b]			0.08
0	56 (42.4)	118 (49.4)	
1	56 (42.4)	102 (42.7)	
2+	20 (15.2)	19 (7.9)	
Walking time for recreation (min/w)	66 ± 101	47 ± 87	0.06
Walking time for transport (min/w)	26 ± 51	35 ± 70	0.12
Maximum walking speed (m/s)	2.2 ± 0.4	2.0 ± 0.4	<0.01

Note. Sample sizes vary due to missing values.

[a] Compares prevalences by gender using *t* test for age, height, weight, body mass index, and maximum walking speed and Mann-Whitney test for others.

[b] Number of the following diseases: cerebrovascular disorder, diabetes, heart disease, liver disease, lung disease, hypertension.

Table 2 Correlations Between Maximum Walking Speed and the Measured Items (Shimane, Japan, 2007)

	Men (n = 132)		Women (n = 240)	
	r or ρ[a]	*P*	*r* or ρ[a]	*P*
Age (years)	–0.45	<0.001	–0.40	<0.001
Height (cm)	0.08	0.37	0.29	<0.001
Weight (kg)	0.05	0.61	0.06	0.37
Body mass index (kg/m²)	0.00	0.97	–0.10	0.13
Hip and knee pain	0.082	0.36	–0.25	<0.001
Number of chronic diseases[b]	–0.17	0.058	–0.13	0.044
Walking time for recreation (min/w)	0.17	0.059	0.19	<0.01
Walking time for transport (min/w)	–0.18	0.040	–0.12	0.061

Note. Sample sizes vary due to missing values.

[a] Pearson's correlation coefficients (*r*) for age, height, weight, and body mass index and Spearman's ρ for other variables with nonnormal distributions.

[b] Number of the following diseases: cerebrovascular disorder, diabetes, heart disease, liver disease, lung disease, hypertension.

Table 3 Multiple Linear Regression Analyses for the Assessment of Associations Between Walking Behavior and Maximum Walking Speed (Shimane, Japan, 2007)

	Model 1[a]		Model 2[a]	
	β[b]	*P*	β[b]	*P*
Men (n = 132)				
Walking behavior				
Walking time for recreation (min/w)	0.16	0.046	0.18	0.024
Walking time for transport (min/w)	–0.12	0.14	–0.094	0.24
Covariates				
Age (years)	–0.43	<0.001	–0.46	<0.001
Height (cm)			0.035	0.71
Weight (kg)			–0.14	0.18
Hip and knee pain			0.10	0.21
Number of chronic diseases[c]	–0.033	0.68	–0.0037	0.97
Adjusted R^2 of the model	0.22		0.22	
Women (n = 240)				
Walking behavior				
Walking time for recreation (min/w)	0.17	<0.01	0.17	<0.01
Walking time for transport (min/w)	–0.040	0.49	–0.040	0.50
Covariates				
Age (years)	–0.25	<0.001	–0.25	<0.001
Height (cm)	0.20	<0.01	0.19	<0.01
Weight (kg)			0.0088	0.89
Hip and knee pain	–0.22	<0.001	–0.22	<0.001
Number of chronic diseases[c]	–0.060	0.30	–0.062	0.30
Adjusted R^2 of the model	0.25		0.25	

Note. Sample sizes vary due to missing values.

[a] Model 1 is adjusted for covariates those P values were 0.10 and under in univariate correlation analyses with maximum walking speed (ie, age and chronic diseases for men and age, height, pain, and chronic diseases for women) and model 2 is adjusted for all covariates.

[b] β is the standardized partial regression coefficient for maximum walking speed.

[c] Number of the following diseases: cerebrovascular disorder, diabetes, heart disease, liver disease, lung disease, hypertension.

(ie, 0 min/w; >0 to <90 min/w; 90+ min/w), and body mass index was not significantly associated with MWS when it was analyzed in the models instead of height and weight (data not shown).

Discussion

Both in men and women, walking times for recreation had a significant relationship with MWS, while no significant relationship was observed between walking times for transport and MWS. Significant negative simple correlations of walking times for transport in men and a number of chronic diseases in women with MWS became insignificant in multiple linear regression analyses.

As we hypothesized, one possible interpretation of the observed stronger relationship of walking for recreation with MWS is the greater intensity involved with recreational walking in contrast to walking for transport. We believe that if the elderly walk intentionally to improve and maintain health, the intensity of such walking is greater than of those walks involving routine activities of daily living (eg, walking around home, to work, or for shopping).[10,22] Our pilot study examining the intensity of walking for recreation and for transport by use of a walking diary and accelerometer in 16 Japanese elderly individuals showed a trend of greater intensity while walking for recreation than that of walking for transport (unpublished data). However, we believe it likely that in cases of elderly people engage in walking for relaxation,[23] the intensity of such walks are low, although this form of waling is deemed to be recreational. Hills et al conducted an experimental study on Australian adults and reported "walking for pleasure" (included in walking for recreation) was sufficient to improve cardiovascular fitness in obese, but not normal-weight, individuals.[24] There may be intra- and interpersonal variations in the intensities of walking behavior. Further investigation is needed to determine the intensities of walking for particular purposes.

Another possible cause of the lack of a significant relationship between walking time for transport and MWS is the lower standard deviation and the fewer instances of transport-walking than walking for recreation for this particular study population. In rural areas such as Unnan City, where the automobile is a dominant and necessary form of transportation, the interpersonal difference in walking times for transport is considered to be small. Thus, it is possible we were unable to detect any association between walking for transport and MWS because of insufficient statistical power.

The mean age of our subjects was less than 75 years. Shinkai et al suggested that MWS was most sensitive in predicting future functional dependence for those aged between 65 to 74 years, while usual walking speed was most sensitive for people aged ≥75 years.[12] Our observed stronger relationship of walking time for recreation with MWS, compared with walking time for transport, is also believed to be based on the fact that MWS is a relatively vigorous mobility index compared with other indices of physical fitness (eg, usual walking speed) in the elderly. These results did not contradict the health benefits of active transport (ie, walking or bicycling for transport), especially in younger adults.[25]

Previous study has shown that time spent in moderate to vigorous intensity physical activity significantly decreased with aging, even though the number of counted steps did not differ significantly.[26] Recent recommendations for physical activity in older adults have stated the importance of increased levels of aerobic activity over and above the routine activities of daily living which include light to moderate-intensity activity of less than 10 min duration.[1] Our present study also supports walking for recreation as an effective moderate physical activity for maintaining functional ability in the elderly. Both the promotion of walking for recreation and improvement of public transportation service to promote active transport is needed, especially in rural areas.[27]

The determinants of walking behavior have been reported to vary with the purposes of walking,[28,29] so it may be necessary to consider walking for recreation and for transport as separate behaviors, especially in the case of planning health promotion strategies and promoting these behaviors. Differences between the specific association of walking time for recreation and for transport with health benefits require further study.

In addition, the presence of hip or knee pain was associated to low MWS in women. Musculoskeletal conditions have been suggested as determinants of physical activity[18] and functional ability[19] in the elderly. Assistance in the care and treatment of musculoskeletal conditions may be of importance in promoting physical activity and maintaining functional ability in the elderly.

Limitations

This study had several limitations. First, the exclusion of other domains of physical activity,[2,30] visual and mental health status,[31] and/or socioeconomic status,[32] may cause low model R^2 values (0.22 and 0.25) in multiple linear regression analyses. Assessment of how long the participants had been walking for recreation and for transport would also provide important insight into their effects on functional abilities. Second, our findings may not be attributable generally to populations of elderly people in other geographic locations, given that our subjects were restricted only to Japanese elderly in a rural town. Finally, we were unable to confirm any causality from this cross-sectional study. There is the possibility of reverse causation in the observed associations (eg, participants with higher MWS might be more capable of participating in recreational activities). Future prospective and intervention studies focusing on differences in health outcomes of walking for particular purposes would provide valuable knowledge to health professionals.

In spite of these limitations, the results of this study are notable in that they serve to advance our knowledge of differences between walking for recreation and for transport in association with maintained functional ability, which has not previously received much scrutiny.

Conclusions

Elderly people with longer walking times for recreation had faster MWS. However, walking time for transport was not significantly associated with MWS. Walking for recreation in addition to that for routine activities of daily living may contribute to the maintaining of functional ability in the elderly. Considering the several limitations of this study, further research is needed to confirm the differences in the health benefits associated with walking for recreation and those for transport.

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Article

Perceived Environmental Factors Associated with Physical Activity among Normal-weight and Overweight Japanese Men

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Abstract: Although it is crucial to examine the environmental correlates of physical activity (PA) for developing more effective interventions for overweight populations, limited studies have investigated differences in the environmental correlates on body mass index (BMI). The purpose of the present study was to examine the perceived environmental correlates of PA among normal-weight and overweight Japanese men. Data were analyzed for 1,420 men (aged 44.4 ± 8.3 years), who responded to an internet-based cross-sectional survey of answering the short version of the International Physical Activity Questionnaire and its Environment Module. Binary logistic regression analyses were utilized to examine the environmental factors associated with meeting the PA recommendation (150 minutes/week) between the normal-weight and overweight men. After adjusting for socio-demographic variables, common and different environmental correlates of PA were observed among normal-weight and overweight men. Furthermore, significant interactions regarding PA were observed between BMI status and two environmental correlates: access to public transportation (P = 0.03) and crime safety during the day (P = 0.01). The results indicated that BMI status is a potential moderator between perceived environmental factors and PA and suggested that different environmental intervention approaches should be developed for overweight populations.

Keywords: BMI; overweight; moderator; perceived environment; walking; moderate-to-vigorous physical activity; physical activity recommendation; Japan

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1. Introduction

Overweight and obesity are associated with an increased risk of morbidity from chronic diseases, as well as with higher health-care costs and lower quality of life [1-4]. An increasing prevalence of obesity has been reported in Western countries, and in those countries, the groups with higher risk of obesity varied by age, gender, and race/ethnicity [5-7]. Compared to the U.S. (where the prevalence of obesity is approximately 30%), the prevalence of obesity in Japan is much lower (approximately 3%) and has changed little during the last 40 years [8,9]. However, more recently, the prevalence of overweight adults in Japan has grown to 28.6% in men and 20.6% in women, and men aged 40–49 years had the highest percentage (35.9%) [10]. Therefore, with regard to the obesity epidemic, identifying effective, population-based strategies for preventing weight gain would be a public health priority, not only in Western countries, but also in Japan.

Numerous longitudinal and cross-sectional studies have shown that engaging in physical activity (PA) is beneficial for the prevention of obesity and overweight [11-16]. Based on these findings, the World Health Organization has recommended engaging almost daily in at least 30 minutes of moderate-intensity PA for the prevention of obesity and other chronic diseases [5,17]. Despite such a benefit, overweight and obese individuals spent less time on PA and were less likely than normal-weight individuals to meet the minimum recommended level of PA [moderate-to-vigorous PA (MVPA) at least 30 minutes per day, 5 or more days per week; ≥150 minutes per week] [12-16]. Therefore, developing effective strategies to promote PA to overweight and obese subgroups is needed to prevent further increases in the obesity rate among populations.

A better understanding of factors associated with PA is critical in designing relevant policies and effective interventions. From an ecological perspective, the manipulation of environmental attributes would be expected to provide a long-term impact on the PA of an associated population [18,19]. In this context, the association between environmental factors and PA behaviors has been reported in many countries [20]. However, many of these previous studies have been conducted in general populations [20,21]. Recent studies have suggested that environmental factors associated with PA differ between socio-demographic subgroups, such as men and women [22,23], older and younger adults [24], African-American and white adults [25], and driving and non-driving rural women [26]. In addition to these differences, BMI status has been also suggested as a potential moderator for the correlates of PA [27]. It is important to examine the factors associated with engaging in PA in the overweight subgroup to develop more tailored intervention strategies. However, to date only a Portuguese study has examined the environmental dimensions associated with meeting the PA recommendation among overweight/obese women [22], although previous studies have consistently observed gender differences in environmental correlates [22,28]. Thus, the present study examined the differences in perceived environmental factors associated with PA among normal-weight and overweight Japanese men.

2. Methods

2.1. Participants

An internet-based cross-sectional survey was conducted in January 2009 by a Japanese internet research service organization, which listed approximately 264,000 voluntarily registered subjects across Japan and their detailed socio-demographic attributes. Thus, the organization could access data from the targeted group on the basis of the requirements of each survey. In the current study, the sample size and personal attributes of the targeted group was set as follows: (1) approximately 3,000 adults aged between 30 and 59 years. (2) 500 men and 500 women in each age group (aged 30–39, 40–49, and 50–59 years). A total of 9,418 potential respondents, aged 30–59 years, were randomly selected from the database and invited to attend this internet-based survey via email (final respondents: 3,000 adults; response rate: 31.9%). The email invitations included the URL for access to this survey, and the potential respondents could log in using their own ID and password to answer the questionnaire voluntarily. The present study received prior approval from the Ethics Committee of the Faculty of Sports Sciences, Waseda University, Japan.

2.2. Measures

BMI: Self-reported height and weight were used to calculate the body mass index (BMI; body weight in kilograms divided by the square of height in meters). The participants were classified as normal-weight men (BMI < 25) and overweight men (BMI ≥ 25) in the present study.

Physical activity: Physical activity was measured by the self-administered, short version of the International Physical Activity Questionnaire (IPAQ-SV), which was recommended for the national prevalence studies [29]. IPAQ-SV, which includes seven items, was used to measure the frequency and duration of vigorous-intensity PA, moderate-intensity PA, and walking level for young and middle-aged adults (15–69 years). The test-retest reliability ($r = 0.72$–0.93) and criterion validity ($r = 0.39$) of the Japanese version of the IPAQ-SV are good and acceptable [30]. The total minutes of each PA category in a week were first computed. In the present study, two independent variables, the total minutes of walking and MVPA (excluding walking), were calculated. MVPA (excluding walking) was computed by summing the minutes per week of moderate- and vigorous-intensity PA time in the IPAQ-SV. Both walking and MVPA excluding walking were dichotomized at 150 minutes or more per week according to the public health PA recommendation [31]. In each variable, the respondents could be categorized into two groups: either meeting the recommended level or not.

Perceived environmental factors: The Japanese version of the International Physical Activity Questionnaire-Environmental Module (IPAQ-E) was utilized to measure the perceived environmental factors associated with PA. The IPAQ-E questionnaire was originally developed by the International Physical Activity Prevalence Study (IPS), has been used in several countries, and has shown good reliability [18,32-34]. This self-administered questionnaire consists of three sets of items, which include seven core items, four recommended items, and six optional items [35]. In this study, all 17 items were included using a 4-point Likert scale (strongly agree, somewhat agree, somewhat disagree, and strongly disagree), with the exception of the following two questions: (1) *What is the main type of housing in your neighborhood*? For this question, the five options were detached single-family housing; apartments with 2–3 stories; mix of single-family housing and apartments with 2–3 stories; condos with 4–12 stories; and condos with >13 stories. (2) *How many household cars or auto bikes are there at your household?* This question was open ended.

For the analyses, similar to previous studies [18,36], the 17 environmental variables were converted into binary items. Residential density was divided into "detached single-family housing" and "others", and having household car or auto bikes was classified into "0" and ">0". Other items were categorized as "agree" (strongly agree and somewhat agree) and "disagree" (somewhat disagree and strongly disagree).

Socio-demographic variables: In the present study, socio-demographic correlates included gender, age, marital status, educational level, household income, and employment status. Age was categorized as 30–39, 40–49, and 50–59 years. Marital status was classified into married and unmarried. Educational level was divided into three categories: less than high school graduate, junior college graduate or equivalent, and college graduate or higher. Household income was categorized as less than 5 million yen, 5–10 million yen, and >10 million yen. Employment status was classified into full-time job and not full-time job.

2.3. Statistical Analyses

The data were analyzed from 1,420 men who provided complete information for study variables. All analyses were stratified by BMI. Forced-entry adjusted logistic regression for gender, age, marital status, educational level, household income, and employment status was conducted to examine the association between environmental factors and meeting the PA recommendation. Adjusted odd ratios (ORs) and 95% confidence intervals (CI) were calculated for each variable. Likelihood ratio tests were used to compare models with or without interaction terms between environmental variables and BMI status. Inferential statistics were performed using SPSS 15.0, and the level of significance was set at $p < 0.05$.

3. Results

3.1. The Characteristics of the Participants

Table 1 presents the basic characteristics of the participants (mean age was 44.4 ± 8.3 years). Of all respondents, 31.1% were overweight, 70.4% were married, 64.4% had an education level of 4-year college/graduate school, 92.0% had full-time jobs, and 49.7% had a household income between 5,000,000 yen and 10,000,000 yen. The prevalence of achieving the PA recommendation (the sum of walking and other MVPA times) was 57.4% in the present study.

Table 1. Basic characteristics of all respondents stratified by normal-weight and overweight men.

	Total sample N = 1,420		Normal weight N = 979 (68.9%)		Overweight N = 441 (31.1%)			
	N	%	N	%	N	%	X^2	*p*
Age group							3.43	0.18
30–39	475	33.4	338	34.5	137	31.1		
40–49	474	33.4	312	31.9	162	36.7		
50–59	471	33.2	329	33.6	142	32.2		
Mean age (± SD)	44.4 ± 8.3							
Marital status							0.03	0.86
Married	1,000	70.4	688	70.3	312	70.7		
Unmarried	420	29.6	291	29.7	129	29.3		
Educational level							2.04	0.36
Junior high/high school	330	23.2	219	22.4	111	25.2		
2-year college	176	12.4	118	12.1	58	13.2		
4-year college/ graduate school	914	64.4	642	65.5	272	61.6		
Job status							0.09	0.77
full-time job	1,306	92.0	899	91.8	407	92.3		
not full-time job	114	8.0	80	8.2	34	7.7		
Household income							2.46	0.65
<5,000,000 yen	488	34.4	343	35.0	145	32.9		
<10,000,000 yen	706	49.7	481	49.1	225	51.0		
>10,000,000 yen	226	15.9	155	15.9	71	16.1		

SD = standard deviation.

3.2. Perceived Environmental Factors Associated with Walking and MVPA (Excluding Walking) among Men

Table 2 shows the results of the adjusted logistic regression analysis in walking and MVPA (excluding walking) among normal-weight and overweight men. Ten significant environmental correlates of walking in normal-weight men and three in overweight men were observed. For normal-weight men, good access to shops (OR = 1.61; 95% CI: 1.24–2.10), good access to public transport (OR = 2.30; 95% CI: 1.57–3.38), good access to recreational facilities (OR = 1.42; 95% CI: 1.09–1.84), seeing people being active (OR = 1.49; 95% CI: 1.15–1.94), aesthetics (OR = 1.74; 95% CI: 1.33–2.29), street connectivity (OR = 1.48; 95% CI: 1.11–1.98), good maintenance of sidewalks (OR = 1.49; 95% CI: 1.14–1.94), good maintenance of bike lanes (OR = 1.58; 95% CI: 1.22–2.04), and presence of destination (OR = 1.61; 95% CI: 1.24–2.10) were significantly associated with engaging in 150 minutes of walking per week. However, having household cars or auto bikes (OR = 0.60; 95% CI: 0.41–0.88) was inversely associated with walking in normal-weight men. For overweight men, environmental factors associated with engaging in 150 minutes of walking per week were good access to recreational facilities (OR = 1.75; 95% CI: 1.18–2.58) and presence of destination (OR = 1.63; 95% CI: 1.10–2.41). Furthermore, lack of