Table 4
Environmental correlates of three categories of physical activity by multinomial logistic regression model without interaction term among total respondents ($n=434$, Shimane, Japan, 2006).

	Insufficiently active[a]		Sufficiently active[a]	
	Crude OR (95% CI)	Adjusted OR[b] (95% CI)	Crude OR (95% CI)	Adjusted OR[b] (95% CI)
Perceived environments				
Residential density				
High	0.91 (0.25–3.29)	0.78 (0.21–2.89)	0.73 (0.31–1.72)	0.81 (0.33–1.96)
Low	1.00	1.00	1.00	1.00
Access to shops				
Good	1.89 (0.96–3.71)†	1.88 (0.92–3.83)†	0.88 (0.59–1.33)	1.14 (0.72–1.80)
Poor	1.00	1.00	1.00	1.00
Access to public transport				
Good	2.60 (1.35–5.03)**	2.53 (1.29–4.97)**	1.49 (0.99–2.26)†	1.57 (1.01–2.44)*
Poor	1.00	1.00	1.00	1.00
Access to recreational facilities				
Good	2.55 (1.31–4.95)**	2.26 (1.15–4.47)*	1.15 (0.76–1.74)	1.17 (0.75–1.81)
Poor	1.00	1.00	1.00	1.00
Sidewalks				
Yes	1.15 (0.60–2.17)	1.09 (0.57–2.11)	1.27 (0.84–1.93)	1.35 (0.87–2.10)
No	1.00	1.00	1.00	1.00
Bike lanes				
Yes	1.73 (0.91–3.29)†	1.87 (0.96–3.62)†	1.78 (1.18–2.71)**	2.05 (1.30–3.22)**
No	1.00	1.00	1.00	1.00
Aesthetics				
Good	0.84 (0.43–1.62)	0.76 (0.39–1.48)	1.74 (1.15–2.63)**	1.69 (1.09–2.63)*
Poor	1.00	1.00	1.00	1.00
Seeing people being active				
Yes	1.36 (0.71–2.59)	1.35 (0.70–2.61)	1.00 (0.67–1.51)	1.16 (0.75–1.80)
No	1.00	1.00	1.00	1.00
Safety from crime				
Yes	0.53 (0.26–1.09)†	0.58 (0.28–1.20)	1.02 (0.67–1.56)	1.10 (0.70–1.72)
No	1.00	1.00	1.00	1.00
Traffic safety				
Yes	1.82 (0.87–3.80)	1.64 (0.77–3.49)	0.90 (0.59–1.38)	0.93 (0.59–1.47)
No	1.00	1.00	1.00	1.00
Household motor vehicles				
0–2	1.17 (0.59–2.33)	1.06 (0.52–2.16)	0.92 (0.60–1.41)	0.82 (0.52–1.31)
3+	1.00	1.00	1.00	1.00
Objective environments				
Distance to train station (m)				
Close (≤1147)	2.32 (1.06–5.07)*	2.13 (0.94–4.81)†	0.95 (0.56–1.60)	1.02 (0.58–1.80)
Moderate (1148–4515)	0.70 (0.28–1.74)	0.62 (0.24–1.56)	0.72 (0.43–1.19)	0.72 (0.42–1.24)
Far (4516+)	1.00	1.00	1.00	1.00
Distance to bus stop (m)				
Close (≤95)	1.17 (0.52–2.67)	1.07 (0.46–2.51)	0.86 (0.51–1.47)	1.01 (0.57–1.79)
Moderate (96–236)	1.22 (0.54–2.77)	1.12 (0.49–2.60)	1.03 (0.61–1.74)	1.17 (0.68–2.04)
Far (237+)	1.00	1.00	1.00	1.00
Frequency of bus service				
High (10+)	2.11 (1.02–4.36)*	1.90 (0.89–4.04)†	0.96 (0.59–1.56)	1.05 (0.63–1.77)
Moderate (5–9)	2.56 (1.05–6.27)*	2.25 (0.90–5.60)†	1.30 (0.70–2.44)	1.32 (0.69–2.54)
Low (≤4)	1.00	1.00	1.00	1.00
Convenience of bus service[c]				
High	2.55 (1.15–5.67)*	2.21 (0.96–5.09)†	0.95 (0.55–1.62)	1.07 (0.60–1.92)
Moderate	1.35 (0.60–3.05)	1.25 (0.55–2.88)	0.83 (0.51–1.36)	0.86 (0.51–1.45)
Low	1.00	1.00	1.00	1.00

Note. Sample sizes vary due to missing values.
[a] Reference category is inactive.
[b] Odds ratios (ORs) and 95% confidence intervals (CIs) are adjusted for age, body mass index, general state of health, household economy, and engaged in farming. †$P<0.10$, *$P<0.05$, **$P<0.01$.
[c] See Fig. 1 for category definitions.

distance to a bus stop and frequency moderate" status (center cell) (data not shown).

Discussion

As previous studies suggested, our results revealed both consistent and inconsistent links of social and physical environments to physical activity. To our knowledge, findings from this study demonstrated for the first time the potentially moderating effect of driving status on those associations.

Previous studies suggested the importance of seeing others engaged in exercise (Wilcox et al., 2000; Sanderson et al., 2003), enjoyable scenery (Wilcox et al., 2000), perceived neighborhood safety (Wilcox et al., 2003), and street lighting (Eyler, 2003) in encouraging rural US women's physical activity. In the present study, perceived good aesthetics was significantly associated among rural Japanese women with physical activity, whereas perceived neighborhood safety from crime was not. Other studies have clarified the contributions of good access to bike lanes and public transport to physical activity mainly in urban areas (De Bourdeaudhuij et al., 2003; Troped et al., 2001; Pikora et al., 2006; McCormack et al., 2008). The present study has shown their importance even in rural areas.

The significant interaction, a slightly opposite direction in the associations between physical activity and the convenience of bus

Table 5
Significances of interactions between driving status and environmental variables by multinomial logistic regression models (Shimane, Japan, 2006).

	P value for interaction term with driving status
Perceived environments	
Residential density	0.37
Access to shops	0.38
Access to public transport	0.31
Access to recreational facilities	0.59
Sidewalks	0.48
Bike lanes	0.20
Aesthetics	0.61
Seeing people being active	0.94
Safety from crime	0.56
Traffic safety	0.78
Household motor vehicles	0.78
Objective environments	
Distance to train station (m)	0.87
Distance to bus stop (m)	0.40
Frequency of bus service	0.73
Convenience of bus service	0.023

Interactions are tested by likelihood ratio tests in multinomial logistic regression models adjusted for age, body mass index, general state of health, household economy, and engagement in farming.

service by driving status, revealed driving status to be a potential moderator of such relationships. Possible interpretations of observed significance in not high but moderate bus service convenience among non-drivers were the lack of statistical power to detect weak to moderate associations between highly convenient bus service and physical activity and/or the nonlinear relationship between physical activity and bus service convenience. As an example of a nonlinear relationship, a curvilinear relationship between physical activity and the daily means of ambient temperature was reported (Togo et al., 2005). Considering the significant contribution of perceived good access to public transport, inconvenient public transport might at least have a negative effect on being physically active. People using public transport often walk to and from the public transport facility, and thus bouts of physical activity arise (Besser and Dannenberg, 2005). In addition, it is natural to consider that for non-drivers unable to cover a long distance by themselves, convenient public transport would exert a greater influence on their daily use of it when compared with drivers. The fact that non-drivers were apt to have more convenient bus service than drivers suggested the non-driver subgroup included people who would more readily use public transport.

People who drive more are considered to have less time for transport-related physical activity (Villanueva et al., 2008; Wen et al., 2006). However, time given to physical activity did not vary significantly by driving status. When interpreting differences based on driving status, the finding that non-drivers were less likely to be employed than drivers in the present investigation should also be considered. For example, half of non-drivers were not employed, and non-employed people possibly have less money to spend and buy cars (Raphael and Rice, 2002), so they would depend more on public transport than employees. Socioeconomic status and driving status might interact, thus influencing physical activity status both directly and indirectly as moderators (Van Lenthe et al., 2005).

Rearranging the locations of bus stops and how often buses run is considered to be a feasible intervention for administrations to promote physical activity of people who cannot drive. However, it must be recalled that the present study is a cross-sectional observation, and we are not suggesting causality. A study showed a new rail stop was associated with increased ridership (Brown and Werner, 2007). Further study including prospective and intervention research is needed to clarify the most beneficial proximity (McCormack et al., 2008) and frequency of public transport for promoting physical activity.

Limitations

This study has several limitations. First, because the sample size was not large, its low statistical power could lead to underestimations of any associations or interactions. Second, the self-reported responses may be subject to recall and response bias. Third, since we did not investigate other environmental factors not included in the IPAQ-E, the possibility cannot be denied that we overlooked other important environmental determinants of physical activity in a rural setting. Open-ended questions and/or focus group interviews might be useful (Sanderson et al., 2003; Folta et al., 2008). Finally, the study findings may not be generalizable to populations of women in non-rural areas or in other geographic locations, given that our subjects were restricted only to Japanese women in Unnan City.

Conclusions

This study enhanced overall knowledge and understanding of environmental factors of physical activity among rural Japanese women and their differences in driving status, results that should prove useful for planning future interventions. Good access to public transport and recreational facilities, the presence of bike lanes, and good neighborhood aesthetics are likely to be important factors promoting physical activity. Especially in non-drivers, convenient bus service is considered important for promoting their physical activity.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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Table 6
Associations between convenience of bus service and sufficiently active level of physical activity in driving status groups (Shimane, Japan, 2006).

	Drivers (n = 319)		Non-drivers (n = 111)	
	Crude OR (95% CI)	Adjusted OR[a] (95% CI)	Crude OR (95% CI)	Adjusted OR[a] (95% CI)
Convenience of bus service[b]				
High	0.70 (0.38–1.27)	0.80 (0.42–1.52)	1.05 (0.39–2.84)	1.77 (0.52–5.98)
Moderate	0.62 (0.36–1.08)†	0.62 (0.35–1.11)	1.74 (0.65–4.67)	3.23 (1.00–10.41)*
Low	1.00	1.00	1.00	1.00

Note. Sample sizes vary due to missing values.
Reference is combined category of insufficiently active and inactive.
[a] Odds ratios (ORs) and 95% confidence intervals (CIs) are calculated by binary logistic regression models adjusted for age, body mass index, general state of health, household economy, and engagement in farming. †$P<0.10$, *$P<0.05$, **$P<0.01$.
[b] See Fig. 1 for category definitions.

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Original Article

Sociodemographic Variation in the Perception of Barriers to Exercise Among Japanese Adults

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ABSTRACT

Background: The perception of barriers to exercise is an important correlate of exercise participation. However, only a limited number of studies—mostly from Western countries—have attempted to describe the perceptions of barriers to exercise in specific population groups. This study examined the associations between sociodemographic attributes and perceived barriers to exercise in Japanese adults.

Methods: A population-based cross sectional study of 865 participants (age: 20–69 years old, men: 46.5%) was conducted in 4 cities in Japan. Nine sociodemographic attributes (sex, age, location of residence, educational attainment, marital status, employment status, presence of dependents in the household, self-rated health, body mass index), along with exercise frequency and perception of barriers to exercise (discomfort, lack of motivation, lack of time, lack of social support, poor environment) were assessed by self-administered questionnaire.

Results: The most strongly perceived barrier was lack of time. Five of 9 sociodemographic attributes were significantly related to certain types of perceived barriers. Participants who more strongly perceived barriers were younger, more highly educated, more likely to be employed, and had relatively poor self-rated health and a high BMI. The specific types of barriers that were strongly perceived varied with the sociodemographic attributes of the participants.

Conclusions: The results show that the perception of barriers to exercise varies among specific population groups, which indicates the importance of targeting exercise promotion strategies to specific populations.

Key words: exercise; physical activity; perceived barrier; sociodemographic correlates

INTRODUCTION

Although regular physical activity reduces the risks of morbidity and mortality of diseases such as cardiovascular disease, diabetes, and cancer,[1] a large proportion of the adult population is not sufficiently physically active to gain these health benefits. In Japan, only 31% of men and 28% of women engage in 30 minutes or more of exercise 2 or more times per week.[2] A similarly low prevalence of exercisers has been noted in many countries in the world. For example, in the United States less than half the adult population meets the physical activity recommendation to participate in at least 30 minutes of moderately intense physical activity on most days of the week.[3,4] Physical activity promotion remains one of the priorities of public health.

The World Health Organization Guide for Population-based Approaches to Increase Levels of Physical Activity encourages national action plans, including large-scale interventions to reach the whole population.[5] This guide also emphasizes that, "Some interventions may be tailored to specific population groups, such as adults, children, older persons, employees, people with disabilities, women, men, cultural groups, and people at risk to develop non-communicable diseases." To accomplish this, determinants of physical activity among specific population groups must be understood.

Exercise is an important domain of physical activity. Therefore, understanding exercise determinants is a key area of physical activity promotion. Perceptions of barriers to exercise can be important determinants of exercise participation.[6–8] Janz et al[9] indicated that, "Perceived barriers will be strong predictors of behavior change." According to the health belief model, a person will have a negative attitude toward exercise as a means to promote health

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when there are more perceived barriers than benefits.[10] Strategies that consider barriers should be incorporated into interventions to promote exercise.[11] Thus, the understanding of perceived barriers among specific population groups is important for promoting exercise.

Studies have examined the perception of barriers in convenience samples[12] and among specific populations, such as students and overweight persons.[8,13–16] However, there have been only a limited number of population-based studies, which were conducted in Europe,[17] Brazil,[18] and Australia.[19] These studies demonstrated that perception of barriers varied according to the sociodemographic attributes of the populations. In addition, the relationships differed by country. Therefore, conducting research in a number of countries should prove useful in better understanding exercise behavior. There are few published studies on sociodemographic variation in perceived barriers to exercise among Japanese.[15,20] The present study therefore examined the perception of barriers to exercise in specific population groups among Japanese adults.

METHODS

Participants and data collection

In this cross-sectional study, data were collected from February 2007 through January 2008. A total of 4000 residents, aged 20 to 69 years, who lived in 4 Japanese cities (Koganei, Tsukuba, Shizuoka, Kagoshima) were randomly selected from the registry of residential addresses of each city, and stratified by sex (male/female), age (20–29 years, 30–39 years, 40–49 years, 50–59 years, and 60–69 years), and city of residence so that the sample included 2000 subjects of each sex, 800 subjects of each age category, and 1000 subjects from each city. As a result, the addresses of 100 subjects of a specific sex, in a specific age category, and living in a specific city were obtained. Four divergent Japanese cities were chosen in order to account for lifestyle variations. Koganei is a suburban city of Tokyo; Tsukuba is a university town located 50 km northeast of Tokyo; and Shizuoka and Kagoshima are middle-sized cities located in central and west Japan, respectively.

Because of the large number of questions and the use of an accelerometer for other purposes of this project, the survey was divided into 2 parts. Both parts of the survey were conducted by mail. Questionnaires were sent to and collected from participants via post. Participants who agreed to participate in the second survey were sent the materials approximately 7 days after receiving their response to the first survey. Participants were asked to sign the questionnaire before answering. The first survey was a self-administered questionnaire that included questions on sociodemographic status and exercise habits. The second survey consisted of a 7-day accelerometer survey and a second self-administered questionnaire with additional items, which included the scale of perceived barriers to exercise. To obtain a better response rate, participation letters that described the contents of the study were sent to all 4000 subjects 2 weeks before the first survey. During the survey, a call center was set up for subjects who had enquiries regarding the survey. For nonrespondents, requests to join the survey were mailed twice. If the survey was incomplete, we asked the participant to redo the survey. As a result, among the 4000 residents asked to participate, 1508 (37.7%) responded to the first survey; 865 (57.4%) of these 1508 participated in the second survey, which resulted in a final response rate of 21.6%. The response rates for the 4 cities were 20.7% (Tsukuba, 207/1000), 24.8% (Koganei, 248/1000), 22.2% (Shizuoka, 222/1000), and 18.8% (Kagoshima, 188/1000), respectively. In this study, we used data on sociodemographic status and exercise habits from the first survey and data on perceived barriers to exercise from the second survey.

All participants signed an informed consent document before answering the questionnaire. This study received prior approval from the Tokyo Medical University Ethics Committee.

Measures

Perceived barriers to exercise

The Perceived Barriers to Exercise Scale[20] was the dependent variable. All items of this scale and Cronbach's alpha coefficients in this study sample are shown in Table 1. The scale consists of 5 subscales: (1) "discomfort," which comprises 7 items, including "causes sore muscles" and "get

Table 1. Scale for perceived barriers to exercise

Factors	Items	Alpha*
Discomfort		0.85
	Causes sore muscles	
	Look silly	
	Too uncoordinated	
	Too boring	
	Get hot and sweaty	
	Too fatigued by exercise	
	Uncomfortable	
Lack of motivation		0.70
	Too lazy	
	Lack of motivation	
Lack of time		0.85
	Too busy	
	Not enough time	
	Too much work to do	
	Interferes with work	
	Too tired	
Lack of social support		0.73
	Family does not encourage	
	Friends do not exercise	
	Interferes with social life	
	No one to exercise with	
Poor environment		0.60
	Bad weather	
	Lack of facilities	

*Cronbach's coefficient alpha.

hot and sweaty" (Cronbach's alpha, 0.85), (2) "lack of motivation," which comprises "too lazy" and "lack of motivation" (0.70), (3) "lack of time," which comprises 5 items, including "too busy" and "not enough time" (0.85), (4) "lack of social support," which comprises 4 items, including "family does not encourage" and "friends do not exercise" (0.73), and (5) "poor environment," which comprises "bad weather" and "lack of facilities" (0.60). Participants provided ratings on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) to the statement: "When I do not exercise, the important barrier is ..." followed by 20 barrier items. The mean values of the number of selected choices were calculated as scores of factors (range, 1 to 5). A higher score meant a stronger perception of the barrier. The factor structure, reliability, and criterion-related validity of the scale, as compared with the stage of change in exercise behavior, were confirmed in a previous study.[20]

Sociodemographic attributes and exercise habits

Sex, age, location of residence, educational attainment, employment status, marital status, presence of dependents (living with a child or a person in need of care), self-rated health, body mass index (BMI), and exercise habits were assessed by self-administered questionnaire. In this study, a child was defined as a junior high school student or younger. Self-rated health was measured with a single item that asked participants to rate their health. Participants chose the most suitable answer from a 5-point scale: excellent, very good, good, fair, and poor, for the statement of, "In general, would you say that your health is ...?". BMI was calculated based on self-reported weight and height. Regular exercise frequency (days/month) in a typical month was queried if the participant engaged in exercise for at least 60 minutes per month.

Statistical analysis

The Mann–Whitney U test and Kruskal–Wallis test were used to examine differences in perceptions of barriers to exercise by sociodemographic attributes. Responses to sociodemographic attributes and exercise habits were categorized as: sex (men/women), age (20–39 years/40–59 years/60–69 years old), location of residence (Tsukuba/Koganei/Shizuoka/Kagoshima), educational attainment (<13 years/≥13 years), employment status (employed/not employed), marital status (married/not married), presence of dependents (living with a child or a person in need of care/without dependent), self-rated health (good: excellent, very good, or good/fair or poor: fair or poor), BMI (<25.0/≥25.0), and exercise habits (<3 days/week/≥3 days/week). To examine the independent relationships between each sociodemographic variable and perceived barriers to exercise, multiple logistic regression analyses were conducted. For these analyses, all 9 sociodemographic variables were included in the model. Scores for perceived barriers were converted into dichotomous variables at the median. Locations of residences were included in the model as dummy variables. The odds of higher perceived barriers for the 9 sociodemographic attributes (sex, age, location of residence, educational attainment, employment status, marital status, presence of dependents, self-rated health, and BMI) were calculated. A P value of less than 0.05 was considered to indicate statistical significance. All statistical analyses were performed with SPSS 12.0J for Windows, SPSS Inc., Chicago, USA.

RESULTS

Participant characteristics

Table 2 shows the characteristics of the participants. In the overall sample, 46.5% of the participants were men. The mean age (SD: standard deviation) was 47.9 (13.9) years old. Average BMI was 23.5 (3.0) in men and 21.5 (3.1) in women. The percentage of regular exercisers (≥3 days/week) was 19.4% in men and 22.3% in women. The characteristics of participants living in each city are also shown in Table 2. The prevalence of exercisers and 3 sociodemographic variables—educational attainment, employment status, and living status—significantly differed by city.

Associations between perceived barriers and sociodemographic attributes

Among the overall sample, the medians (25th percentile to 75th percentile) of barrier scores were lack of time 3.0 (2.3–3.8), lack of motivation 2.9 (2.1–3.7), poor environment 2.2 (1.4–3.0), discomfort 1.8 (1.3–2.4), and lack of social support 1.6 (1.1–2.3) (Table 3). Perceptions of barriers to exercise differed significantly for 8 of 9 sociodemographic attributes and by exercise habit. Only location of residence was not related to perceived barriers. Men perceived significantly stronger barriers to exercise, as did participants who were younger, more highly educated, not married, employed, living with a child or person in need of care, overweight, nonexercisers, and had poorer self-rated health. Subscales of perceived barriers related to these variables differed by sociodemographic attributes. For example, subscales related to age were lack of motivation and lack of time, while those related to BMI were discomfort, lack of social support, and poor environment.

Table 4 shows the odds ratios of participants who perceived higher barriers. According to the results, 5 of 9 variables—age, education, employment status, self-rated health, and BMI—were independently related to the perception of barriers. Sex, location of residence, marital status, and presence of dependents were not associated with barrier perception. Younger participants perceived lack of motivation and lack of time more strongly than did older participants. Middle-aged participants perceived poor environment as a less of a barrier than did those who were older (60–69 years old). As for employment status, employed participants strongly perceived lack of time. Poorer self-rated health was significantly related to strong perceptions of

Table 2. Descriptive characteristics (numbers and percentages) of subjects and subsamples

	Overall n = 865	Men n = 403	Women n = 462	P value*	Tsukuba n = 207	Koganei n = 248	Shizuoka n = 222	Kagoshima n = 188	P value†
	n (%)	n (%)	n (%)		n (%)	n (%)	n (%)	n (%)	
Age, years									
20–29	135 (15.6)	52 (12.9)	83 (18.0)		37 (17.9)	36 (14.5)	31 (14.0)	31 (16.5)	
30–39	140 (16.2)	53 (13.2)	87 (18.8)		36 (17.4)	40 (16.1)	33 (14.9)	31 (16.5)	
40–49	185 (21.4)	85 (21.1)	100 (21.6)		48 (23.2)	50 (20.2)	53 (23.9)	34 (18.1)	
50–59	188 (21.7)	104 (25.8)	84 (18.2)		43 (20.8)	51 (20.6)	51 (23.0)	43 (22.9)	
60–69	217 (25.1)	109 (27.0)	108 (23.4)		43 (20.8)	71 (28.6)	54 (24.3)	49 (26.1)	
Mean ± SD	47.9 ± 13.9	49.3 ± 13.5	46.6 ± 14.3	0.001	45.5 ± 13.7	48.7 ± 14.1	48.3 ± 13.9	47.3 ± 14.3	0.090
Education, years									
<13	332 (38.6)	148 (37.1)	184 (39.8)	0.440	74 (35.9)	62 (25.2)	101 (45.5)	95 (50.8)	<0.001
≥13	529 (61.4)	251 (62.9)	278 (60.2)		132 (64.1)	184 (74.8)	121 (54.5)	92 (49.2)	
Marital status									
Married	650 (75.5)	321 (79.9)	329 (71.7)	0.005	153 (74.6)	183 (74.1)	179 (81.0)	135 (71.8)	0.148
Not married	211 (24.5)	81 (20.1)	130 (28.3)		52 (25.4)	64 (25.9)	42 (19.0)	53 (28.2)	
Employment status									
Employed	644 (74.5)	345 (85.6)	299 (64.9)	<0.001	169 (81.6)	179 (72.5)	172 (77.5)	124 (66.0)	0.002
Not employed	220 (25.5)	58 (14.4)	162 (35.1)		38 (18.4)	68 (27.5)	50 (22.5)	64 (34.0)	
Living with a child or person in need of care									
Yes	313 (36.2)	136 (33.8)	177 (38.3)	0.178	87 (42.0)	75 (30.4)	94 (42.3)	57 (30.3)	0.004
No	551 (63.8)	266 (66.2)	285 (61.7)		120 (58.0)	172 (69.6)	128 (57.7)	131 (69.7)	
Self-rated health									
Fair or poor	407 (47.2)	205 (50.9)	202 (43.9)	0.047	98 (47.8)	117 (47.2)	111 (50.0)	81 (43.1)	0.571
Good	456 (52.8)	198 (49.1)	258 (56.1)		107 (52.2)	131 (52.8)	111 (50.0)	107 (56.9)	
BMI, kg/m^2									
<25	689 (79.9)	288 (71.6)	401 (87.2)		161 (77.8)	204 (82.6)	181 (81.5)	143 (76.9)	
≥25	173 (20.1)	114 (28.4)	59 (12.8)		46 (22.2)	43 (17.4)	41 (18.5)	43 (23.1)	
Mean ± SD	22.4 ± 3.2	23.5 ± 3.0	21.5 ± 3.1	<0.001	22.5 ± 3.3	22.3 ± 3.2	22.4 ± 3.2	22.4 ± 3.2	0.926
Exercise, days/week									
<3	684 (79.1)	325 (80.6)	359 (77.7)	0.315	156 (75.4)	202 (81.5)	163 (73.4)	163 (86.7)	0.004
≥3	181 (20.9)	78 (19.4)	103 (22.3)		51 (24.6)	46 (18.5)	59 (26.6)	25 (13.3)	

Abbreviations: BMI, body mass index; SD, standard deviation.
*Comparisons between men and women, using the chi-square test or t-test.
†Comparisons between locations of residence, using the chi-square test or ANOVA.
The total numbers of respondents are not always equal, due to missing data.

discomfort, lack of motivation, and lack of social support. Regarding BMI, overweight participants (≥25.0) perceived stronger barriers of discomfort, lack of social support, and poor environment.

DISCUSSION

This study examined specific barriers to exercise perceived by populations of Japanese adults characterized by 9 sociodemographic attributes. The results indicated that 5 of 9 sociodemographic attributes were independently related to perception of barriers. In general, those who perceived higher barriers were younger, more highly educated, employed, had fair or poor self-rated health, and a high BMI. The specific types of perceived barriers varied by sociodemographic characteristics. For example, age was related to lack of motivation, lack of time, and poor environment, but not to other barriers. As for BMI, discomfort, lack of social support, and poor environment were more strongly perceived among overweight participants. Additional associations between population characteristics and specific types of barriers were also revealed in this study. These findings are important to better understand the correlates of exercise habits among specific population groups, and have implications for the development of exercise promotion strategies that are adjusted to the needs of target populations.

Among all participants, lack of time was the barrier for which the median was highest. As compared to 3 studies from other countries using population-based samples, our results are similar to those of the European[17] and Australian[19] studies, but not to those of the Brazilian study.[18] Because these studies used different scales to measure barriers, comparison and interpretation of the results must be undertaken carefully. Depending on the wording of items in each study, work/study, no time, and lack of time were the strongest barriers, respectively, in the European, Australian, and the present study, while in the Brazilian study, lack of money was reported as the strongest barrier. Lack of time was fourth-

Table 3. Comparison of scores for perceived barriers to exercise, by sociodemographic variables and exercise habits

	n*	Discomfort	Lack of motivation	Lack of time	Lack of social support	Poor environment
		Median (25%–75%)†	Median (25%–75%)†	Median (25%–75%)†	Median (25%–75%)†	Median (25%–75%)†
Overall		1.8 (1.3–2.4)	2.9 (2.1–3.7)	3.0 (2.3–3.8)	1.6 (1.1–2.3)	2.2 (1.4–3.0)
Sex						
Male	403	2.0 (1.4–2.5)	2.9 (2.1–3.7)	3.0 (2.3–3.8)	1.8 (1.1–2.4)	2.3 (1.5–3.0)
Female	462	1.7 (1.3–2.4)	3.0 (2.2–3.6)	3.1 (2.3–3.8)	1.6 (1.1–2.2)	2.2 (1.4–3.0)
P value‡		0.028	0.944	0.952	0.102	0.282
Age, years						
20–39	275	1.8 (1.3–2.5)	3.1 (2.3–3.9)	3.3 (2.6–3.9)	1.6 (1.1–2.3)	2.3 (1.4–3.1)
40–59	373	1.9 (1.4–2.5)	3.0 (2.2–3.7)	3.2 (2.5–3.9)	1.6 (1.1–2.3)	2.1 (1.4–2.9)
60–69	217	1.8 (1.3–2.4)	2.6 (1.8–3.3)	2.4 (1.7–3.2)	1.6 (1.1–2.3)	2.4 (1.5–3.0)
P value§		0.320	<0.001	<0.001	0.706	0.155
Location of residence						
Tsukuba	207	1.8 (1.3–2.5)	2.9 (2.1–3.7)	3.0 (2.3–3.9)	1.6 (1.1–2.3)	2.2 (1.4–3.0)
Koganei	248	1.8 (1.4–2.4)	3.0 (2.3–3.8)	3.1 (2.5–3.7)	1.6 (1.1–2.2)	2.3 (1.6–3.0)
Shizuoka	222	1.9 (1.3–2.5)	3.0 (2.2–3.6)	3.0 (2.2–3.9)	1.7 (1.1–2.4)	2.3 (1.5–3.0)
Kagoshima	188	1.8 (1.3–2.3)	2.8 (2.0–3.5)	2.9 (2.1–3.6)	1.7 (1.1–2.3)	2.1 (1.3–2.9)
P value§		0.501	0.203	0.149	0.603	0.215
Education, years						
<13	332	1.8 (1.4–2.5)	2.7 (1.9–3.4)	2.8 (2.1–3.6)	1.7 (1.1–2.3)	2.2 (1.4–3.0)
≥13	529	1.8 (1.3–2.4)	3.1 (2.3–3.8)	3.2 (2.4–3.8)	1.6 (1.1–2.3)	2.2 (1.5–3.0)
P value‡		0.751	<0.001	0.001	0.193	0.979
Marital status						
Married	650	1.9 (1.3–2.4)	2.9 (2.1–3.6)	3.0 (2.3–3.7)	1.6 (1.1–2.2)	2.2 (1.4–3.0)
Not married	211	1.8 (1.3–2.6)	3.0 (2.2–3.8)	3.2 (2.4–4.0)	1.7 (1.1–2.5)	2.3 (1.4–3.1)
P value‡		0.515	0.491	0.020	0.344	0.594
Employment status						
Employed	644	1.8 (1.3–2.5)	3.0 (2.2–3.7)	3.2 (2.5–3.9)	1.6 (1.1–2.3)	2.2 (1.5–3.0)
Not employed	220	1.8 (1.3–2.4)	2.9 (2.0–3.5)	2.5 (1.7–3.2)	1.6 (1.1–2.3)	2.2 (1.4–3.0)
P value‡		0.600	0.317	<0.001	0.832	0.740
Living with a child or person in need of care						
Yes	313	1.7 (1.3–2.5)	2.9 (2.0–3.7)	3.2 (2.4–3.9)	1.6 (1.1–2.3)	2.2 (1.4–3.0)
No	551	1.9 (1.4–2.4)	3.0 (2.2–3.7)	3.0 (2.2–3.6)	1.6 (1.1–2.3)	2.2 (1.5–3.0)
P value‡		0.301	0.473	0.010	0.941	0.944
Self-rated health						
Fair or poor	407	2.1 (1.5–2.6)	3.1 (2.3–3.8)	3.0 (2.3–3.8)	1.8 (1.1–2.4)	2.3 (1.6–3.0)
Good	456	1.7 (1.2–2.3)	2.8 (2.0–3.5)	3.1 (2.3–3.8)	1.5 (1.1–2.2)	2.1 (1.3–3.0)
P value‡		<0.001	<0.001	0.849	0.008	0.037
BMI, kg/m^2						
<25	689	1.8 (1.3–2.4)	2.9 (2.1–3.7)	3.0 (2.3–3.7)	1.5 (1.1–2.3)	2.2 (1.4–2.9)
≥25	173	2.1 (1.4–2.6)	3.1 (2.4–3.7)	3.1 (2.2–3.9)	1.9 (1.2–2.4)	2.5 (1.7–3.3)
P value‡		0.010	0.169	0.732	0.028	0.001
Exercise, days/week						
<3	684	1.9 (1.4–2.5)	3.0 (2.2–3.7)	3.1 (2.4–3.9)	1.7 (1.1–2.3)	2.3 (1.5–3.0)
≥3	181	1.5 (1.1–2.3)	2.7 (1.7–3.4)	2.8 (1.9–3.5)	1.3 (1.0–2.1)	2.2 (1.3–3.0)
P value‡		<0.001	<0.001	0.001	0.001	0.519

Abbreviation: BMI, body mass index.
Higher score means higher perception of a barrier to exercise.
*Total numbers of respondents are not equal, due to missing data.
†Twenty-fifth and 75th percentiles.
‡The Mann–Whitney U test was used to compare the scores of barrier perception between groups.
§The Kruskal–Wallis test was used to compare the scores of barrier perception between groups.

ranked among the 8 barriers in the Brazilian study. Regarding the relationship between sociodemographic characteristics and this barrier, all studies reported that lack of time was perceived more strongly among younger, as compared to older, age groups. However, the relationship between sex and the lack of time barrier is more complicated. In the European study, men strongly perceived this barrier; however, it was perceived more strongly among women in Brazil. By contrast, there were no sex differences in the perception of time constraints in either the present study or the Australian study. This suggests that the associations between specific types of barriers and population characteristics vary according to cultural

Table 4. Odds ratios and 95% confidence intervals for participants who perceived higher barriers to exercise, after evaluation by multiple logistic regression analyses

	Discomfort			Lack of motivation			Lack of time			Lack of social support			Poor environment		
	OR	95% CI	*P* value	OR	95% CI	*P* value	OR	95% CI	*P* value	OR	95% CI	*P* value	OR	95% CI	*P* value
Sex															
Male	1.32	0.95–1.84	0.096	1.06	0.75–1.49	0.749	0.78	0.55–1.09	0.148	1.22	0.88–1.69	0.241	1.08	0.78–1.50	0.649
Female	1.00			1.00			1.00			1.00			1.00		
Age, years															
20–39	1.13	0.68–1.86	0.640	2.31	1.34–3.99	0.003	2.52	1.47–4.32	0.001	1.11	0.67–1.82	0.693	1.01	0.61–1.67	0.955
40–59	1.22	0.79–1.89	0.375	1.74	1.08–2.82	0.023	2.22	1.39–3.56	0.001	1.00	0.64–1.54	0.983	0.56	0.36–0.87	0.010
60–	1.00			1.00			1.00			1.00			1.00		
Location of residence															
Tsukuba	0.92	0.57–1.47	0.712	1.05	0.64–1.74	0.842	0.97	0.59–1.58	0.897	1.13	0.70–1.80	0.620	0.92	0.57–1.48	0.735
Koganei	0.79	0.50–1.24	0.302	0.81	0.50–1.31	0.393	0.78	0.49–1.26	0.312	1.03	0.65–1.62	0.907	0.66	0.41–1.04	0.072
Shizuoka	0.72	0.45–1.15	0.173	0.90	0.55–1.48	0.676	0.88	0.54–1.43	0.609	0.85	0.54–1.35	0.495	0.81	0.51–1.28	0.361
Kagoshima	1.00			1.00			1.00			1.00			1.00		
Education, years															
≥13	0.99	0.70–1.40	0.959	1.63	1.13–2.34	0.009	1.29	0.91–1.84	0.158	0.84	0.59–1.18	0.304	0.95	0.67–1.33	0.747
<13	1.00			1.00			1.00			1.00			1.00		
Marital status															
Not married	0.93	0.61–1.41	0.724	0.85	0.55–1.33	0.487	1.21	0.78–1.88	0.386	1.03	0.67–1.56	0.908	0.93	0.61–1.41	0.728
Married	1.00			1.00			1.00			1.00			1.00		
Employment status															
Employed	0.87	0.58–1.29	0.478	0.96	0.63–1.47	0.866	2.77	1.81–4.25	<0.001	0.97	0.65–1.43	0.862	1.07	0.72–1.59	0.752
Not employed	1.00			1.00			1.00			1.00			1.00		
Living with a child or person in need of care															
Yes	0.73	0.51–1.03	0.072	0.86	0.60–1.24	0.425	1.20	0.84–1.72	0.307	0.98	0.69–1.38	0.889	1.09	0.77–1.54	0.634
No	1.00			1.00			1.00			1.00			1.00		
Self-rated health															
Fair or poor	1.64	1.20–2.25	0.002	1.88	1.35–2.61	<0.001	1.03	0.74–1.42	0.881	1.42	1.04–1.93	0.029	1.19	0.87–1.63	0.270
Good	1.00			1.00			1.00			1.00			1.00		
BMI, kg/m^2															
≥25	1.53	1.03–2.27	0.037	1.08	0.72–1.62	0.712	1.04	0.69–1.56	0.865	1.90	1.28–2.82	0.001	1.79	1.21–2.65	0.004
<25	1.00			1.00			1.00			1.00			1.00		

Abbreviations: BMI, Body mass index; CI, confidence interval; OR, odds ratio.
Odds ratios were calculated after adjustment for all variables listed in the table.

background. Employment status was also related to lack of time in the present study. For those who have little discretionary time for exercise, time-saving interventions such as lifestyle intervention rather than structured exercise programs, internet programs rather than face-to-face counseling, and individual counseling rather than group programs may be more effective.

Discomfort was significantly associated with fair or poor self-rated health and overweight, which suggests that exercise programs of proper intensity that are adjusted to a participant's fitness level and do not induce discomfort such as muscle soreness may be effective among individuals who are overweight or in poor health. Other relationships between sociodemographic variables and barriers indicated that certain population groups have their own profile of barrier perception.

This study was conducted using a community-based random sample from residents living in 4 cities in Japan. Participants were randomly selected from the registry of residential addresses, from a list encompassing the entire population of each city. The response rate was 21.6%. One reason for this low rate was that we included a 7-day accelerometer survey for other purposes of this project. To estimate the representativeness of this sample, we compared the age-adjusted prevalence of overweight individuals, exercisers, and employees in our sample with those in the national survey. The prevalence of overweight participants (BMI ≥25.0) was 28.4% in men and 12.8% in women in this study, while the age-adjusted prevalence in the sample of the Japanese National Health and Nutrition Survey 2005[2] was 29.6% in men and 19.0% in women. The prevalence of overweight persons in this study was similar in men and 6.2% lower in women. There are 2 possible reasons for this lower prevalence of overweight among women. One is that this sample of women was relatively healthier than the general population of Japanese. Another is that the assessment of BMI in this study was based on self-reports and women tend to report a lower weight than their actual body weight.[21,22] As for exercise habits (≥3days/week), 19.4% of men and 22.3% of women in this study were exercisers, while 20.4% of men and 18.2% of women were reported to be exercisers (≥3days/week) in the national survey.[2] Although the survey methods were different, the sample of this study seems to include a slightly higher percentage of women exercisers. Regarding employment status, 85.6% of men and 64.9% of women in the present study had gainful employment, while 76.3% of men and 55.2% of women worked full-time or part-time in the national survey.[23] The participants of this study may have included more employed persons, which indicates that our sample was slightly different from the general population. Therefore, we cannot exclude the possibility of selection bias. This study sample may have been slightly healthier and higher in socioeconomic status. If we assume that this bias in our population results in behavioral skills that are more likely to overcome the actual barriers caused by sociodemographic status, as compared to an unhealthier population with lower socioeconomic status, then this study would underestimate the influence of sociodemographic status on barrier perceptions.

This study possesses several strengths. First, we used a sample from the general population, whereas most previous studies of perceived barriers were conducted using certain populations such as students, employees, and research volunteers. Therefore, this study contributes to the understanding of the perception of barriers in the general population, and the difference in barriers among specific population groups. Second, most studies of exercise barriers were conducted in Western countries. There have been few reports from Japan, which has important cultural differences from Western countries. Our results have implications for exercise promotion strategies developed specifically for Japanese. Third, our analysis integrated a large variety of sociodemographic attributes. Most studies examined barriers by sex, age, and a few other attributes such as BMI and employment status, but the present study investigated a larger number of attributes. Finally, the reliability and validity of the barrier scale were comprehensively examined and confirmed in a previous study.[20]

However, some limitations of the present study should be acknowledged. First, the response rate was relatively low. As discussed above, this low rate could result in selection bias. However, there have been few previous studies that have addressed perceived barriers to exercise, with respect to a variety of sociodemographic variables, among the general population. Thus, we believe that our results are useful for understanding the psychological aspects of exercise behavior. Second, we examined barriers to exercise, but did not investigate other domains of physical activity such as work activity, commuting, and household work, which are also beneficial to health. The perception of barriers to exercise and to other domains of physical activity may be different. In the future, research on barriers to specific domains of physical activity would be useful in understanding determinants of physical activity.

In spite of these limitations, the results of this study helped to identify subgroups that perceive specific barriers to exercise among Japanese, and to gain a better understanding of the psychological aspects of exercise behavior. Characteristics of specific population groups should be considered in the development of exercise promotion strategies.

CONCLUSION

Perception of barriers to exercise varied in a Japanese population characterized by age, educational attainment, employment status, self-rated health, and BMI. These results should prove helpful in developing population-specific interventions, such as time-saving interventions for younger and employed populations and, for groups with poorer health, exercise programs that are adjusted to the participants' fitness level. The results of this study highlight the importance of adjusting exercise promotion strategies to match the characteristics of the target population.

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Neighborhood Environments and Physical Activity Among Adults in 11 Countries

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Background: Understanding environmental correlates of physical activity can inform policy changes. Surveys were conducted in 11 countries using the same self-report environmental variables and the International Physical Activity Questionnaire, allowing analyses with pooled data.

Methods: The participating countries were Belgium, Brazil, Canada, Colombia, China (Hong Kong), Japan, Lithuania, New Zealand, Norway, Sweden, and the U.S., with a combined sample of 11,541 adults living in cities. Samples were reasonably representative, and seasons of data collection were comparable. Participants indicated whether seven environmental attributes were present in their neighborhood. Outcomes were measures of whether health-related guidelines for physical activity were met. Data were collected in 2002–2003 and analyzed in 2007. Logistic regression analyses evaluated associations of physical activity with environmental attributes, adjusted for age, gender, and clustering within country.

Results: Five of seven environmental variables were significantly related to meeting physical activity guidelines, ranging from access to low-cost recreation facilities (OR=1.16) to sidewalks on most streets (OR=1.47). A graded association was observed, with the most activity-supportive neighborhoods having 100% higher rates of sufficient physical activity compared to those with no supportive attributes.

Conclusions: Results suggest neighborhoods built to support physical activity have a strong potential to contribute to increased physical activity. Designing neighborhoods to support physical activity can now be defined as an international public health issue.
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Introduction

The well-documented health burdens of physical inactivity have led national[1–3] and international[4,5] health agencies to prioritize physical activity promotion. Efforts to motivate and educate individuals can be complemented by creating social and built environments that make physical activity safe and convenient.[6] Authoritative groups found convincing evidence from a few developed countries that people are more active, especially for transportation, if they live in communities characterized by mixed land use (i.e., with stores in walking distance of homes); well-connected street networks; and high residential density than if they live in communities designed for automobile-dependent transportation with the opposite characteristics.[7,8] Other reviewers concluded that proximity to recreational facilities, along with pleasing aesthet-

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ics, was associated with more recreational physical activity.[9,10]

Limitations of the existing research examining associations between built environments and physical activity are apparent. First, the lack of experimental and prospective studies prevents conclusions about the direction of causality.[8] Second, specific characteristics of neighborhoods related to physical activity need to be identified to guide designers and planners to create more activity-friendly environments. Third, most studies examined subcomponents of physical activity, such as transportation or recreational activities, but the contribution of built environments to total physical activity, which should be most strongly related to health outcomes, has seldom been reported.[11–13] Finally, because studies have been conducted within single countries, limited environmental variability may lead to underestimation of true associations with physical activity. Such underestimation could reduce the apparent relevance of built-environment changes as physical activity promotion strategies.

The present study aimed to address all but the first limitation with a cross-sectional analysis of how neighborhood attributes in 11 countries help adults meet health-enhancing physical activity guidelines. The use of common methods and survey translation/adaptation protocols justified pooling across countries, creating a database with very wide variability in environments and populations.

Methods

International Physical Activity Prevalence Study (IPS)

The aim of the IPS was to collect nationally representative and internationally comparable prevalence estimates on physical activity from diverse countries. Interested investigators were required to show capacity and intent to follow rigorous guidelines to address known limitations in physical activity prevalence studies (i.e., seasonality, instrument translation and training, data coding, analysis strategy). As described elsewhere,[14] protocols for recruiting population samples and collecting data were established, with some allowances for modifications needed for local contexts. The sample was required to be representative of national populations or a significant region(s) within a country (defined as a population of >1,000,000), with an age range of 18–65 years. Households were typically selected at random, and individuals within households were selected either randomly or by most recent birthday.

Data collection in Spring or Fall 2002/2003 was required to reduce seasonal variations. If data were collected across 12 months, only Spring and Fall data were used, in most cases. Data were analyzed in 2007.

Of the 20 countries in which data were collected,[14] 11 completed an environmental survey: Belgium, Brazil, Canada, Colombia, China (Hong Kong), Japan, Lithuania, Norway, New Zealand, Sweden, and the U.S. Guidelines for survey translation and adaptation had to be followed (www.ipaq.ki.se), and translations of surveys back into English were approved.

Measure of Perceived Neighborhood Environment

Neighborhood attributes of relevance to physical activity were measured with seven items from the Physical Activity Neighborhood Environment Survey (PANES; also known as the IPS Environmental Module) that were used by all 11 countries (Appendix A, available online at www.ajpm-online.net; full survey available at www.ipaq.ki.se and www.drjamessallis.sdsu.edu). Most countries included additional items. Neighborhood was defined as the area within a 10- to 15-minute walk from home. Each item assessed an environmental attribute shown in previous studies to be related to physical activity for recreation[10] or transportation.[7,8,15] The main type of housing in neighborhoods (e.g., apartment, single-family) was used as an indicator of residential density. Having many stores within walking distance was used as an indicator of mixed land use. Access to a transit stop was included because transit use involves walking.[16] The presence of sidewalks and bicycling facilities was used to assess pedestrian and bicycling infrastructure. The presence of free or low-cost recreation facilities was assessed. Citing crime as a barrier to walking at night was used as an indicator of perceived crime, a social environmental variable.

With the exception of the item on the main type of housing, items were phrased as statements about an attribute of their neighborhood, with the following response options: strongly disagree, somewhat disagree, somewhat agree, strongly agree, don't know/not sure, or refused. For data analysis, responses were combined to create two levels: agree (strongly agree and somewhat agree) and disagree (strongly disagree and somewhat disagree). For types of housing, detached single-family (i.e., low-density) was compared to all others. Survey respondents (n=754) were excluded from data analysis if they selected responses of don't know/not sure or refused for any neighborhood-attribute item. Most items were taken or adapted from previously evaluated surveys of neighborhood environments.[13,17,18]

Test–retest reliability was evaluated in a separate sample of 135 adults recruited from neighborhoods that varied in income and walkability in Cincinnati OH, San Diego CA, and Boston MA. Intraclass correlations ranged from 0.64 for free or low-cost recreation facilities to 0.84 for sidewalks on most streets. Items had similarly high reliability in a Swedish study (except for perceived crime),[19] and reliability was also supported in a Nigerian sample.[20]

Neighborhood environment index. Analyses with individual environmental attributes indicated which items were most strongly related to physical activity. However, individual item results could not estimate the overall effect size of activity-friendly neighborhoods. A neighborhood environment index was constructed by summing the number of favorable "activity-friendly" environmental attributes. Preliminary analyses indicated that perceived crime, the only social environmental variable, reduced the Cronbach's alpha. Thus, the index was composed of the six built-environment items. Scores ranged from 0 to 6, with higher scores indicating a more favorable built environment for physical activity; Cronbach's alpha= 0.55. In the separate sample from three U.S. cities, the intraclass correlation (ICC) test–retest reliability for the sum of the six items was ICC=0.86, with Cronbach's alpha=0.92. The difference in alpha coefficients may be a result of wider environmental variation in the international sample and the high education level of the U.S. reliability sample.

Physical Activity Measure

The short interviewer-administered International Physical Activity Questionnaire (IPAQ) measured the frequency and duration of walking, and moderate-intensity and vigorous physical activity, for leisure, transportation, and occupational purposes; and of inactivity (i.e., sitting) during the past week (except for Sweden, which used the self-administered format). For each question, respondents were given physiologic guidelines for breathing and heart rate, and country-specific examples of activities, to help them recall activities with an appropriate intensity level. Reliability and validity were evaluated with over 2500 adults from 12 countries.[21] One-week test–retest reliability of the short, interviewer-administered IPAQ was good (Spearman r =0.70–0.97). Criterion validity for the IPAQ total minutes per week was acceptable as measured against accelerometer total counts (Spearman r =0.23) and for the average correct classification of respondents accumulating ≥150 minutes per week of physical activity (Spearman r =0.74).[21]

Meeting guidelines for physical activity. The IPAQ was scored using the IPS scoring protocol (www.ipaq.ki.se) to classify participants as performing moderate amounts of physical activity, equivalent to meeting physical activity guidelines.[22,23] Meeting guidelines for moderate amounts of physical activity was defined by any of three criteria:

- ≥3 days of vigorous-intensity activity for at least 20 minutes per day;
- ≥5 days of moderate-intensity activity or walking for at least 30 minutes per day;
- ≥5 days of any combination of walking, or moderate- or vigorous-intensity activities, with a minimum of 600 MET-minutes per week.

A MET-minute is defined as the MET intensity multiplied by the minutes per week of activity. A MET is the activity metabolic rate divided by the resting metabolic rate, with one MET representing the energy expended while sitting quietly at rest. Intensity levels used to score the IPAQ were vigorous (8 METs), moderate (4 METs), and walking (3.3 METs).

Analyses

Data analyses were performed using SAS version 9.1. Data from each country were pooled and weighted to account for differential probabilities of sample selection and were post-stratified to the world 2001 population to facilitate comparisons among countries with varying age and gender distributions. Education could not be used as a covariate because it was missing for two countries. Descriptive characteristics of the analysis sample are presented unweighted for each country in Table 1; however, all additional analyses employed sample weights.

Neighborhood environmental variables have not been validated for rural residents and may not be relevant, so analyses were conducted among IPS participants living in towns or cities with populations ≥30,000. Prevalence of the seven environmental attributes was reported for each country. Odds of meeting guidelines for physical activity were modeled for each neighborhood environment item using the logistic regression program PROC LOGISTIC in SAS software. Models included age, gender, and country as covariates. Data were presented as ORs with 95% CIs. The strength of association between number of physical activity–supportive environmental attributes (the neighborhood environment index) and physical activity was examined using PROC LOGISTIC. The Wald statistic for the neighborhood index variable was interpreted as a test for a linear gradient and was considered significant at $p<0.05$.

Results

Description of Samples

About 70% of all participants (N=11,541) reported living in towns and cities with populations ≥30,000, ranging from 27.6% (Belgium) to 100% (Brazil, Colombia [Bogota], Hong Kong). Demographic characteristics of each country sample are shown in Table 1. Sample sizes ranged from 357 (Belgium) to 2674 (Colombia); genders were well balanced; and age distributions in the range of 20–64 years were generally balanced, except for that in Japan. Percentages of participants with >13 years of education ranged from <20% (Colombia) to >60% (Canada and the U.S.).

Table 2 shows substantial variation across countries in the percentage of participants who reported the presence of the seven built-environment characteristics. For example, having single-family homes as the main housing type varied from <1% (Hong Kong) to 88% (Brazil); sidewalk availability ranged from 25% (Brazil) to 97% (Hong Kong); and perceived lack of safety because of crime ranged from 16% (Canada and Norway) to almost 75% (Colombia and Lithuania).

Relationship Between Environmental Attributes and Meeting Health-Enhancing Physical Activity Guidelines

Seventy-seven percent of participants reported that they met guidelines for physical activity. As reported by Bauman and colleagues,[14] physical activity prevalence in the IPS is comparable to that found in other studies, especially a recent international study[24] using the short IPAQ. However, the IPAQ is known to demonstrate higher prevalence than other self-report surveys,[25–27] in part because IPAQ assesses all physical activity domains.

Physical activity prevalence was significantly related to five of the seven environmental variables (Figure 1): many shops nearby (OR=1.29 [95% CI=1.15, 1.44]); transit stop in neighborhood (OR=1.32 [95% CI=1.16, 1.54]); sidewalks on most streets (OR=1.47 [95% CI=1.32, 1.65]); bicycle facilities (OR=1.21 [95% CI=1.10, 1.33]); and low-cost recreational facilities (OR=1.16 [95% CI=1.05, 1.27]). All associations were in the expected direction, and only single-family homes and perceived crime were not significant.

Table 1. Unweighted sample characteristics of city (population ≥30,000) residents by country, *n* (%) unless otherwise indicated

Characteristic	Total sample *n* (%N)	Country				
		Belgium	Brazil	Canada	Colombia	Hong Kong
Total	11,541 (100)	357 (100)	876 (100)	619 (100)	2,674 (100)	990 (100)
Gender						
Male	5,129 (44.4)	208 (52.3)	433 (49.4)	314 (50.7)	1,083 (40.5)	466 (47.1)
Female	6,412 (55.6)	149 (41.7)	443 (50.6)	305 (49.3)	1,591 (59.5)	524 (52.9)
Age (years)						
18–29	3,665 (31.8)	38 (10.6)	330 (37.7)	143 (23.1)	1,052 (39.3)	186 (18.8)
30–39	2,894 (25.1)	79 (22.1)	227 (25.9)	152 (24.6)	668 (25.0)	271 (27.4)
40–49	2,512 (21.8)	103 (28.9)	174 (19.9)	165 (26.7)	517 (19.3)	305 (30.8)
50–65	2,470 (21.4)	137 (38.4)	145 (16.6)	159 (25.7)	437 (16.3)	228 (23.0)
Educational attainment						
≤13 years	5,625 (54.8)	—	—	200 (32.5)	2,174 (81.3)	769 (77.9)
>13 years	4,633 (45.2)	—	—	416 (67.5)	500 (18.7)	218 (22.1)
Meet guidelines by walking						
Yes	7,062 (61.2)	147 (41.2)	332 (37.9)	383 (61.9)	2,012 (75.2)	843 (85.2)
No	4,479 (38.8)	210 (58.8)	544 (62.1)	236 (38.1)	662 (27.8)	147 (14.9)
Meet guidelines for physical activity						
Yes	9,147 (79.3)	203 (56.9)	571 (65.2)	527 (85.1)	2,139 (80.0)	853 (86.2)
No	2,394 (20.7)	154 (43.1)	305 (34.8)	92 (14.9)	535 (20.0)	137 (13.8)

	Country					
	Japan	Lithuania	New Zealand	Norway	Sweden	U.S.
Total	442 (100)	1,291 (100)	803 (100)	492 (100)	434 (100)	2,563 (100)
Gender						
Male	281 (63.6)	508 (39.4)	318 (39.6)	237 (48.2)	194 (44.7)	1,087 (42.4)
Female	161 (36.4)	783 (60.7)	485 (60.4)	255 (51.8)	240 (55.3)	1,476 (57.6)
Age (years)						
18–29	356 (80.5)	538 (41.7)	190 (23.7)	128 (26.0)	111 (25.6)	593 (23.1)
30–39	86 (19.5)	255 (19.8)	227 (28.3)	128 (26.0)	116 (26.7)	685 (26.7)
40–49	—	268 (20.8)	185 (23.0)	107 (21.8)	80 (18.4)	608 (23.7)
50–65	—	230 (17.8)	201 (25.0)	129 (26.2)	127 (29.3)	677 (26.4)
Educational attainment						
≤13 years	248 (56.9)	498 (38.9)	464 (57.8)	196 (41.2)	237 (54.9)	839 (32.9)
>13 years	188 (43.1)	782 (61.1)	339 (42.2)	280 (58.8)	195 (45.1)	1,715 (67.2)
Meet guidelines by walking						
Yes	223 (50.5)	698 (54.1)	469 (58.4)	288 (58.5)	235 (54.2)	1,432 (55.9)
No	219 (49.5)	593 (45.9)	334 (41.6)	204 (41.5)	199 (45.9)	1,131 (44.1)
Meet guidelines for physical activity						
Yes	289 (65.4)	1,074 (83.2)	677 (84.3)	390 (79.3)	316 (72.8)	2,108 (82.3)
No	153 (34.6)	217 (16.8)	126 (15.7)	102 (20.7)	118 (27.2)	455 (17.8)

Strength of Association

The number of physical activity–supportive built-environment attributes was positively related to meeting guidelines for physical activity (Figure 2). The Wald statistic for the regression coefficient can be interpreted as a test for linear gradient; Wald χ^2=64.86, p<0.0001. There were significant differences in physical activity prevalence for those reporting four, five, or six attributes compared to those reporting zero, and the OR for six supportive attributes was 2.00.

Because education may confound the relation between physical activity and built-environment attributes, the analysis was repeated, covarying for education, using samples from the nine countries with education data. Only participants with all six favorable neighborhood environmental attributes were significantly more likely than those with zero favorable attributes to meet physical activity recommendations. For the score of six built-environment neighborhood attributes, the OR adjusting for education was 1.7 (95% CI=1.2, 2.4), whereas the original OR was 2.0 (95% CI=1.4, 2.8).

Discussion

Five of seven neighborhood environmental variables were significantly associated with meeting guidelines for physical activity in a study of 11 countries. There was evidence of a linear gradient in the relationship, such that the more supportive the reported built-environment attributes were for the neighborhood, the more likely the person was to be sufficiently physically active. Although adjusting for education reduced the associa-

Table 2. Weighted percentage of city residents, by country, who agree their neighborhood environment has given attributes

	Country										
Environmental variable	Belgium (n=357)	Brazil (n=876)	Canada (n=619)	Colombia (n=2674)	Hong Kong (n=990)	Japan (n=442)	Lithuania (n=1291)	New Zealand (n=803)	Norway (n=492)	Sweden (n=434)	U.S. (n=2563)
Single-family houses the main housing type	32.7	88.0	60.9	21.7	0.3	30.0	15.3	74.5	40.6	28.1	60.8
Many shops within walking distance	62.1	85.2	69.0	93.2	88.4	83.2	82.5	74.8	84.1	78.2	59.6
Transit stop within 10–15 minutes from home	74.1	94.8	82.8	96.5	96.4	91.0	91.1	92.1	97.4	97.2	68.0
Sidewalks on most streets	83.9	25.2	77.2	91.1	96.9	59.1	86.7	94.6	76.5	95.7	73.9
Facilities to bicycle in or near neighborhood	78.5	33.9	67.9	45.4	37.2	24.8	47.6	45.7	72.0	78.7	57.4
Low-cost recreation facilities	78.8	28.3	87.3	50.9	72.9	59.8	54.5	87.0	75.1	78.8	69.8
Crime rate makes it unsafe to walk at night	24.3	65.5	16.1	74.8	36.3	32.9	74.6	39.4	16.3	39.3	31.5

Note: Sample consists of those who reported living in cities with populations ≥30,000.

tion somewhat, having many favorable neighborhood environmental characteristics remained positively associated with physical activity. The present results demonstrate that previous findings linking neighborhood environments with physical activity, based on studies in a few developed countries, can be generalized to a broad range of countries. Designing neighborhoods to support physical activity can now be defined as an international public health issue.

The environmental attribute with the highest OR was having sidewalks on most streets in the neighborhood. This finding may reflect the fact that sidewalks can be used for many common types of physical activity, including walking, jogging, and skating, for both recreation and transportation purposes. Ensuring access to sidewalks may be a practical and effective policy for encouraging physical activity.

The hypothesis that a cluster of activity-friendly attributes would be needed to support higher rates of meeting physical activity guidelines was supported. Although single attributes were associated with 15%–50% higher rates of meeting guidelines, when all six built-environment attributes were present, rates of physical activity were 100% higher, compared to those in neighborhoods with no supportive attributes. After adjusting for education in an analysis of nine countries, the OR was still a significant 1.7. These strong associations contrast with reports that neighborhood environments had weak associations with physical activity.[28–30] Including the full range of environmental variation across countries likely accounts for the stronger associations found in the current study.

The multiple significant individual variables suggest that a variety of environmental interventions may affect physical activity, with different environmental variables having particular relevance for physical activity for transportation versus recreation purposes.[31,32] There is substantial interest in crime as a barrier to physical activity, but studies to date have produced inconsistent results regarding this variable,[10,33] and the association was not significant in the present study. More sophisticated measures of crime and domain-specific measures of physical activity are needed to further explore this important topic. All other significant associations with physical activity were consistent with previous findings,[7,8,10,16,34] except for the lack of association with residential density in the current study.

The perceived built-environment items may be useful for environmental surveillance because they revealed substantial variation by country, and the associations with physical activity supported the construct validity of the items. Each country had a unique profile on this set of items (Table 2). Hong Kong appeared to have the most "activity-friendly" built environment on most items, but bicycling facilities were available to few residents.

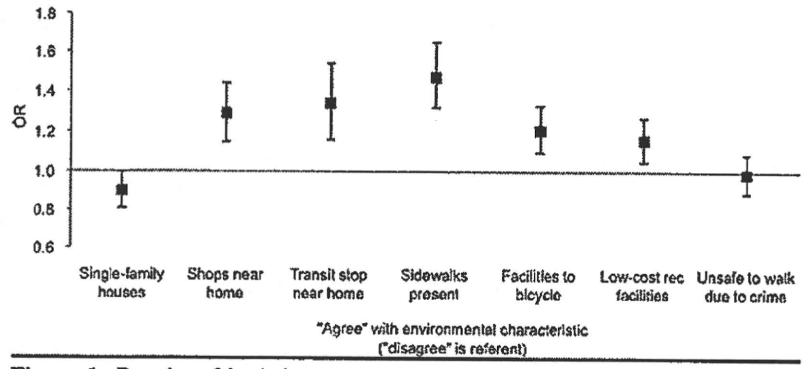

Figure 1. Results of logistic regression analysis of the relationship of seven perceived neighborhood attributes to meeting physical activity guidelines among city residents only, adjusted for gender, age, and country (pooled sample N=11,541)

The U.S. had the most limited access to transit stops and was the only country in which less than 60% of participants were within walking distance of shops. These findings help explain the small percentage of trips made by walking and bicycling in the U.S.[8] Although the U.S. has one of the highest violent crime rates in the world,[35] the perceived level of crime was lower than that in Lithuania, Colombia, and Brazil. The majority of participants in all countries except Brazil reported having free or low-cost recreation facilities and sidewalks on most streets in their neighborhoods. European countries had the highest access to bicycling facilities.

Strengths of the study include the assessment of large samples of adults in 11 countries using standardized methods. Participating countries provided broad geographic and sociopolitical diversity, including five continents and some developing nations. Survey items had evidence of good test–retest reliability in multiple countries. Authoritative guidelines[22,23] were used as the criteria for health-enhancing physical activity. However, there were challenges to conducting a multi-country study. Despite efforts to standardize and adapt the survey items, interpretations and meanings of items could vary by country, especially on subjective items such as perception of crime. The number of environmental variables was limited by the multipurpose survey, so each concept was measured by a single item. The short IPAQ did not provide data on specific domains of physical activity (e.g., transportation, recreation) that may have produced stronger associations with neighborhood characteristics.[31,36] The IPAQ has been shown to overestimate physical activity,[25–27,37] so actual prevalence rates are likely not as high as those reported here. Reliability and validity for IPAQ appear to vary by the country's level of development.[21] The cross-sectional design does not allow interpretations about direction of effect, so self-selection of active people into activity-friendly neighborhoods remains a possibility.[8] Inclusion of people in cities with populations ≥30,000 could be considered a limitation, but the assessed built-environment attributes were not expected to be relevant for rural areas. Reports of environmental attributes could be biased if more active people perceive their environments differently than do inactive people.

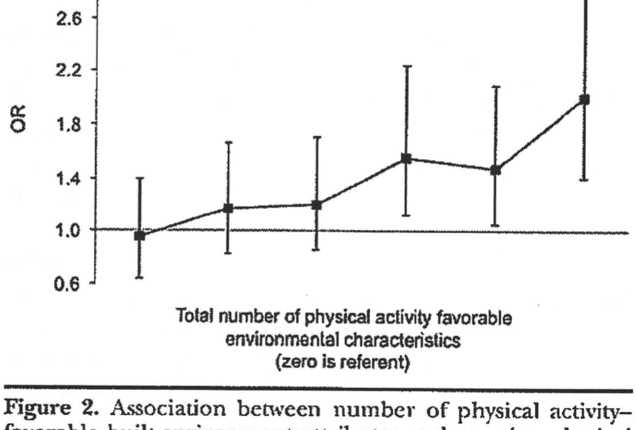

Figure 2. Association between number of physical activity–favorable built-environment attributes and meeting physical activity guidelines among city residents only, adjusted for gender, age, and country (pooled sample N=11,541)

Previous within-country findings that neighborhood environments are related to physical activity[7,8,10,15,31,34] were replicated and extended in the present international study. A variety of neighborhood attributes relevant to physical activity for both the transportation and recreation domains were associated with meeting health-enhancing guidelines. These findings suggest that changes to the built environment may be effective in increasing physical activity, but multiple environmental changes are likely needed to have a substantial effect. Prospective and experimental studies are required to strengthen evidence of causality. In the present study, highly supportive environments were associated with a 100% higher likelihood of sufficient physical activity and with a 70% higher likelihood of meeting guidelines after adjusting for education. These are large effects for a potential intervention, and they are expected to be relatively permanent. Each country had a unique profile of environmental supports, so population surveys of neighborhood characteristics can be used for environmental surveillance.

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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.2009.01.031.

特集｜運動療法の新展開
Q&A　　肥　満

生活環境と歩行の関係は？

どんな生活環境が歩行時間に影響を及ぼしますか.

井上　茂

「肥満と糖尿病」Vol.8 No.6（通巻 53 号）：806-807, 2009　別刷

丹水社

Question

生活環境と歩行の関係は？

どんな生活環境が歩行時間に影響を及ぼしますか.

井上　茂
東京医科大学公衆衛生学講座

Answer

最近，身体活動と環境要因との関連に関心が集まっています．どのような地域環境で人々の身体活動は高まるのでしょうか？　ここで述べる環境要因の考え方は，おおよそ図に示したようなものです[1]．私たちは日々患者と接し，効果的な行動変容の方法を探っていますが，これまで，指導の中で考えてきたことは，病気や身体活動に関する知識を伝えることや，行動変容を導くためにどのような心理的要因に働きかければ良いのかといったことでした．しかし，患者が生活している地域の環境にも注目すべきではないか，と考えるわけです．

それでは，具体的にどのような環境要因が身体活動に影響しているのでしょうか？　表にこれまでの研究でよく検討されてきた環境要因をまとめてみました．環境に関する研究は地理学，都市計画学などとの協力により進められてきた経緯があるため，いくつかの概念は医療関係者にとって目新しいものとなっています．最近，環境が歩行に適しているかどうかを表現する言葉としてwalkabilityという用語が使われるようになっていますが，この用語を使うならば，表に示した要因が地域のwalkabilityを形作っているとも言えるでしょう．日本における研究では，人の大勢住んでいる地域，土地利用の多様性が高く商店街などのサービスへのアクセスが良い地域，歩道のよく整備された地域に住む住民において，歩行時間が長いことが示されています[2]．今後さらに研究が必要な領域ですが，

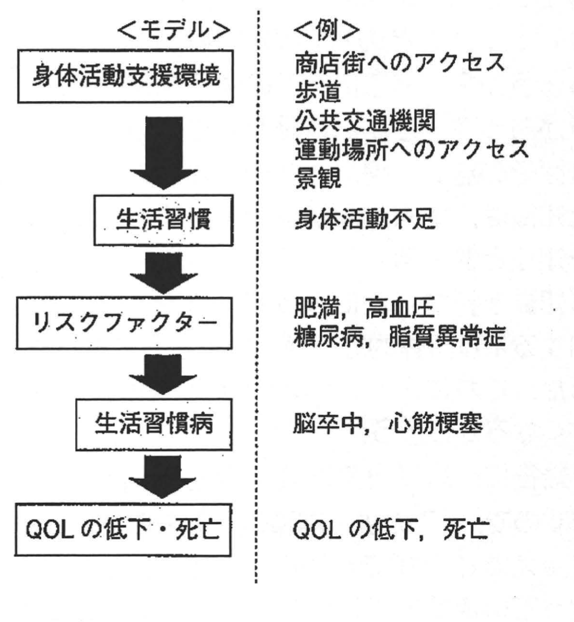

図　環境要因と身体活動，生活習慣病

同じ歩行であっても「買い物などの日常生活の歩行」と「余暇時間に行うウォーキング」では関連している環境要因が異なるようです．また，このような環境と身体活動との関連は，男女でも異なることが予想されています．

さて，このような研究結果を，私たちは実際の指導の中にどのように生かすことができるでしょうか．まず，「環境が身体活動に影響している」ということを指導者が十分に意識し，環境に関心を持つことが大切です．患者指導を行いながら，患者がどのような環境で生活しているの