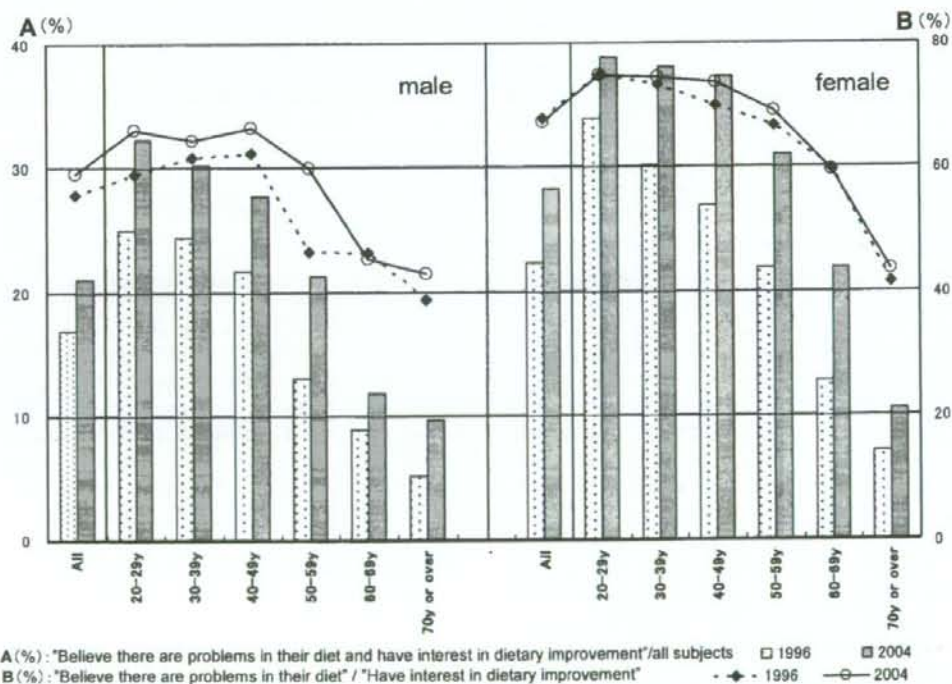


Figure 3. The secular changes in vegetable intake in adults (sex and age group)



A (%): "Believe there are problems in their diet and have interest in dietary improvement"/all subjects
 B (%): "Believe there are problems in their diet" / "Have interest in dietary improvement"

Figure 4. Percentage of the proportion of persons who show interest in dietary improvement among those who believe there are problems in their diet (sex and age group)

The above findings would indicate that the amount of vegetable intake remained unchanged as a whole. Since the effect of prices and the differences among generations constitute major factors associated with vegetable intake, it may be important to implement measures with respect to food environment. In other words, future actions

should be placed on the price control of vegetable, the dissemination and enlightenment of the "Japanese Food Guide Spinning Top" and the activities at the restaurants and convenience stores for people who have less interest in diet or those whose vegetable intake is low so as to increase vegetable intake.^{19,20}

ASSESSMENT OF THE "INDICATORS AT THE KNOWLEDGE, ATTITUDE AND PRACTICE LEVEL"

In order to improve one's nutritional status and nutrient intake, it is crucial to modify his/her knowledge, attitude and practice.

Established specific goal items include: "increase persons who are aware of their own optimal weight and practice weight control", "decrease the proportion of persons who skip breakfast in the young adults aged 20-39 years", "Increase persons who read nutrition labels when eating at restaurants or purchasing food", "increase persons who know size of meal for maintaining optimal weight" and "increase the proportion of persons who show interest in dietary improvement among those who believe there are problems in their diet".

At the practice level, in order to decrease the proportion of obesity, each individual should undertake appropriate weight control. As for the goal item "increase persons who are aware of their own optimal weight (Height(m)² × 22 (standard BMI)) and practice weight control," the proportion was 62.6% for males and 80.1% for females among individuals aged 15 years or older in 1998, and the target value was set at 90% or more. However, the mid-term achievement value in 2004 was 60.2% for males and 70.3% for females (Table 1-1.6).¹⁵ Although it was merely a comparison of data obtained in two survey periods, 1998 and 2004, and detailed changes were not ascertained, the values for males were rather unchanged and the values for females showed a decreasing trend (Table 1).¹⁵

At the knowledge level, it would be needed to acquire knowledge about the quantity and content of meals, and it is particularly important to know how much one should eat to maintain optimal weight. Another goal item, "increase persons who know the appropriate size of meal for maintaining optimal weight" was established. Its baseline value in 1997 was 65.6% for males and 73.0% for females, and the mid-term achievement value in 2004 was 69.1% and 75.0% respectively, showing a slight increase. In particular, a favorable finding was that its proportion has increased among males in the age group of 30-39 year, who are at the life stage with the risk of developing obesity (Table 1-1.10).¹⁵

At the attitude level, it is important for individuals to have the motivation to improve their diet when they recognize the problems in their diet. In 1997, the percentage of individuals who believed there were problems in their diet was 31.6% for adult males and 33.0% for adult females. Among them, the proportion of persons who show interest in dietary improvement was 55.6% for males and 67.7% for females, and the target value was set at 80% or more. For the goal item "increase the proportion of persons who show interest in dietary improvement among those who believe there are problems in their diet", the mid-term achievement value in 2004 was 59.1% for males and 67.3% for females, indicating an increasing trend in males whereas it was rather unchanged in females (Table 1-1.11).¹⁵ Figure 4 shows the results of self-assessment of diet and the proportion of persons who show interest in dietary improvement according to sex and age group. "A" represents the percentage of individuals

who "believe there are problems in their diet and have interest in dietary improvement" among all subjects, and "B" represents the percentage of individuals who "have interest in dietary improvement" among those who "believe there are problems in their diet".³ Although "A" showed an increasing trend in both sexes and across all age groups, an increasing trend of "B" was observed in males only, not in females. In particular, males in the age group of 50-59 years showed significant increases in both "A" and "B" (Figure 4). These results suggest that there is an increased awareness of inappropriate diet and also in the motivation to improve it. Having the motivation to improve diet and also controlling diet is required particularly for males aged 20-59 years, from the view of prevention and control of lifestyle-related diseases and metabolic syndrome. Therefore, the increase in proportion of persons who show interest in dietary improvement indicates a favorable trend.

SUMMARY AND PROBLEMS TO BE SOLVED

This paper discussed the goal items in the "Nutrition and diet" area that should be noted in the mid-term evaluation of "Health Japan 21". Some other goal items that were not reviewed in this paper also showed no trend towards improvement from the baseline value obtained at the establishment of "Health Japan 21." Therefore, the overall progress of "Health Japan 21" has been evaluated as "not necessarily satisfactory".

The findings on the goal items at the actual "nutritional status level" indicate a slowdown in the increasing trend in the proportion of obesity, especially among middle-aged males, who have a high risk for metabolic syndrome. Yet, these percentage values remain still at high level. The results of the items regarding "knowledge, attitude and practice" indicate improving trends in awareness and behavior, such as an increase of persons who are aware of their own optimal weight and practice weight control, though the actual food choice and dietary behavior have not yet been modified adequately.

Under this circumstance, a new strategy of non-communicable diseases prevention will be launched from April 2008, focusing on the control of metabolic syndrome. By which, the "high-risk approach" will be enhanced, in addition to the "population approach" where individuals' efforts are supported by the society through a national health promotion program. It is expected that combining these two approaches would bring synergistic effects. In response to the mid-term evaluation of "Health Japan 21," it is now required to further promote "Health Japan 21" and the "The Medical Expenditure Optimizing Plan"²¹ in a well-coordinated manner through the structural reform of the healthcare system.

It is well acknowledged that various factors, such as genetics, environment, and lifestyle, are associated with development and progress of lifestyle-related diseases. In particular, dietary habit is a major factor associated with these diseases. There is a concern that westernized and simplified/convenient diet, increase in the frequency of eating out and also in consumption of processed foods, breakfast skipping, frequent eating alone, and inappropriate dietary intake (e.g. excessive intake, unbalanced diet) would also lead to the increase in prevalence of

lifestyle-related diseases. Based on the mid-term evaluation of "Health Japan 21," it is now required to effectively enhance national health promotion through dissemination and enlightenment of the "Japanese Food Guide Spinning Top" and the effective implementation of a new strategy of non-communicable diseases prevention focusing on the control of metabolic syndrome.

AUTHOR DISCLOSURES

Udagawa K, Miyoshi M, and Yoshiike N, no conflicts of interest.

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Association of physical activity and neighborhood environment among Japanese adults

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ABSTRACT

Objective. Although environmental attributes related to physical activity is an emerging research topic, most studies have been reported from Western countries. This study aimed to examine the relationship between perceived environment and physical activity among Japanese adults.

Methods. The sample included 492 adults aged 20 to 74 years (61%: male) living in Tokyo and Himeji in Japan. Primary measures were the short version of International Physical Activity Questionnaire and its Environmental Module. Data were collected between October and December 2003. Odds ratio (OR) of meeting physical activity recommendations was examined in relation to neighborhood environmental characteristics, adjusted for age, sex, employment status and education.

Results. Three perceived environmental attributes were significantly related to walking 150 min/week or more: high residential density (OR=1.82), good access to shops (OR=1.65) and presence of sidewalks (OR=1.65). Two environmental attributes, access to shops (OR=2.32) and the presence of bike lanes (OR=1.57), were related to high levels of moderate to vigorous physical activity (950 MET*min/week or more).

Conclusion. Associations of physical activity with four environmental attributes emerged in this Japanese sample. These results support the generalizability of findings on physical activity environments across Western countries and Japan.

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Introduction

Regular physical activity reduces the risk of mortality, incidence of cardiovascular diseases, diabetes and some kinds of cancers (U.S. Department of Health and Human Services, 1996). However, large proportions of the population in Japan and in many countries in the world are insufficiently physically active (Haskell et al., 2007; Sjöström et al., 2006). According to pedometer measurements in the Japan National Health and Nutrition Survey 2005, only 21.3% of Japanese walk more than 10,000 steps a day (Ministry of Health, Labour and Welfare of Japan, 2008). Physical activity promotion is one of the priorities of public health, but to establish effective intervention strategies, evidence of physical activity correlates is needed. To date, many studies have focused on individual demographics and psychological correlates. More recent research has revealed that certain neighborhood environmental characteristics, such as residential density, access to destinations, walking facilities, aesthetics, and

safety also are consistently associated with physical activity (Saelens and Handy, 2008; Gebel et al., 2007; Trost et al., 2002; Sallis and Owen, 2002; Hill et al., 2003; Humpel et al., 2002; Owen et al., 2004). Manipulations of environmental variables are expected to have a long-term and substantial impact on the population, which could complement the usually short-term effects of individually-targeted interventions.

Although an increasing number of studies examining the association between physical activity and environment have been reported, most studies were conducted in Western countries, especially in the United States and Australia (Humpel et al., 2002; De Bourdeaudhuij et al., 2003; Saelens et al., 2003; Owen et al., 2004; Wendel-Vos et al., 2007). On the other hand, few studies on physical activity and neighborhood environments could be located in English language journals from Asian countries including Japan (Takano et al., 2002). Limited variability of environmental attributes where the studies were conducted is one of the limitations of this research area. Thus, one of the directions of this research area is to conduct studies in a greater variety of cultures and geographic settings and to examine if evidences from US and Australia could be generalized to other countries.

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Japan is the most economically developed Asian country, but it has a population density that is more than ten times greater than that of the US. Because both the culture and physical environment are very different from the US and Australia, while the level of economic development is roughly comparable, Japan is an interesting country in which to test the generalizability of built environment–physical activity associations. The physical activity environment in Japan appears to be different from the US and Australia on several dimensions. For instance, in contrast to Australia, the low proportion of commuters who drive their cars to work, only 32% in the Tokyo metropolitan area and 36% in the Osaka metropolitan area (Ministry of Land, Infrastructure, Transport and Tourism, 2008), compared with 80.1% in Australia (Australian Bureau of Statistics, 2006), may be due to environmental differences, such as the extent of walkable environment and the development of public transportation network, between the two countries. The difference of overweight prevalence (BMI ≥ 25 kg/m²) between Japan; 27.6% in males, 21.4% in females (Ministry of Health, Labour and Welfare of Japan, 2008) and the US; 70.8% in males, 61.8% in females (Ogden et al., 2006) may be partially explained by the differences in environment and physical activity.

In the present study, we examined the association between the perceived neighborhood environment and physical activity among Japanese adults using the International Physical Activity Questionnaire and its Environmental Module.

Methods

Participants and data collection

Four hundred and ninety-two Japanese adults aged 20 to 74 years (61%: male) were recruited. Study collaborators at eight worksites, including four universities and four private companies, approached employees at the worksites or their acquaintances as potential research volunteers. Seven of eight worksites were located in and around the Tokyo metropolitan area, while one was in Himeji city,

located in western Japan, which has a population of about 536,000. If the person was interested in joining the survey, the collaborator delivered a study consent form and a set of self-administered questionnaires for data collection. To examine the test–retest reliability, 93 of the 492 participants were asked to answer the same questionnaire after a 7-day interval. Written informed consent was obtained from all participants. Data were collected between October 2003 and December 2003.

Environmental measure and its translation

The International Physical Activity Questionnaire Environment Module (IPAQ-E) was used to measure perceived neighborhood environmental attributes related to physical activity. This questionnaire was originally developed as an optional component of the International Prevalence Study of Physical Activity (Craig et al., 2003). Most questions were taken or adapted from previous measures developed in the United States (Addy et al., 2004; Saelens et al., 2003). The IPAQ-E consists of 17 questions; 7 core items, 4 recommended items, and 6 optional items. In this study, we used 11 items, including core and recommended items (Table 1). These questions refer to a neighborhood environment where the person could walk within 10 to 15 min from their residences. Nine of 11 items, excluding residential density and household motor vehicles, involve statements which explain neighborhood features believed to be related to physical activity, followed by four response options: strongly disagree, somewhat disagree, somewhat agree and strongly agree. The residential density item asks about the main types of houses in neighborhoods (e.g., detached single-family residences, condos, apartments), with higher scores indicating higher densities. The question about motor vehicles concerns the number of motor vehicles in the participant's household. The Swedish version of IPAQ-E has shown good test–retest reliability (Alexander et al., 2006).

In this study, the Japanese version of the IPAQ-E was used. The original English version was directly translated into Japanese. The

Table 1
Items of International physical activity questionnaire environmental module in original English version

Scale composition	Items	Response categories
Residential density	What is the main type of housing in your neighborhood?	Detached single-family residences/townhouses, row houses, apartments, or condos of 2–3 storeys/mix of single-family residences and townhouses, row houses, apartments or condos/apartments or condos of 4–12 storeys/apartments or condos of more than 12 storeys
Access to shops	Many shops, stores, markets or other places to buy things I need are within easy walking distance of my home. Would you say that you...	
Access to public transport	It is within a 10–15 minute walk to a transit stop (such as bus, train, trolley, tram) from my home. Would you say that you...	
Presence of sidewalks	There are sidewalks on most of the streets in my neighborhood. Would you say that you...	
Presence of bike lanes	There are facilities to bicycle in or near my neighborhood, such as special lanes, separate paths or trails, shared use paths for cycles and pedestrians. Would you say that you...	
Access to recreational facilities	My neighborhood has several free or low-cost recreation facilities, such as parks, walking trails, bike paths, recreation centers, playgrounds, public swimming pools, etc. Would you say that you...	Strongly disagree/somewhat disagree/somewhat agree/strongly agree
Crime safety	The crime rate in my neighborhood makes it unsafe to go on walks at night. Would you say that you...	
Traffic safety	There is so much traffic on the streets that it makes it difficult or unpleasant to walk in my neighborhood. Would you say that you...	
Social environment	I see many people being physically active in my neighborhood. Physically active means doing things like walking, jogging, cycling, or playing sports and active games. Would you say you...	
Aesthetics	There are many interesting things to look at while walking in my neighborhood. Would you say that you...	
Household motor vehicles	How many motor vehicles in working order (e.g., cars, trucks, motorcycles) are there at your household?	Number of household motor vehicles

translation was conducted according to the standardized translation manual of IPAQ (IPAQ website, 2008). At first we made sure of the concept of each question via discussion with the IPAQ Reliability and Validity Committee. Then the questionnaire was translated into Japanese by two independent physical activity researchers. These translations were reviewed by a group of bilingual individuals to develop the first draft. After the pilot test of the first draft, the wording was revised. Then a bilingual person who was not a researcher and who had no conflicts of interest in this research back-translated it into English. Finally, the translation was checked up by the IPAQ Reliability and Validity Committee. Then, the Japanese version of IPAQ-E was adopted. Table 1 indicates the contents of IPAQ-E according to the wording of the original English version. The Japanese version of IPAQ-E is available from website (Japanese version of IPAQ-E website, 2008).

Physical activity measure

To assess physical activity, the self-administered, short form of IPAQ was used (Craig et al., 2003; Murase et al., 2002). Participants were asked about the frequency and duration of vigorous activity, moderate activity and walking for all purposes such as transportation, work, recreation and household chores. To avoid overlap, moderate activity did not include walking.

In this study, two variables, walking time (min/week) and total moderate to vigorous physical activity (MVPA) energy expenditure (MET*min/week) were used as dependent variables. MET means Metabolic Equivalent and is a unit of intensity of activity. One MET is equivalent to the intensity of resting while sitting. Walking time was calculated using frequency and duration of walking. MVPA was calculated according to the IPAQ scoring manual (IPAQ website, 2008). MET values used in the calculation were 8 METs for vigorous activity, 4 METs for moderate activity and 3.3 METs for walking.

The reliability and validity of this questionnaire in 12 countries, including Japan, has been reported. Test-retest reliability for total physical activity of the Japanese IPAQ was adequate (Spearman's rho=0.76). Criterion validity for total physical activity assessed against the accelerometer was comparable to other survey measures (Spearman's rho=0.32) (Craig et al., 2003).

Statistical analyses

The reproducibility of the Japanese IPAQ-E was evaluated by test-retest with a 7-day interval, calculating the Spearman rank-correlation coefficient and Kappa statistic for each question.

To examine the relationship between the neighborhood environment as the independent variable and physical activity, i.e. walking time and MVPA, as the dependent variable, odds ratios of meeting walking and physical activity criteria were examined using logistic regression models. For the analysis, environmental variables were converted into dichotomous variables. For residential density, the choice of 'detached single-family residences' formed a category indicating low residential density, while others were included in another category indicating high residential density. As to the number of household motor vehicles, responses were categorized as 'none' and as 'one or more'. Regarding other questions, responses were classified into two categories of agree (strongly agree and somewhat agree) and disagree (somewhat disagree and strongly disagree). For walking, participants were classified as active if they walked 150 min or more, consistent with current physical activity guidelines (Haskell et al., 2007). MVPA was divided into two levels at the median of all participants: >950 MET*min/week or more, and <950 MET*min/week. To calculate odds ratios, the references were environmental characteristics expected to be associated with lower levels of physical activity, meaning that an odds ratio of more than 1.00 indicates an expected positive association. All odds ratios were adjusted for reported age, sex, employment status and educational level.

Significance was considered to be at a level of $P < 0.05$. Analyses were conducted by SPSS ver15.0 for Windows (SPSS Inc., Chicago, IL, USA).

Results

Table 2 presents the demographic characteristics of participants. The sample included 62% of male. Age was widely distributed from 20 to 74 years, and the mean age (SD) was 42 (12) years. The locations of participants were mainly urban settings. In this population, 43% of participants walked more than 150 min/week. The characteristics of 93 participants for test-retest reliability were similar to the overall sample.

Spearman correlation coefficients and Kappa statistics for test-retest reliability of the questionnaire are shown in Table 3. Spearman correlation coefficients were from 0.79 for the presence of bike lanes to 0.99 for residential density. Kappa statistics were also good and ranged from 0.63 for the presence of bike lanes to 0.97 for residential density.

Logistic regression analyses revealed that three of eleven environmental attributes were significantly associated with walking (Table 4). Participants were more likely to walk 150 min/week or more when they perceived high residential density (OR, 95% CI: 1.82, 1.16–2.84), good access to shops (OR, 95% CI: 1.65, 1.05–2.58) and presence of sidewalks (OR, 95% CI: 1.65, 1.13–2.42). The number of household motor vehicles indicated borderline association with walking. Participants who did not have motor vehicles in their household were more likely to satisfy the criterion of 150 min of walking per week (OR, 95% CI: 1.54, 0.99–2.41). All of these associations were in the expected direction. Regarding the association of meeting the MVPA criterion with environmental attributes, people who perceived good access to shops (OR, 95% CI: 2.32, 1.47–3.66) and presence of bike lanes (OR, 95% CI: 1.57, 1.04–2.36) reported more physical activity. Three additional environmental attributes, the presence of sidewalks, aesthetics and

Table 2
Characteristics of participants (Tokyo and Himeji, Japan, 2003)

	Overall sample n (%)	Test-retest reliability sample ^a n (%)
Sex		
Male	303 (61.6)	58 (62.4)
Female	189 (38.4)	35 (37.6)
Age (years)		
20–39	253 (51.4)	49 (52.7)
40–59	181 (36.8)	30 (32.3)
60–	58 (11.8)	14 (15.1)
Education (years)		
<12	125 (25.7)	19 (20.7)
13–	361 (74.3)	73 (79.3)
Employment status (h/week)		
≥40	336 (68.6)	62 (68.1)
<40	154 (31.4)	29 (31.9)
Location (population of city)		
100,000–	227 (55.6)	51 (64.6)
30,000–99,999	99 (24.3)	18 (22.8)
<29,999	74 (18.1)	2 (2.5)
Unknown	8 (2.0)	8 (10.1)
BMI (kg/m ²)		
<24.9	400 (81.5)	72 (78.3)
25.0–29.9	80 (16.3)	18 (19.6)
30.0–	11 (2.2)	2 (2.2)
Walking (min/week)		
150–	211 (42.9)	38 (40.9)
<149	281 (57.1)	55 (59.1)
MVPA ^b (MET*min/week)		
950–	245 (49.8)	45 (48.4)
<949	247 (50.2)	48 (51.6)

^a Participants in the test-retest reliability sample are included in the overall sample.

^b MVPA: moderate to vigorous physical activity.

Table 3
The reproducibilities of each item of the Japanese IPAQ Environmental Module estimated by test–retest with a seven day interval (Tokyo and Himeji, Japan, 2003)

	Spearman's correlation coefficients	P values	Kappa statistics	P values
Residential density	0.99	<0.001	0.97	<0.001
Access to shops	0.90	<0.001	0.85	<0.001
Access to public transport	0.83	<0.001	0.79	<0.001
Presence of sidewalks	0.85	<0.001	0.67	<0.001
Presence of bike lanes	0.79	<0.001	0.63	<0.001
Access to recreational facilities	0.82	<0.001	0.75	<0.001
Crime safety	0.86	<0.001	0.71	<0.001
Traffic safety	0.82	<0.001	0.69	<0.001
Social environment	0.88	<0.001	0.78	<0.001
Aesthetics	0.90	<0.001	0.83	<0.001
Household motor vehicles	0.96	<0.001	0.91	<0.001

household motor vehicles, also showed borderline associations with MVPA.

Discussion

The results of this study demonstrated that 4 of 11 environmental variables: residential density, access to shops, presence of sidewalks and presence of bike lanes, were significantly associated with walking or MVPA among Japanese adults. Adults who reported living in neighborhoods with high residential density, good access to shops, presence of sidewalks, and presence of bike lanes had higher physical activity levels. In addition, borderline significant associations between physical activity and 2 additional environmental variables: aesthetics

and household motor vehicles were observed. The environmental measures used in the present study have been developed and used mainly in Western countries, such as the United States and Australia (Humpel et al., 2002; Saelens et al., 2003; Owen et al., 2004; Mota et al., 2005). To date, few studies have been reported from Asian countries, where neighborhood environmental characteristics and physical activity patterns of people are different from Western countries (Takano et al., 2002). Present results indicate that the same kinds of neighborhood attributes related to physical activity in Western countries are also related to physical activity among Japanese. In other words, these results support the generalizability of previous findings in Western countries to different environments and cultures like Japan.

On the other hand, five environmental variables: access to public transport, access to recreational facilities, crime safety, traffic safety and social environment were not significantly related to physical activity among Japanese adults. There are some possible reasons for these results. As for access to public transport, 85% of participants in this study reported good access. This clustering of responses may cause weak statistical power and the result of no significant relationship. Access to recreation facilities has been related repeatedly to leisure time physical activity (Humpel et al., 2002; Gebel et al., 2007). However, in this study, we used the short version of IPAQ which did not assess specific purposes of physical activity, leading to a limited test of the hypothesis regarding recreation facilities. Environmental attributes regarding crime safety and traffic safety were not related to physical activity. These issues may be more relevant in specific populations such as women, children, and older adults. Results, especially for crime safety, have been inconsistent in the previous

Table 4
Odds ratios for environmental variables and likelihood of subjects meeting walking and physical activity criteria (Tokyo and Himeji, Japan, 2003)

	n (%)	Walking >= 150 min/week			MVPA ^a >= 950 MET ^b min/week		
		Odds ratios	95% CI ^b	P values	Odds ratios	95% CI	P values
Residential density							
High	111 (23.6)	1.82	(1.16, 2.84)	0.009	1.07	(0.69, 1.68)	0.753
Low	360 (76.4)	1.00			1.00		
Access to shops							
Good	373 (76.7)	1.65	(1.05, 2.58)	0.029	2.32	(1.47, 3.66)	<0.001
Poor	113 (23.3)	1.00			1.00		
Access to public transport							
Good	420 (86.4)	1.43	(0.82, 2.48)	0.205	1.50	(0.87, 2.59)	0.148
Poor	66 (13.6)	1.00			1.00		
Presence of sidewalks							
Yes	288 (59.6)	1.65	(1.13, 2.42)	0.010	1.39	(0.95, 2.04)	0.087
No	195 (40.4)	1.00			1.00		
Presence of bike lanes							
Yes	140 (29.0)	0.93	(0.62, 1.40)	0.739	1.57	(1.04, 2.36)	0.032
No	343 (71.0)	1.00			1.00		
Access to recreational facilities							
Good	283 (58.4)	1.14	(0.79, 1.66)	0.484	1.09	(0.75, 1.58)	0.663
Poor	202 (41.6)	1.00			1.00		
Crime safety							
Safe	321 (66.6)	1.30	(0.87, 1.94)	0.200	1.37	(0.92, 2.04)	0.126
Not safe	161 (33.4)	1.00			1.00		
Traffic safety							
Safe	309 (63.8)	0.80	(0.55, 1.17)	0.258	1.01	(0.69, 1.48)	0.963
Not safe	175 (36.2)	1.00			1.00		
Social environment							
Good	318 (65.6)	1.05	(0.72, 1.55)	0.795	1.35	(0.92, 1.99)	0.128
Poor	167 (34.4)	1.00			1.00		
Aesthetics							
Good	216 (44.5)	1.04	(0.71, 1.50)	0.855	1.38	(0.95, 2.02)	0.090
Poor	269 (55.5)	1.00			1.00		
Household motor vehicles							
None	107 (22.0)	1.54	(0.99, 2.41)	0.055	1.47	(0.93, 2.32)	0.097
One or more	379 (78.0)	1.00			1.00		

Note. All odds ratios were calculated, adjusted for age, sex, employment status and educational attainment. The references were the categories which were hypothesized to be associated with lower levels of physical activity.

^a MVPA: moderate to vigorous physical activity.

^b CI: confidence interval.

studies (Humpel et al., 2002). Due to the relatively small sample size of this study, stratified analyses of these demographic characteristics were not conducted in this study. Further studies are needed to examine associations of specific environments with specific physical activities among specific populations.

IPAQ (Craig et al., 2003) and IPAQ-E, internationally-standardized measurement tools, were used in this study. Translation into Japanese was strictly conducted according to the standardized manual of IPAQ. Test-retest reliability of the Japanese IPAQ-E was supported in this study. The ICCs of items in the Swedish version were from 0.47 to 0.98 (Alexander et al., 2006). The Japanese version of IPAQ-E also demonstrated good reliability in this study.

There are several limitations in this study. Due to the cross-sectional design, we were unable to address the direction of the causality. Secondly, the sample was relatively small and consisted of volunteers as participants and therefore not a representative of the general population in Japan. This study supports the generalizability of findings from previous studies in Western countries to Japan. However, there might be limited generalizability of findings among the Japanese population. Thirdly, we used the short form of IPAQ which did not differentiate domain-specific physical activity, such as leisure time and transportation activities. Thus, we were not able to examine activity-specific associations with environmental attributes that were expected (Owen et al., 2004). Fourth, residential preference which is controlled as covariate in recent studies was not assessed in this study. However, this study, conducted in Japan where people live in different environmental characteristics and have different physical activity patterns from Western countries, is important for better understanding environmental attributes related to physical activity. Studies of specific physical activity–environment relationships in specific populations living in a variety of environments are needed to clarify the role of environmental effects in shaping physical activity.

Conclusion

Four environmental variables, residential density, access to shops, presence of sidewalks and presence of bike lanes, were significantly associated with walking or moderate to vigorous physical activity among Japanese adults. These results support the generalizability of findings from previous studies conducted in Western countries to Japan and suggest that targeting these environmental characteristics could be an effective strategy for promoting physical activity.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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