

Association between Residents' Perception of the Neighborhood's Environments and Walking Time in Objectively Different Regions

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Abstract

Objective: The purpose of this study is to delineate the association between residents' perception of the neighborhood's environments and walking time in objectively different regions in Japan.

Methods: Two regions were selected as high and low walkable regions on the basis of differences in their residential density, mixed land use and street connectivity. The subjects in this study were participants in a health promotion program focused on walking sponsored by local governments. A questionnaire was sent to the participants asking about how their perception of the neighborhood's environment related to walking, and the time spent walking per week. There were 237 residents from the high walkable region and 195 from the low walkable region who completed the study survey.

Results: The high walkable region had a larger residential density, a high mixed land use and a higher street connectivity than the low walkable region. Walking time, and the scores of the perception of the neighborhood's environment for the high walkable region residents were significantly higher than those for the low walkable region residents. Thus, residents' perception of the neighborhood's environment generally reflected the actual physical environmental characteristics. Residents in the high walkable region whose scores for accessibility and aesthetics were high, spent significantly more walking time. Residents in the low walkable region whose scores for accessibility, safety, convenience and aesthetics were high, spent significantly more walking time.

Conclusion: The study results suggested that the neighborhood's environment may influence daily walking time. The perceptions of the neighborhood's environmental factors that correlate with walking times differ between the different regional physical environments. Therefore, to promote physical activity, the consideration of environmental factors unique to residents' neighborhood's environments is needed.

Key words: physical environment, perception of neighborhood environment, physical activity, walking, health promotion

Introduction

A low physical activity level is a well-documented risk factor for chronic diseases including coronary heart disease,

stroke, cancer, diabetes, and depression (1). Current public health recommendations emphasize the benefits of performing 30 minutes of daily physical activity of at least moderate intensity (1). Nevertheless, the majority of middle-aged people do not meet the recommendations for specific national targets in developed countries (1–5).

The most common activity of moderate intensity is walking (2), which can be performed at any age and at any time. To date, many studies have examined how psychological and social variables are associated with physical activity, but little is known about the correlation between neighborhood's physical environmental factors and physical activity level (6, 7). High

Received Feb. 28, 2006/Accepted Sep. 12, 2006

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walkable neighborhood's environmental characteristics suggest a high residential density and mixed land use (e.g., close proximity of houses, shops, work, and other nonresidential land uses) (8, 9), and neighborhood street connectivity (10) positively correlates with walking time among residents (8, 9). The presence and characteristics of walking trails are associated with increased physical activity (11, 12). Walking as a means of commuting or shopping is the primary source of overall differences in walking time between high and low walkable neighborhoods, because walking time for exercise did not differ between these different types of neighborhood (13).

Among developed countries, Japan has a relatively high residential density, mixed land use and high street connectivity. However, the effect of the neighborhood's physical environment on walking time has not yet been made clear. Furthermore, the association between the perception of the neighborhood's environment and walking time has not been clear either.

This study was based on earlier studies that showed comparisons between different regions with large variations in neighborhood's physical environments that correlate to the factors affecting the walking behavior of residents, such as residential density, mixed land use and street connectivity (14–16). In this study, we proposed exploring the association between residents' perception of their neighborhood's environment and daily walking time. Also, the correlation between the neighborhood's environments that are high walkable region (relatively high residential density, mixed land use, and street connectivity) or low walkable region (relatively low residential density, mixed land use and street connectivity) and walking time was also examined.

Methods

Sampling of study regions and study subjects

Two regions where the authors had coordinated health promotion programs focusing on walking for the residents every year in collaboration with local governments were selected. One was a ward from Metropolitan Tokyo, which was considered a relatively high walkable region and the other was a city from the rural northeastern region of Japan, which was considered a relatively low walkable region.

The health promotion programs of the two regions were the same. Participants were recruited by the ward or city newsletters, the duration of the program was 12 weeks, and lectures were provided once a week, which included information on proper walking posture, how to use a pedometer, and how to record walking steps and walking time.

In the past 5 years, the health promotion programs have had 495 participants in the high walkable region and 277 participants in the low walkable region. These 772 participants were considered eligible for this study and a questionnaire was sent to all of them in January 2004.

This study was conducted in accordance with the ethical principles stated in the Declaration of Helsinki (by the World Medical Association). The autonomy of the participants was fully respected and written information including the purpose of the study, use and application of the study, assurance of their right to refuse, and the security of personal information was

provided to each participant. All participants signed a consent form to participate in this study. This study was approved by the Ethics Division of the Health Promotion Committee of each municipality.

Survey method and questionnaire items

A self-administered questionnaire was mailed to the subjects of the study along with a notice of the purpose of the study, a letter of request for cooperation and a self-addressed envelope.

The questionnaire included items for the following: sex, age, current job including part time jobs, daily neighborhood walking time (minutes per week) and exercise habits besides walking (duration and frequency per week). The question "How many minutes per week do you usually walk in your neighborhood?" was used to determine walking time. In this study, we focused on the time spent walking in the neighborhood. However, the neighborhood was not clearly defined in the questionnaire and the range of the residents' neighborhoods depended on their perception. Thus, the questionnaire included four questions about the time spent walking in the neighborhood to distinguish the purpose of the walking. The four questions concerned the walking time for exercise; walking time for commuting or shopping; walking time for purposes other than exercise, commuting or shopping; and the total walking time in the neighborhood. Thus the total walking time (walking time for exercise, commuting or shopping and others) was used as the neighborhood walking time in this study.

Questions regarding how the perception of neighborhood's environment correlated to walking time, which included categories on accessibility, safety, convenience, aesthetics (which included the friendliness of the neighborhood) and weather, were also asked. The responses regarding the perception of neighborhood characteristics were selected from a 6-point Likert scale: 0 to 5. Only the descriptions "I strongly disagree" for the number 0 and "I strongly agree" for the number 5 were added to the questionnaire. The higher the score, the more positive the perception of the neighborhood was. The questions in this study were developed for Japanese neighborhood environmental characteristics by modifying questions from earlier studies (17, 18).

Statistical analysis

The score of the 6-point Likert scale from 0 to 5 was used for an analysis of the perception of the neighborhood's environment. The student's t test or Chi-square test was used to compare the subjects' characteristics between the two regions. Analysis of covariance was used to compare mean walking time and the mean scores of the perception of the neighborhood's environment after adjustment for age, sex and the presence or absence of habitual exercise. Habitual exercise was defined as exercise of moderate intensity for more than 30 minutes at one time with a frequency of more than twice a week.

The distribution of the scores of perception of the neighborhood's environment was not even owing to a larger number of people scoring on the higher end of the scale. Therefore, scores of 0 to 3 were classified as lower in perception whereas

scores of 4 and 5 were classified as higher in perception. The association between the perception of a resident's neighborhood's environment within either the low or high walkable region and walking time was analyzed by analysis of covariance after adjustment for age, sex and the presence or absence of habitual exercise.

Statistical analysis was conducted using the SAS statistical package (release 9.1) Windows version. All analyses were two-tailed and a p-value<0.05 was considered statistically significant.

Results

Comparison of physical environmental characteristics between high and low walkable regions

Table 1 shows physical environmental characteristics of the two regions. The area (km²) of the low walkable region was 6-fold larger than that of the high walkable region, although the population and number of households in the low walkable region were one fourth and one fifth those in the high walkable region, respectively. Thus, population density and residential density were more or less 20-fold and 30-fold larger in the high walkable region, respectively. The number of worksites was more than 3-fold larger in the high walkable region than in the low walkable region. The total length of roads were longer in the low walkable region than in the high walkable region; however, the length of roads per square kilometer was much larger in the high walkable region. The high walkable region was more industrialized overall than the low walkable region. The number of sports facilities was much larger in the high walkable region.

Comparisons of subjects' characteristics and walking times between high and low walkable regions

A study survey using a questionnaire was conducted among 495 subjects who participated in the past 5 years' health promotion program in the high walkable region and 277 subjects in the low walkable region. Among these 772 subjects,

454 (58.8%) responded to the survey. Because of the lack of information on sex, age, or the answers to some of the questions, 22 subjects were excluded. Thus, there were 237 subjects (47.8%) from the high walkable region and 195 (70.3%) from the low walkable region who completed this study survey.

Table 2 shows subjects' characteristics and walking times. The mean age and percentage of males were significantly higher

Table 1 Comparisons of physical environmental characteristics between high and low walkable regions

Region	High walkable	Low walkable	Sources
Area (km ²)	39.5	233.9	HP ¹
Population (n)	398,438	98,724	Census ²
Population density	9549.4	430.2	Census ²
Households (n)	161,963	32,726	Census ²
Residential density	4100.3	139.9	
Worksites (n)	22,227	6,478	Minryoku ³
Employees (n)	277,097	52,411	Minryoku ³
Railroads (n)	10	1	HP ¹
Stations (n)	25	5	HP ¹
Length of roads (m)	371,398	803,248	Census ⁴
Length of roads per/km ²	9402.5	3434.2	
Automobile ownership (n)	74,966	46,547	HP ¹
Number of cars per km ²	1897.9	199.0	
Traffic accidents (n)	2,508	3,880	HP ¹
Parks (n)	175	57	Census ⁴
Total area of parks (ha)	37.8	55.9	Census ⁴
Number of parks per km ²	4.43	0.24	
Rivers (n)	19	15	Census ⁴
Public sports facilities (n)	11	10	HP ¹
Private sports facilities (n)	9	1	HP ⁵
Annual mean temperature (°C)	16.5	13.3	AMeDAS ⁶
Annual rainfall (mm)	1,581	2,264	AMeDAS ⁶

¹ Home page of each autonomy, 2004. ² Census of Japan, 2000.

³ Asahi Shimbun, Fujitsu Learning Media Limited, Tokyo, 2002.

⁴ Census of autonomy, 2003. ⁵ Home page of Fitness Online, 2004.

⁶ Japan Meteorological Agency, 2004.

Table 2 Comparisons of subjects' characteristics and walking times between high and low walkable regions

	High walkable region	Low walkable region	
Subjects (n)	237	195	
Age (years)	62.6±7.6	60.4±9.5	* ¹
Male (%)	56 (23.6)	30 (15.4)	* ²
Currently employed (%) ⁴	105 (44.3)	75 (38.5)	ns ²
Habitual exercisers (%) ⁵	67 (28.2)	71 (36.4)	ns ²
Total walking time (min/week) ⁶	274.4±265.4	173.1±214.5	** ^{1,3}
Walking time for exercise	82.7±97.5	59.6±87.1	ns
Walking time for commuting or shopping	128.4±250.7	79.5±160.6	ns
Walking time for other purposes ⁷	59.3±91.6	36.0±67.4	ns

Data are mean±SD.

¹ Student's t test; *: p<0.05, **p<0.01.

² Chi-square test; *: p<0.05, ns: not significant.

³ Analysis of covariance after adjustment for age, sex and habitual exercise: ** p<0.01.

⁴ Persons who are currently employed including part time jobs.

⁵ Persons who are engaged in regular exercise for more than 30 minutes at one time, and more than two times a week.

⁶ Time spent walking in their neighborhood during a week.

⁷ Time spent walking for purposes other than exercise, commuting or shopping.

in the high walkable region than in the low walkable region. The percentages of subjects who have jobs including part time jobs were not significantly different between the two regions. The percentages of subjects who exercise regularly showed no statistically significant difference between the two regions.

In addition, comparisons of the subjects who have jobs or who exercise regularly were conducted separately by sex between the two regions. The percentages of subjects who have jobs were not different between the two regions among males ($\chi^2=1.93$, $p=0.16$) or females ($\chi^2=1.54$, $p=0.21$). However, in females, the percentage of subjects who exercise regularly was significantly higher ($\chi^2=5.09$, $p=0.02$) in the low walkable region than in the high walkable region. However, significant differences were not observed between the two regions among males ($\chi^2=0.00$, $p=1.00$).

The total walking time in the neighborhood was significantly higher in the high walkable region than in the low walkable region. Further, there were significant differences after the adjustment for age, sex and habitual exercise by analysis of covariance. However, the walking times for exercise, commuting or shopping, and other purposes were not significantly different between the two regions.

Comparison of scores for perception of the neighborhood's environment between two regions

Table 3 shows the mean scores of the perception of the neighborhood's environment for the two regions after adjusting for age, sex and habitual exercise by analysis of covariance. The scores for all 7 factors in the accessibility category were

significantly higher in the high walkable region than in the low walkable region. In the safety category, the score for "Vehicular traffic does not hinder taking a walk" was significantly higher in the low walkable region, whereas that for "The sidewalk is well-lit even at night" was significantly higher in the high walkable region. For other factors, there were no significant differences between the two regions. In the convenience category, the score for "The sidewalks are wide enough to walk on" was significantly higher in the low walkable region, whereas that for "The walking map of the neighborhood is useful" was significantly higher in the high walkable region. Other factors did not show any regional differences. In the aesthetics category, the score for "The sidewalks are clean and without any trash" was only significantly high in the low walkable region, and other factors did not show any regional differences. In the weather category, the score for "Bad weather does not hinder taking a walk" was higher in the high walkable region than in the low walkable region.

Correlations between perception of the neighborhood's environments and walking time

Table 4 shows a comparison of the mean walking time between the two groups; the group that has a higher score of perception of their neighborhood's environment and the group that has a lower score of perception of their neighborhood's environment in both regions. Analysis of covariance was used to compare the mean walking time by adjusting for sex, age and habitual exercise. Those who had high scores for "There are sidewalks suitable for walking in the neighborhood" (ac-

Table 3 Comparisons of scores of residents' perception of the neighborhood's environment between high and low walkable regions

Categories	High walkable region	Low walkable region	
Accessibility (Cronbach's $\alpha=0.76$)			
There are sidewalks suitable for walking in the neighborhood	4.04±1.38	3.36±1.60	**
There is a park nearby that is suitable for taking a walk in	4.07±1.32	2.89±1.84	**
There is a river (or a beach) within walking distance	3.94±1.50	2.53±1.97	**
There is a train station (or bus stop) within walking distance	4.69±0.74	3.39±1.78	**
There are shops for daily necessities within walking distance	4.41±1.06	3.58±1.65	**
There are several ways to get to one place	3.92±1.07	3.53±1.33	**
There are walking trails in the neighborhood	3.28±1.63	2.21±1.85	**
Safety (Cronbach's $\alpha=0.68$)			
It is easy to cross streets	3.33±1.41	3.06±1.54	
Vehicular traffic does not hinder taking a walk	2.49±1.48	3.08±1.55	**
The sidewalk is well-lit even at night	2.97±1.32	2.11±1.42	**
It is safe from crime	2.72±1.28	2.74±1.36	
Convenience (Cronbach's $\alpha=0.74$)			
The sidewalks have few inclines and are easy to walk on	4.00±1.20	3.74±1.45	
The sidewalks are well-maintained	3.80±1.17	3.56±1.37	
The sidewalks are wide enough to walk on	2.54±1.50	3.04±1.50	**
The walking map of the neighborhood is useful	3.58±1.29	2.45±1.64	**
Aesthetics (Cronbach's $\alpha=0.66$)			
There are many scenic places nearby	3.39±1.34	3.42±1.51	
The sidewalks are clean and without any trash	2.77±1.33	3.02±1.36	*
The neighborhood is conducive toward taking a walk	3.02±1.40	2.96±1.34	
Residents in the neighborhood are friendly	3.16±0.94	3.28±1.22	
Weather			
Bad weather does not hinder taking a walk	2.55±1.57	2.02±1.53	**

Data are mean±SD. Analysis of covariance after adjustment for sex, age and habitual exercise: * $p<0.05$, ** $p<0.01$.

cessibility category), and “Residents in the neighborhood are friendly” (aesthetics category) spent significantly more walking time in both regions. The factor, “Bad weather does not hinder taking a walk” (weather category), did not show any significant difference between the two groups in both regions.

In the high walkable region, those who had high scores for “There is a park nearby that is suitable for taking a walk in”, “There is a river (or a beach) within walking distance” (accessibility category), and “The neighborhood is conducive toward taking a walk” (aesthetics category) spent significantly more walking time. In the low walkable region, those who had high scores for “There are several ways to get to one place” (accessibility category), “It is easy to cross streets” (safety category), “The sidewalks have few inclines and are easy to walk on” and “The sidewalks are wide enough to walk on” (convenience category) spent significantly more walking time. For the other factors, there were no significant differences between the higher and the lower scores of perception of the neighborhood’s environment in both regions.

Discussion

This study design is based on those of earlier studies in which it was hypothesized that daily walking time would differ between high and low walkable regions in Japan that have different physical environmental characteristics particularly

regarding residential density, mixed land use and street connectivity. The purpose of this study is to examine this hypothesis and to also clarify the association between the residents’ perception of the neighborhood’s environment and walking time.

To obtain a more accurate data on walking time in the neighborhood, the questionnaire consisted of four questions about the time spent walking to classify the purpose of the walking; walking time for exercise; walking time for commuting or shopping; walking time for other than exercise, commuting or shopping; and the total walking time in the neighborhood. The total walking time was used as the neighborhood walking time in this study. All the study participants had previously participated in a walking program in each community. Thus, they could be expected to report walking time accurately.

Understanding the regional physical environmental characteristics that affect physical activity has practical implications and political implications such as those relating to transportation, urban planning and environmental initiatives. The characteristics of regional physical environments have been shown to affect the residents’ physical activity in earlier studies (19–23). Regions that have a high residential density, mixed land uses and street connectivity, are divided into small blocks of various functions such as industries and residences. They also have a more extensive network of roads as well as various means of

Table 4 Correlations between residents’ perception of the neighborhood’s environment and walking times in neighborhood

Score of perception of neighborhood environment	High walkable region				Low walkable region			
	Low (0 to 3)		High (4 and 5)		Low (0 to 3)		High (4 and 5)	
	n		n		n		n	
Accessibility								
There are sidewalks suitable for walking in the neighborhood	60	191.7±200.6	177	302.9±279.7 *	91	125.9±182.1	104	211.3±234.5 *
There is a park nearby that is suitable for taking a walk in	55	190.8±195.0	182	300.2±279.5 *	105	137.5±142.6	90	204.6±261.7
There is a river (or a beach) within walking distance	69	217.2±211.7	168	299.1±283.6 *	121	180.4±240.3	74	165.4±169.0
There is a train station (or bus stop) within walking distance	12	156.0±90.8	225	282.4±271.0	80	138.6±144.4	115	192.2±251.6
There are shops for daily necessities within walking distance	34	238.0±266.2	203	282.5±267.3	75	134.7±143.3	120	192.1±247.6
There are several ways to get to one place	72	266.9±294.7	165	287.5±255.5	88	124.9±139.9	107	201.4±249.4 *
There are walking trails in the neighborhood	112	242.5±222.2	125	305.7±299.6	136	176.1±239.7	59	160.9±148.8
Safety								
It is easy to cross streets	124	282.0±288.9	113	269.8±241.9	116	145.1±162.7	79	214.6±270.2 *
Vehicular traffic does not hinder taking a walk	173	264.0±250.7	64	312.0±305.4	107	142.4±170.9	88	213.3±255.8
The sidewalk is well-lit even at night	159	272.6±264.9	78	280.8±274.1	165	170.7±209.3	30	191.6±254.2
It is safe from crime	177	268.7±280.3	60	285.0±222.8	146	157.8±185.1	49	219.5±284.5
Convenience								
The sidewalks have few inclines and are easy to walk on	65	273.6±296.8	172	278.1±255.4	64	89.7±88.2	131	215.6±245.9 **
The sidewalks are well-maintained	84	299.4±326.0	153	264.2±231.0	87	125.5±134.8	108	209.4±259.6
The sidewalks are wide enough to walk on	170	264.3±264.0	67	302.5±273.7	116	132.2±138.8	79	232.8±284.5 **
The walking map of the neighborhood is useful	111	249.6±251.8	126	306.3±282.0	147	180.3±235.9	48	160.1±156.3
Aesthetics								
There are many scenic places nearby	124	266.6±291.7	113	285.8±236.5	86	137.0±148.2	109	188.9±241.6
The sidewalks are clean and without any trash	171	255.5±260.4	66	323.1±280.3	122	151.5±178.8	73	215.8±268.5
The neighborhood is conducive toward taking a walk	147	245.0±233.5	90	323.4±308.5 *	136	161.4±217.4	59	200.1±207.6
Residents in the neighborhood are friendly	170	234.2±212.2	67	381.0±354.5 **	116	135.9±157.1	79	228.3±271.0 *
Weather								
Bad weather does not hinder taking a walk	168	261.7±250.0	69	307.5±303.0	161	162.8±219.1	34	228.8±187.8

Data are mean±SD of the time spent walking (minutes/week). Analysis of covariance after adjustment for sex, age and habitual exercise: * p<0.05, ** p<0.01.

transportation. The two regions that were chosen in this study have different residential densities, mixed land uses and street connectivities. The region with the higher residential density, mixed land use and street connectivity was defined as the high walkable region. As a result, walking time per week was significantly higher in the high walkable region than in the low walkable region. The results of this study support the findings of earlier studies conducted in the USA and Australia (7, 19–23). This study showed a correlation between the regional physical environment and walking time. However, that correlation is not direct or causal. The current study attempted to select residents with similar characteristics from both regions using an earlier studies' design. However, the study subjects do not represent all the residents in the region because the number of study subjects was small and they were all participants of a health promotion program and therefore they were considered to be more concerned about enhancing their physical activity than general residents. Therefore, these results suggest the need for further research in various regions using representative residents of the regions.

The scores of perception of the neighborhood's environment among the residents from the high walkable region were higher in all factors under the accessibility category than those among the residents from the low walkable region. This result shows that the higher level of accessibility in a highly urbanized region directly affects the residents' perception. Also, residents scored higher in the high walkable region for the factor, "The sidewalk is well-lit even at night". There are more street lights and commercial neon signs in high walkable regions. High walkable region residents also had higher scores for the factor, "Bad weather does not hinder taking a walk" (weather category). This may be due to the fact that the high walkable region in this study has less annual rainfall, and higher temperatures even in the winter than the low walkable region in this study. The weather may have more effects on residents in the low walkable region than on those in the high walkable region.

Residents from the low walkable region had significantly higher scores for the factor under the safety category, "Vehicular traffic does not hinder taking a walk." This perception might reflect the fact that the average number of cars per square kilometer in the low walkable region is much smaller than in the high walkable region. Therefore, the low walkable region might be perceived to be safer. Also, the low walkable region residents had significantly higher score for the factor, "The sidewalks are wide enough to walk on" (convenience category). This may be due to the fact that land is spacious and roads are wide in the low walkable regions. Low walkable region residents also scored higher for the factor, "The sidewalks are clean and without any trash" (aesthetics category). This may also be correlated to the fact that sidewalks are wider and residential density is lower in the low walkable region.

An earlier study (24) found there was agreement between residents' perception and the actual evaluation of the environments concerning accessibility, safety, and the friendliness of residents in the communities. This study also found that the residents' perception of their neighborhood environment generally reflects the physical environmental characteristics concerning accessibility, safety, convenience, aesthetics and the weather.

Thus, neighborhood's physical environmental characteristics measured by perceived neighborhood's environmental characteristics may be used in further studies.

Earlier studies of the correlation between the perception of the neighborhood's environment and walking time showed that a favorable perception of accessibility (7, 17, 22, 25, 26), safety (7, 11, 17, 27), convenience (7, 17, 25, 28), aesthetics (7, 17, 18, 21, 25, 28), and the weather (7, 18) promoted the time spent walking.

However, until now, there has been no study to ascertain whether subtle differences in the residents' perception could affect walking time. Therefore, this study delineated the correlation between the resident's perception of the environment and walking time within a region with only small variations in the physical environmental characteristics. Also, the correlation was compared in objectively different regions for the first time. From the study results, the correlation between the perception of the neighborhood's environment and walking time differs between the high walkable and the low walkable regions. The environmental factors that associated with walking time in the high walkable region only included the following: "There is a park nearby that is suitable for taking a walk in" and "There is a river (or a beach) within walking distance" (accessibility category), and "The neighborhood is conducive toward taking a walk" (aesthetics category). Those who had higher scores for those factors reported significantly longer walking time. On the other hand, environmental factors that are correlated with walking time in the low walkable region only included the following: "There are several ways to get to one place" (accessibility category), "It is easy to cross streets" (safety category), "The sidewalks have few inclines and are easy to walk on" and "The sidewalks are wide enough to walk on" (convenience category). Those who had higher scores for those factors spent more walking time.

Factors that correlated to walking times in both regions included "There are sidewalks suitable for walking in the neighborhood" (accessibility category), and "Residents in the neighborhood are friendly" (aesthetics category). However, the factor "There are walking trails in the neighborhood" (accessibility category) was not correlated with walking time. Walking trails are present in only about 20% of the regions in Japan; therefore, people's awareness of walking trails is still low. It is speculated that the availability of sidewalks that are convenient for walking may promote walking behavior more than the accessibility of walking trails. The factor, "Bad weather does not hinder taking a walk" did not affect residents' walking behavior in either region. This indicates that people need to walk to do daily errands such as shopping or commuting to work regardless of the weather; therefore, weather was not an influential factor for daily walking.

The neighborhood environmental factors that are correlated with walking time differ depending on regional physical characteristics. Environmental factors of aesthetics, along with accessibility, may promote walking time in the high walkable region. In urban regions, accessibility is high because the installation of streets/sidewalks and their maintenance is a priority. Therefore, good scenery and a park or river (or beach) in the neighborhood appear to affect walking time for residents

in urban regions. On the other hand, environmental factors of convenience, along with the factors of accessibility, safety, and aesthetics may promote walking time in the low walkable region. Street connectivity, the installation of street equipment and the maintenance of streets may enhance the residents' walking behavior in the less urbanized regions. To promote physical activity, the consideration of environmental factors unique to the residents' neighborhood environment is needed.

Because this study is a cross-sectional study, no causal relationships can be delineated. Because there is no standard method for this type of study in Japan, the environmental factors of neighborhood perception used in this study were developed by modifying the factors referred to in earlier studies (17, 18). The reliability of the questionnaire has been proven through internal consistency (Table 3: Cronbach's α coefficient of all categories was about 0.70).

The generalization of the study results may be limited because the study design was cross-sectional and the study subjects do not represent all the residents in the region. The number of study subjects was small and they were all participants of a health promotion program; thus, they were considered to be more concerned about enhancing their physical activity than general residents. Also, the proportion who responded to the survey was differed between the two study regions. Further research on various regions and representative residents of the regions is needed. This study focused on the perception of the neighborhood's environment and did not distinguish the effects of the neighborhood environment from other factors influencing residents' walking behaviors. Further study on other factors such as psychological and social factors may be needed in the future. However, the participants in this study had attended lectures on health promotion and learned about enhancing physical activities in the past; therefore, their answers to the

questions regarding walking times may be more reliable than those from the general population.

Conclusion

This study compared the residents' perception of the neighborhood's environment with their walking time in high walkable and low walkable regions in Japan. The comparison of the two regions showed significant differences regarding both the residents' perception of their neighborhood environment and walking time. The results suggest that residential density, mixed land use and street connectivity may be influential factors for walking time. Further, residents' perception of the neighborhood's environment that correlated with walking time differ between the two regions. Therefore, the consideration of the environmental factors unique to each region is crucial in designing and implementing effective support and the promotion of physical activity for people in Japan.

Acknowledgments

This study was supported by a grant from the Japan Ministry of Health, Labour and Welfare (ID #H15-059) as a part of the Study of the Evaluation of Community Environments for the Effective Health Promotion Plan (principal investigator: Kiyoshi KAWAKUBO), and by a grant from the Japan Ministry of Education, Culture, Sports, Science and Technology (ID #17200041) as a part of the Study of the Evaluation of Neighborhood Environments Affecting Residents' Daily Physical Activity (principal investigator: Jung Su LEE).

We express our thanks to the study participants.

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