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Influence of urban neighbourhood environment on physical activity and obesity-related diseases

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ABSTRACT

Objectives: The impact of characteristics of neighbourhood environment on physical activity and obesity-related diseases is still the subject of debate. This study aimed to explore the impact of urban neighbourhood environment on physical activity and obesity-related diseases.
Study design: Cross-sectional study.
Methods: Individuals who participated in the 2009 national health-screening programme, submitted all necessary information, and had lived in Community 1 (Haengdang) or Community 2 (Ilsan) for at least 2 years ($n = 16,178$) were selected for inclusion in this study. Anthropometric measures were taken and physical activity was assessed using a short questionnaire.
Results: No significant difference in the trigger factors for walking, including the amount of neighbourhood park space, number of shopping malls, and distance between the community and shopping malls, was found between the two communities. However, Community 2 had a better street environment than Community 1. Participants who lived in Community 2 were more physically active [adjusted odds ratio (OR) 1.31, 95% confidence interval (CI) 1.16–1.48] and walked more regularly (adjusted OR 1.09, 95% CI 1.02–1.17) than participants who lived in Community 1, and were less likely to have abdominal obesity (adjusted OR 0.83, 95% CI 0.77–0.91), hypertension (adjusted OR 0.88, 95% CI 0.80–0.97) and diabetes (adjusted OR 0.86, 95% CI 0.75–0.99). However, the risk of dyslipidaemia, especially in terms of low-density lipoprotein cholesterol, was higher in Community 2.

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Conclusions: These results suggest that a walkable environment has a positive influence on hypertension and diabetes, and physical activity is the possible mechanism for this association. A walkable environment may function as an important tool for health promotion in urban areas.

Introduction

Globally, obesity and obesity-related comorbidities including hypertension, diabetes mellitus and dyslipidaemia are increasing dramatically.[1–3] In the US population, for example, recent data from the National Health and Nutritional Examination Survey show that the current prevalence of obesity and overweight in adults is approximately 68%.[4] In Korea, the prevalence of obesity has increased annually. In 1998, the Korea National Health and Nutritional Examination Survey (KNHANES) data showed that 26.7% of Korean adults were obese, and the proportion had increased to 30.9% in 2007–2009.[5] Unhealthy lifestyle is one of the main causes of these diseases. Physical activity, in particular, is believed to be an important determinant of health and body weight, but most people do not exercise regularly.[6,7]

There is growing evidence that neighbourhood environment, such as green space, parks and pedestrian environment, is associated with physical activity and various health outcomes, especially obesity-related diseases.[8–12] However, among the possible factors contributing to physical activity and obesity-related diseases, little is known about the urban neighbourhood environment, such as slopes or street patterns, and trigger factors that encourage residents to walk. Previous studies have focused on how individual elements of neighbourhood environment affect physical activity or health outcomes,[13–16] or how urbanization influences population health.[17]

It has been hypothesized that physical activity (walking, sports, etc.) is a possible mechanism that influences the relationship between neighbourhood environment and health outcomes.[18] However, few studies have evaluated all the factors.

As such, this study aimed to explore the impact of urban neighbourhood environment on physical activity and obesity-related diseases.

Methods

Study population

Two representative urban neighbourhood communities were selected to compare the effect of neighbourhood environment on physical activity and health. The criteria for differentiating physical characteristics between the two neighbourhood communities included site planning concepts, development methods, housing types, street patterns, site slope and neighbourhood amenities, which were measured both quantitatively and qualitatively through site observation and geographic information system analyses (see Figs. 1 and 2).

Community 1 (Haengdang) is a built-up area with irregular street networks and a sloped topography with an average inclination angle of 8°. Urban redevelopment of Community 1 has been undertaken at different times by private providers. As a result, the renewed structure is fragmented. Community 2 (Ilsan) is a large urban area that was developed by public providers. It is located on flat land and all the residential areas, street networks and neighbourhood environment were designed and built at the same time (Table 1).

Physical activity and health outcome data were derived from the Korean national health-screening database, as Korea has an extensive national health-screening programme. The Korean National Health Insurance Corporation provides health screening to local and corporate insurance members.

Individuals who participated in the 2009 national health-screening programme and had been living in Community 1 or Community 2 for at least two years ($n = 18{,}598$) were selected for inclusion in this study. It was considered that two years would be sufficient time to reveal the effect of the neighbourhood environment.[19,20] From the neighbourhood sample, 2420 individuals were excluded because they had missing information for physical activity, health outcomes (height, weight, waist circumference, blood pressure, fasting glucose level, cholesterol) or basic information (age, sex, income). As a result, 16,178 people who were eligible for the analysis were included in this study.

Measurement of physical activity

Physical activity was assessed using a short questionnaire. Individuals were asked the following questions: ‘How many days were you physically active for more than 30 min?’ and ‘How many days did you walk for more than 30 min?’. For each question, individuals were classified into two groups based on whether or not they had spent at least 5 days/week on the respective activity.

Measurement of health outcomes

Body mass index (BMI) was calculated as weight divided by height squared (kg/m^2), and was classified into two categories (<25 kg/m^2, ≥25 kg/m^2) based on the International Obesity Task Force and the World Health Organization Regional Office for the Western Pacific Region recommendations for defining obesity in Asians.[21]

Waist circumference was measured at a level midway between the lowest rib and the iliac crest. The Korean Society for the Study of Obesity recommended cut-off points of ≥90 cm for men and ≥85 cm for women. Therefore, waist circumference was classified into two categories (male <90 cm and female <85 cm, male ≥90 cm and female ≥85 cm).[22]

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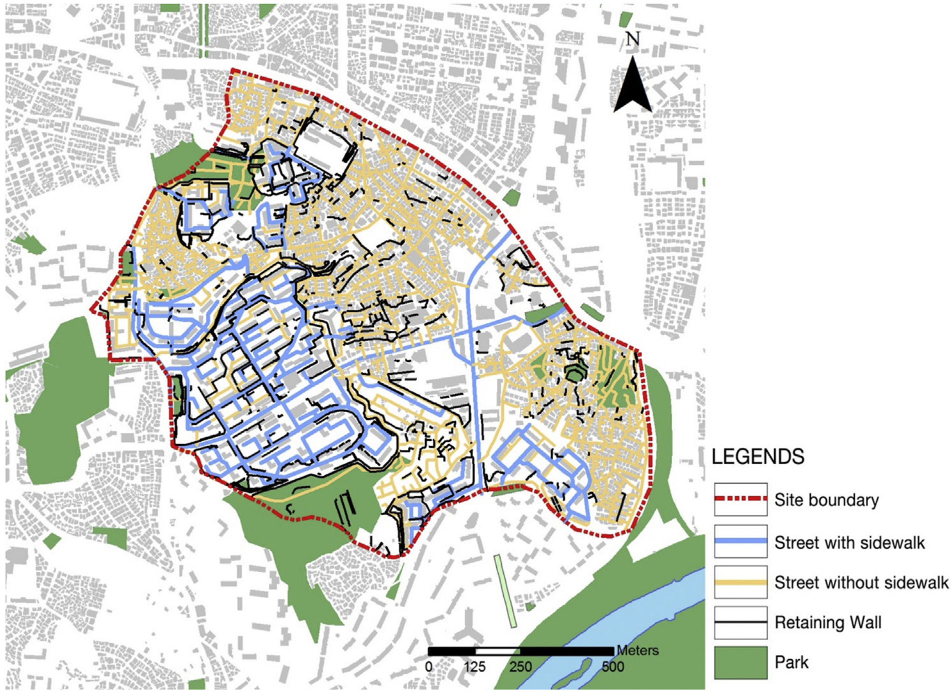

Fig. 1 – Walking environments of Community 1.

Hypertension was diagnosed if participants exhibited a systolic blood pressure ≥140 mmHg or a diastolic blood pressure ≥90 mmHg at first screening. Diabetes was diagnosed if participants exhibited a fasting glucose level ≥126 mg/dl. A diagnosis of hypercholesterolaemia was made in participants who had fasting serum with total cholesterol level >240 mg/dl. Hypertriglyceridaemia was diagnosed if triglyceride was ≥150 mg/dl. Elevated low-density lipoprotein (LDL) was defined as LDL ≥130 mg/dl and decreased high-density lipoprotein (HDL) was defined as HDL <70 mg/dl.

Adjustments were also made for lifestyle behaviours using controls for smoking and drinking. Smoking status was coded using three categories (non-smoker, past smoker, current smoker) and drinking status was coded using two categories

Fig. 2 – Walking environments of Community 2.

Table 1 – Physical characteristics of the case areas by community.

	Community 1	Community 2
Site area (km^2)	1.2	4.2
Year of completion of development	1999	1991
Development method	Old area Urban redevelopment	Suburban new town development
Population density (people/km^2)	43,569	16,702
Average slope (angle of inclination)	More than 8°	0
Housing type	High-rise apartments and detached houses (mixed)	High-rise apartments and detached houses (separated)
Neighbourhood street pattern	Irregular pattern, loop	Grid, loop
Type of pedestrian space	Sidewalks (partly installed)	Sidewalks and pedestrian zones

(non-drinker, drinker). Finally, adjustment was made for monthly insurance premiums as a proxy for economic status and disability status (disabled, non-disabled).

Statistical analysis

Descriptive statistics were used to report the characteristics of the study population. Values were presented as frequency (%), mean (standard deviation) and median (interquartile range), as appropriate.

Multiple logistic regression analysis was used to assess whether a more walkable neighbourhood environment was associated with higher overall physical activity, more walking and better health outcomes. Multivariate analyses for each of the above outcomes were adjusted for age, sex, smoking status, drinking status and income level. Statistical analyses were performed using STATA Version 12.0 (STATA Corp., College Station, TX, USA). Statistical significance was defined as $P < 0.05$ using a two-tailed test.

Results

Study characteristics

Sample descriptive characteristics by community are presented in Table 2. Of the 16,178 adults included in the study, 6303 lived in Community 1 and 9875 lived in Community 2. The proportion of males was 52.09% in Community 1 and 50.30% in Community 2 ($P = 0.027$). The average age was 47.50 years in Community 1 and 47.67 years in Community 2. Compared with Community 2, Community 1 had more residents in their twenties (9.61% vs 7.08%) and sixties (14.69% vs

Table 2 – Baseline characteristics of study participants by community.

	Community 1	Community 2	P-value
	$n = 6303$	$n = 9875$	
Sex			0.027
Male, *n* (%)	3283 (52.09)	4967 (50.30)	
Female, *n* (%)	3020 (47.91)	4908 (49.70)	
Age, years, mean ± SD	47.50 ± 12.87	47.67 ± 11.42	
Age, years, *n* (%)			
20–29	606 (9.61)	699 (7.08)	<0.001
30–39	1095 (17.37)	1109 (11.23)	
40–49	1829 (29.02)	4150 (42.03)	
50–59	1539 (24.42)	2486 (25.17)	
60–69	926 (14.69)	965 (9.77)	
≥70	308 (4.89)	466 (4.27)	
Economic status, median (IQR)	7 (4–11)	9 (5–11)	<0.001
Disability, *n* (%)			<0.001
No	5997 (95.15)	9514 (96.34)	
Yes	306 (4.85)	361 (3.66)	
Smoking, *n* (%)			<0.001
Non-smoker	3861 (61.26)	6051 (61.28)	
Ex-smoker	910 (14.44)	1832 (18.55)	
Current smoker	1532 (24.31)	1992 (20.17)	
Drinking, *n* (%)			0.006
No	3207 (50.88)	5241 (53.07)	
Yes	3096 (49.12)	4634 (46.93)	

SD, standard deviation; IQR, interquartile range.

Table 3 – Measured elements of neighbourhood for walkability evaluation.

	Community 1	Community 2
Area of neighbourhood including 1-km buffer	8.8	15.8
Area of parks in neighbourhood (km^2)	0.21	0.81
Ratio of area of parks in neighbourhood (%)	17.5	19.3
Area of parks in neighbourhood including 1-km buffer (km^2)	1.09	2.33
Ratio of area of parks in neighbourhood including 1-km buffer (%)	12.4	14.7
Number of shopping malls in 1-km buffer	1	2
Total floor area of shopping mall in 1-km buffer (m^2)	93,488	188,357
Total length of streets (m)	57,085	78,269
Total length of streets with pedestrian sidewalks (m)	19,255	41,167
Ratio of pedestrian sidewalks (per total length of streets, %)	33.7	52.6
Total length of trails in 1-km buffer (m)	3252	11,269
Total length of pedestrian zones (m)	0	3611
Total length of retaining wall of apartment complex (m)	2518	0

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9.77%), and fewer residents in their forties (29.02% vs 42.03%). People who lived in Community 2 had better economic status and less disability compared with those who lived in Community 1, but the difference was insignificant. The proportion of current smokers and drinkers was 24.31% and 49.12% in Community 1 and 20.17% and 46.93% in Community 2, respectively.

Neighbourhood environment

Community 1 and Community 2 had differing physical characteristics, including topographic pattern and urban developmental methods, and their physical characteristics had an impact on walking. Trigger factors for walking and the type of street environment could be evaluated as a walkable environment for increased physical activity and positive health outcomes.

In this study, the amount of neighbourhood park space was similar in Community 1 (17.5%) and Community 2 (19.3%) (Table 3). There was one shopping mall within 1 km of Community 1 and two shopping malls within 1 km of Community 2. For all shopping malls, there were no meaningful differences in characteristics or distance from the community.

The street environment of the two communities was quite different. Community 1 was located on a sloped site, which was less convenient for walking. In order to overcome the topography, there were many retaining walls, which had a total length of 2.5 km over the entire site, especially in and around apartment complexes. As the retaining walls cut off pedestrian walkways, residents of Community 1 had to walk longer distances. Longer walking time is inconvenient, so residents of Community 1 were more likely to drive or take public transportation (Fig. 1).

Community 2 had a more walkable environment with trees along the streets, except for the loop street network within the apartment complexes. Community 2 had a grid pattern of pedestrian sidewalks and attractive scenery, which are traditionally known to represent a highly walkable environment[23,24] (Fig. 2). Furthermore, the ratio of pedestrian sidewalk to the total length of streets was higher in Community 2 (52.6%) compared with Community 1 (33.7%). Walkability in Community 2 was further enhanced by a pedestrian zone (Community 1: 0 km, Community 2: 3.6 km) and a greater total trail length within a 1-km buffer (Community 1: 3252 km, Community 2: 11,269 km).

In summary, both communities had similar trigger factors for physical activity – park space and shopping malls – but Community 2 had a more walkable street environment.

Physical activity

Among the people in Community 1, 28.37% reported that they walked regularly (>5 days/week) compared with 29.64% in Community 2. After adjusting for age, sex, smoking status, drinking status and income level, the odds ratio (OR) for regular walking was significantly higher for Community 2 [adjusted OR 1.09, 95% confidence interval (CI) 1.02–1.17]. In Community 2, more people undertook regular physical activity (leisure-time physical activity, including walking and running etc.) compared with Community 1 (7.47% vs 9.77%), and the adjusted OR was significantly higher (adjusted OR 1.31, 95% CI 1.16–1.48) (Table 4).

Table 4 – Regular physical activity and walking by community.

	Community 1	Community 2
Walking		
Number (%)[a]	1788 (28.37)	2927 (29.64)
Crude OR (95% CI)	Reference	1.06 (0.99–1.14)
Adjusted OR (95% CI)[b]	Reference	1.09 (1.02–1.17)
Physical activity		
Number (%)[c]	471 (7.47)	965 (9.77)
Crude OR (95% CI)	Reference	1.34 (1.20–1.50)
Adjusted OR (95% CI)[b]	Reference	1.31 (1.16–1.48)

OR, odds ratio.
[a] People who walked at least 5 days/week.
[b] Adjusted OR was adjusted for age, sex, smoking status, drinking status and income level.
[c] People who undertook physical activity on at least 5 days/week.

Health outcomes

There was no significant difference in obesity between the two communities. However, the more walkable

Table 5 – Health outcomes by community.

	Community 1	Community 2
Obesity[a]		
Crude OR (95% CI)	Reference	0.95 (0.89–1.02)
Adjusted OR (95% CI)[b]	Reference	0.97 (0.90–1.04)
Abdominal obesity[c]		
Crude OR (95% CI)	Reference	0.81 (0.75–0.88)
Adjusted OR (95% CI)[b]	Reference	0.83 (0.77–0.91)
Hypertension		
Crude OR (95% CI)	Reference	0.84 (0.76–0.92)
Adjusted OR (95% CI)	Reference	0.88 (0.80–0.97)
Diabetes mellitus		
Crude OR (95% CI)	Reference	0.81 (0.70–0.92)
Adjusted OR (95% CI)	Reference	0.86 (0.75–0.99)
Hypercholesterolaemia		
Crude OR (95% CI)	Reference	1.10 (0.99–1.22)
Adjusted OR (95% CI)	Reference	1.09 (0.98–1.21)
LDL-cholesterol		
Crude OR (95% CI)	Reference	1.24 (1.16–1.33)
Adjusted OR (95% CI)	Reference	1.22 (1.13–1.31)
HDL-cholesterol		
Crude OR (95% CI)	Reference	0.91 (0.83–0.98)
Adjusted OR (95% CI)	Reference	0.92 (0.85–1.01)
Triglycerides		
Crude OR (95% CI)	Reference	0.93 (0.85–1.02)
Adjusted OR (95% CI)	Reference	0.92 (0.84–1.01)

LDL, low-density lipoprotein; HDL, high-density lipoprotein; OR, odds ratio; CI, confidence interval.
[a] Obesity was defined as body mass index $\geq$25 kg/m^2 in accordance with the International Obesity Task Force and the World Health Organization Regional Office for the Western Pacific Region.
[b] Adjusted OR was adjusted for age, sex, smoking status, drinking status and income level.
[c] Abdominal obesity was defined as men with waist circumference $\geq$90 cm and women with waist circumference $\geq$85 cm.

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environment (Community 2) was associated with less abdominal obesity (adjusted OR 0.83, 95% CI 0.77–0.91). In addition, lower risk of hypertension (adjusted OR 0.88, 95% CI 0.80–0.97) and diabetes (adjusted OR 0.86, 95% CI 0.75–0.99) was seen in Community 2 compared with Community 1. However, the risk of dyslipidaemia, especially elevated LDL-cholesterol, was higher in Community 2 than in Community 1 (adjusted OR 1.22, 95% CI 1.13–1.31). There was no significant difference in total cholesterol, triglyceride or HDL-cholesterol between Community 1 and Community 2 (Table 5).

Discussion

The results suggest that a walkable neighbourhood environment is associated with increased physical activity and walking, and decreased BMI, abdominal obesity and obesity-related diseases. Walkable environment was associated with abdominal obesity and the prevalence of hypertension and diabetes mellitus.

Previous studies found similar results for the association of neighbourhood environment with physical activity.[25–27] However, it is not clear which environmental factors actually affect physical activity. Some studies have claimed that parks and commercial facilities such as shopping malls are the main trigger factors for walking. However, in the present study, both park space and commercial facilities were similar in the two communities. Although trigger factors were similar in both communities, there was a difference in accessibility due to differences in the connectivity of the street networks. Access to the trigger factors was more convenient in Community 2, which has been found to promote neighbourhood walking.[28]

The association between neighbourhood environment and health is still the subject of debate. Some studies have reported that a walkable environment is associated with decreased obesity[15,29–31] and increased health status,[32,33] whereas others have not.[6,18] Some studies reported that leisure-time physical activity (e.g. gym exercise, walking) could reduce abdominal obesity.[34,35] In the present study, a walkable environment was associated with abdominal obesity in two ways: through increased physical activity, including walking, and through lower risk of abdominal obesity.

In this study, the risk of obesity-related diseases including hypertension and diabetes was lower in people who lived in a walkable environment, but the risk of dyslipidaemia, especially LDL-cholesterol, was higher. There are several explanations for these results. First, it is well known that physical activity is associated with hypertension and diabetes mellitus, but has little or no effect on dyslipidaemia. One study found no discernible dose–response relationship between physical activity and LDL-cholesterol.[36] Another study showed that total physical activity was not correlated with dyslipidaemia.[37] Second, physical activity may be most effective in improving plasma lipids in those with abnormal lipid values.[38] Although the present study used a large dataset, only 25–30% of the participants had high LDL-cholesterol. Therefore, the effect of physical activity was likely to be too small to determine.

This study has a number of strengths and limitations. Firstly, as it was not a randomized controlled trial, caution is needed in the interpretation of the study results. Secondly, moving is common in Korea. The population movement rate per year is over 50% in both Community 1 and Community 2, so there is a possibility of self-selection. This study analysed people who had lived in the same address for at least two years in order to allow sufficient lag time to detect the effect of neighbourhood environment. Although some of the residents were self-selected, most of the residents who had lived in the communities for at least 2 years were considered to be affected by neighbourhood environment. Thirdly, questionnaires were used to assess physical activity, smoking status and drinking status. The questions were rather crude and the possibility of recall bias exists; however, objective measures for health status were used to enhance consistency. Finally, height, weight, fasting blood glucose, and systolic and diastolic blood pressure were measured as part of the national screening programme. Few previous studies have included objectively measured health status.

This study used cross-sectional data to determine the association between neighbourhood environment, physical activity and health; personalized environmental data could not be used, so there may have been ecologic fallacy and causality cannot be assessed in cross-sectional data. Despite these limitations, this study showed the association between urban neighbourhood environment and physical activity and obesity-related diseases. These findings encourage future studies that use longitudinal and personalized data.

In conclusion, this study provided evidence that a walkable environment has a positive influence on hypertension and diabetes, and physical activity is the possible mechanism for this association. Walkable environment may function as an important tool for health promotion in urban areas.

Author statements

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Ethical approval

The Research Ethics Board of Seoul National University hospital approved this study (IRB No. 1107-121-371).

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Competing interests

None declared.

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