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Cross-sectional and prospective associations of neighbourhood environmental attributes with screen time in Japanese middle-aged and older adults

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ABSTRACT

Objectives This study examined cross-sectional and 2-year prospective associations of perceived and objectively measured environmental attributes with screen time among middle-aged Japanese adults.

Design Prospective cohort study.

Setting Nerima and Kanuma cities of Japan.

Participants Data were collected from adults aged 40–69 years living in two cities of Japan in 2011 (baseline: n=1011; 55.3±8.4 years) and again in 2013 (follow-up: n=533; 52.7% of baseline sample).

Measures The exposure variables were five geographic information system-based and perceived attributes of neighbourhood environments (residential density, access to shops and public transport, footpaths, street connectivity), respectively. The outcome variables were baseline screen time (television viewing time and leisure-time internet use) and its change over 2 years. Multilevel generalised linear modelling was used.

Results On average, participants' screen time was not statistically different over 2 years (2.3 hours/day at baseline and 2.2 hours/day at follow-up; P=0.24). There were cross-sectional associations of objective (exp(β): 1.11; 95% CI 1.01 to 1.22) and perceived (1.12; 1.02 to 1.23) good access to public transport, perceived good access to shop (1.18; 1.04 to 1.36) and perceived good street connectivity (1.11; 1.01 to 1.23) with higher time spent in screen time at baseline. No objective and perceived environmental attributes were significantly associated with change in screen time.

Conclusions Activity-supportive neighbourhood environmental attributes appear to be related to higher levels of screen time cross-sectionally. Pattern of screen time might be maintained rather than changed over time under the same neighbourhood environments. Environmental interventions that promote physical activity may need to consider the potential negative health impact of screen time in Japan.

INTRODUCTION

Sedentary behaviour, defined as any waking behaviour characterised by an energy expenditure ≤1.5 metabolic equivalents while in a sitting or reclining posture, has been recognised a novel risk factor for health.[1] Literature has shown the deleterious associations between sitting time and all-cause mortality, cardiovascular disease, type 2 diabetes, overweight/obesity, specific types of cancer and mental health, independent of physical activity.[2 3] In particular, among several domains of sedentary behaviour, screen-based sedentary behaviour is highly prevalent and increasing rapidly among adults, partly because of easily available media-related technologies.[4] Research has reported screen time (television (TV) viewing and leisure-time internet use) is associated with negative health outcomes[5–7] and has been found to be a predominant component of leisure-time sedentary behaviour in adults.[8 9] Therefore, with the increasing engagement in screen

time,[4] [10] there is an urgent need to develop effective strategies to reduce screen time to prevent diseases and obesity.

From the ecological perspective, it is crucial to better understand environmental determinants of screen time to develop population-based interventions for a long-term impact.[10] [11] However, previous studies examining associations between built environmental attributes and screen-based sedentary behaviour are limited in several significant ways. Most of these previous studies were of cross-sectional design,[12–14] reporting from Australia[12] [15] and the USA,[13] [14] as well as focusing more on only TV viewing and objectively measured walkability.[12] [13] [15] These previous studies have reported that lowly walkable neighbourhood environment is associated with higher TV viewing time,[12] [14] [15] whereas one study has found no associations.[13] However, it remains unclear what specific conditions of built environment people actually live in and how people perceive and realise these specific environmental attributes could influence their time spent in screen time. Thus, in order to strengthen the basis of evidence for developing environmental interventions, further studies examining the longitudinal relationship between specific built perceived and objectively measured neighbourhood environmental attributes and screen time in adults are needed. In particular, limited studies have focused on Asian countries, and it is crucial to further examine how both perceived and objectively measured environmental attributes are related to changes in screen time in different density, cultural and environmental contexts. These findings would be important to inform policy makers and intervention designers for developing strategies to reduce the increase in screen time through environmental approaches. Therefore, the present study examined cross-sectional and 2-year prospective associations of objective and perceived environmental attributes with screen time in middle-aged Japanese adults.

MATERIALS AND METHODS
Participants
The present study is a prospective cohort study with two waves of data collection: baseline in 2011 and follow-up in 2013. This study used data from a part of the Healthy Built Environment in Japan project. At baseline, a total of 3000 residents aged 40–69 years and living in two cities in Japan (Nerima City, part of the Tokyo metropolitan area with 716 124 residents and an area of 48 km^2; Kanuma City, a regional city with 102 348 residents and an area of 491 km^2) were randomly selected from the registry of residential addresses based on gender, age group and residential city. The baseline survey was completed by 1076 residents (response rate: 35.9%). Excluding the missing data, the final sample was 1011 for the cross-sectional analyses. After 2 years, 533 (52.7% of the baseline respondents) completed the follow-up survey.

Outcome variables
Participants reported their time spent in TV viewing and leisure-time internet use over a usual week (screen time). Participants were asked: 'On how many days did you do the activity during leisure time in the past 7 days?' and 'On average, how many minutes did you do the activity during leisure time on the days that you did it?' Using this format, we identified time spent sitting in screen time by multiplying the number of days participants watched TV and used internet during leisure time by the average amount of time spent doing so per day. The scale was previously shown to have reasonable reliability and validity.[16] The test–retest reliability of the items was moderate (range 0.6–0.8), and the validity, defined as correlations with 3-day behavioural log data, was also moderate (range 0.3–0.6).[17] For cross-sectional associations, the outcome variable was baseline screen time per day. For prospective associations, the outcome variable was change of screen time per week from baseline to follow-up survey.

Exposure variables
The exposure variables of this study were five environmental attributes—population density, sidewalk availability, access to public transportation, access to destinations and street connectivity—measured both subjectively and objectively at baseline. These domains were selected on the basis of walkability components and other environmental attributes from previous reviews.[18] [19] The perceived measures were identified using the Japanese version of the International Physical Activity Questionnaire Environmental Module (IPAQ-E) with a 4-point Likert scale (*strongly agree*, *somewhat agree*, *somewhat disagree* and *strongly disagree*). The scale has been shown to have good reliability.[20] Five items of IPAQ-E were included: (1) population density ('What is the main type of housing in your neighborhood?' For this question, the five options were detached single-family housing; apartments with 2–3 storeys; mix of single-family housing and apartments with 2–3 storeys; condos with 4–12 storeys; and condos with >13 storeys); (2) sidewalk availability ('There are sidewalks on most of the streets in my neighbourhood'); (3) access to public transportation ('It is less than a 10–15 min walk to a transit station from my home'); (4) access to destinations ('There are many places to go within easy walking distance of my home'); and (5) street connectivity ('There are many 4-way intersections in my neighbourhood'). Population density was divided into 'lower (detached single-family housing)' and 'higher (others)'. Other four perceived environmental attributes were categorised into 'agree' (*strongly agree* and *somewhat agree*) and 'disagree' (*somewhat disagree* and *strongly disagree*).

Objective environmental attributes were measured using geographic information systems (GIS). The following five measures were calculated for each participant within an 800 m radius buffer of their residential address (this buffer area corresponded to a neighbourhood setting, which was also used to obtain participants' perceptions): (1) population density (the number of

population per square kilometre); (2) sidewalk availability (the length of roads with sidewalks (m) per square kilometre); (3) access to public transportation (the total number of train stations and bus stops per square kilometre); (4) access to destinations (the total number of 30 destination types including convenience store, supermarket, hardware shop, fruit store, dry cleaning store, coin laundry, clothing store, post office, library, book store, fast food store, café, bank, restaurant, video shop, video rental shop, pharmacy, drug store, the hairdresser's, park, gym, fitness club, sports facility, kindergarten, elementary school, junior high school, high school, 2-year college, 4-year college and university based on a previous study and IPAQ-E [20][21]); and (5) street connectivity (the total number of intersections per square kilometre). These five objectively measured environmental attributes were dichotomised using the median.

Covariates

The selection of covariates was based on previous studies.[22][23] Data on respondents' gender (men, women), age (40–49, 50–59 or 60–69 years), current marital status (married, unmarried), educational level (less than 13 years, 13 years or more), employment status (full-time employment, not full-time employment), household income (less than 5 million yen, or 5 million yen or more), body mass index (less than $25\,kg/m^2$, $25\,kg/m^2$ and higher), residential area (Nerima City and Kanuma City), physical function, and moderate-to-vigorous physical activity (MVPA) were included. Physical function was measured by the Japanese version of the Medical Outcomes Study Short Form 8-Item Health Survey.[24] Participants were asked: 'During the past 4 weeks, how much did physical health problems limit your physical activities (such as walking or climbing stairs)?' MVPA was measured by the self-administered, short Japanese version of the International Physical Activity Questionnaire (IPAQ-SV). The test–retest reliability (r=0.72–0.93) and criterion validity (r=0.39) of the version of the IPAQ-SV are good and acceptable, respectively.[25] The total number of minutes per week in vigorous-intensity physical activity, moderate-intensity physical activity and walking was computed.

Statistical analyses

For cross-sectional associations, generalised linear modelling (GLM), specifying a gamma distribution and a log link, was used to examine cross-sectional associations of perceived and objectively measured environmental attributes with screen time at baseline because the distribution of outcome variable was skewed. The covariates were adjusted for baseline demographic variables including gender, age, marital status, education attainment, household income, working status and MVPA. For prospective associations, GLM was also used to identify the relationships of perceived and objectively measured environmental attributes at baseline with follow-up screen time over 2 years, adjusted for sociodemographic variables

at baseline, screen time at baseline and employment status change. This approach is equivalent to modelling change in screen time and controls for regression to the mean, which has been used in a previous study.[15] Residence area was used as the area level unit of all analysis. Results of each model are reported as antilogarithms of the regression coefficients (and their respective 95% CI). The expected proportional increase (for values >1) or decrease (for values <1) in screen time for 'environmental conditions that would support physical activity' environment (reference: 'not support' category) was calculated. For cross-sectional analysis, coefficients less than 1 denote proportionally less time spent in screen time (eg, $\exp(\beta)=0.95$ means 5% less time), whereas coefficients more than 1 denote proportionally more time spent in screen time, relative to the reference category (eg, $\exp(\beta)=1.06$ means 6% more time). For prospective analysis, coefficients less than 1 denote proportionally decreased time spent in screen time, whereas coefficients more than 1 denote proportionally increased time spent in screen time, relative to the reference category. Statistical analyses were conducted using STATA V.13; the level of significance was set at P<0.05.

RESULTS

Basic characteristics of the baseline sample (n=1011, mean age: 55.8±4.3 years) and follow-up sample (n=553, mean age: 54.6±8.3 years) are presented in table 1. On average, participants' screen time was not statistically different over 2 years (2.3 hours/day at baseline and 2.2 hours/day at follow-up; P=0.24). Table 2 shows that at baseline, after adjusting for potential confounders (model 2), cross-sectional associations of objectively measured ($\exp(\beta)$: 1.11; 95% CI 1.01 to 1.22) and perceived ($\exp(\beta)$: 1.12; 95% CI 1.02 to 1.23) good access to public transport, perceived good access to shop ($\exp(\beta)$: 1.18; 95% CI 1.04 to 1.36) and perceived good street connectivity ($\exp(\beta)$: 1.11; 95% CI 1.01 to 1.23) with higher time spent in screen time were found. As table 3 shows, for the prospective associations, no objectively measured and perceived environmental attributes were significantly associated with change in screen time.

DISCUSSION

To our knowledge, this is the first study to examine cross-sectional and prospective associations between neighbourhood environments and screen time using both perceived and objective measures of specific neighbourhood environmental attributes among middle-aged Japanese adults in an Asian country. The results of this study support previous findings that built environmental attributes of neighbourhoods that are related to physical activity may also play an important role in influencing sedentary behaviours independently,[12][14][15][26] and further extend the results showing that both perceived (good access to public transport, access to shop and street

Table 1 Characteristics of baseline and follow-up respondents

	Sample for cross-sectional analyses (n=1011)	Sample for prospective analyses (n=533)
Baseline		
Gender, % men	512 (51.2)	276 (51.8)
Age, mean (SD)	55.8 (4.3)	54.6 (8.3)
Marital status, % married	844 (84.3)	454 (85.2)
Educational attainment, % with tertiary education	536 (53.6)	308 (57.8)
Household income (yen), %		
<5 000 000 p.a.	492 (49.2)	244 (45.8)
5 000 000 p.a.+	494 (49.4)	283 (53.1)
Refused to answer or missing	15 (1.5)	6 (1.1)
Work status, % non-working	743 (74.2)	406 (76.2)
BMI, mean (SD)	23 (3.2)	22.9 (3.3)
MVPA (hour/week), mean (SD)	9.3 (13.4)	9.2 (12.4)
Screen time (hour/day), mean (SD)	2.3 (1.9)	2.3 (1.9)
Follow-up		
Change in working status	–	
Keep working	–	388 (72.8)
Start working	–	17 (3.2)
Stop working	–	18 (3.4)
Not working	–	110 (20.6)
Screen time (hour/day), mean (SD)	–	2.2 (1.7)

BMI, body mass index; MVPA, moderate-to-vigorous physical activity; p.a, per annum.

connectivity) and objectively measured (good access to public transport) physical activity-supportive environmental attributes are related to higher levels of screen time cross-sectionally. These findings would be important to inform policy makers and intervention designers that when designing environmental approach to promote physical activity, it would be crucial to consider the negative impact of screen time, at least in Japan.

Contrary to expectations, a neighbourhood environment with GIS-measured good access to public transportation, and perceived good access to destinations, good access to public transportation and good street connectivity, was positively associated with higher levels of screen time in adults, which have been found to be positively related to higher levels of physical activity.[18 27] The present results were also inconsistent with previous studies from Western countries that have reported inverse associations between high walkable environment and screen-based sedentary time.[12 14 15] Only one Belgium study reported similar results with the present study that high walkable environment is positively associated with total sitting time.[26] The possible speculation for these results could be that physical activity-supportive neighbourhood environment (eg, there are so many shops, train stations and bus stops within 1.6 km radius of their house) could reduce the time spent in commute and daily errand, and thus adults may have more leisure time to engage in screen time. Although there is limited evidence in existing literature to draw the conclusion and the possible mechanism regarding the inverse associations between environment and screen time, the present study may have several important implications. First of all, the perceptions of environmental attributes should be considered as predictors of screen time in future studies. The present results indicate that perceived environmental attributes might be better predictors of screen time than objective ones. How middle-to-older-aged adults perceive and understand their neighbourhood environment might be important in their decision to spend time in screen time in their home. Moreover, further studies in Asian countries using specific environmental measures are needed due to differences in residential density, culture and built environment between Western and Asian countries. Finally, examining the relationships among environmental factors, physical activity and sedentary behaviour concurrently would be a priority to better understand the potential positive or negative health effects of environment on both physical activity and sedentary behaviours to inform policy initiatives.

Another novel finding is that there were no prospective associations between screen time and objective and perceived environmental attributes over 2 years. The possible explanation for this result could be that the follow-up duration of this study was only 2 years and screen time is a highly domestic behaviour for adults during leisure time, which may be maintained for years unless there is adjustment in home environment or change in employment status. Therefore, the present study might provide a preliminary understanding on built environmental determinants of screen time for developing effective population-based interventions.[10 11] Therefore, to further confirm the prospective associations, studies with a longer follow-up time are needed in the future.

This study has several limitations. First, the outcome variable—self-reported screen time—may be subject to recall bias. Thus, future studies should consider measuring screen time using objective measures to provide more confirmative evidence. Second, the use of the IPAQ-SV may have overestimated the time spent in MVPA. Third, potential confounders such as self-selection of neighbourhoods and home environment were not examined in this study. Finally, the participants who responded to the follow-up survey were more likely to have higher educational levels (58.1% vs 47.4%, P=0.002) and have

Table 2 Proportional change (95% CI) in screen time according to objective and perceived environmental attributes at baseline (n=1011)

	Model 1			Model 2		
	Exp(β)	95% CI	P value	Exp(β)	95% CI	P value
Perceived						
Residential density (high)	1.02	0.91 to 1.14	0.69	1.02	0.93 to 1.13	0.66
Access to destination (good)	1.10	0.99 to 1.22	0.06	1.12	1.02 to 1.23	0.02*
Access to public transportation (good)	1.20	1.03 to 1.39	0.01*	1.18	1.04 to 1.36	0.01*
Sidewalk (yes)	1.04	0.94 to 1.15	0.43	1.06	0.97 to 1.17	0.20
Street connectivity (good)	1.10	0.99 to 1.23	0.08	1.11	1.01 to 1.23*	0.04*
GIS						
Residential density (high)	0.96	0.87 to 1.06	0.45	0.96	0.87 to 1.06	0.44
Access to destination (good)	1.07	0.96 to 1.18	0.21	1.05	0.96 to 1.16	0.29
Access to public transportation (good)	1.13	1.03 to 1.25	0.01*	1.11	1.01 to 1.22	0.03*
Sidewalk (yes)	0.99	0.89 to 1.10	0.88	0.99	0.91 to 1.10	0.98
Street connectivity (good)	0.97	0.88 to 1.08	0.60	1.00	0.91 to 1.11	0.95

Generalised linear model (specifying a gamma distribution and using a log link).
Model 1: unadjusted model; model 2: adjusted for gender, age, marital status, education attainment, household income, employment status, car ownership status, BMI, physical function and MVPA at baseline.
Results of each model are reported as antilogarithms of the regression coefficients (and their respective 95% CI). Coefficients less than 1 denote proportionally less time spent in screen time, whereas coefficients more than 1 denote proportionally more time spent in screen time, relative to the reference category.
*P<0.05.
BMI, body mass index; GIS, geographic information system; MVPA, moderate-to-vigorous physical activity.

Table 3 Proportional change (95% CI) in screen time over 2 years according to objective and perceived environmental attributes, after adjusting for baseline leisure-time sitting for transport (n=533)

	Model 1			Model 2		
	Exp(β)	95% CI	P value	Exp(β)	95% CI	P value
Perceived						
Residential density (high)	1.06	1.16 to 1.25	0.37	1.11	0.97 to 1.27	0.14
Access to destination (good)	0.96	0.84 to 1.10	0.54	1.00	0.88 to 1.14	0.97
Access to public transportation (good)	1.06	0.87 to 1.29	0.54	1.08	0.89 to 1.30	0.46
Sidewalk (yes)	0.96	0.84 to 1.09	0.50	0.99	0.87 to 1.12	0.84
Street connectivity (good)	1.03	0.89 to 1.19	0.72	1.06	0.92 to 1.22	0.39
GIS						
Residential density (high)	1.01	0.88 to 1.14	0.94	1.05	0.92 to 1.20	0.47
Access to destination (good)	1.06	0.93 to 1.20	0.41	1.07	0.94 to 1.23	0.29
Access to public transportation (good)	1.02	0.90 to 1.16	0.78	1.02	0.90 to 1.16	0.74
Sidewalk (yes)	1.10	0.97 to 1.24	0.16	1.11	0.98 to 1.26	0.10
Street connectivity (good)	1.04	0.91 to 1.18	0.58	1.08	0.94 to 1.24	0.26

Generalised linear model (specifying a gamma distribution and using a log link).
Model 1: unadjusted model; model 2: adjusted for gender, age, marital status, education attainment, household income, BMI, physical function and MVPA at baseline, change in employment status and car ownership.
Results of each model are reported as antilogarithms of the regression coefficients (and their respective 95% CI). Coefficients less than 1 denote proportionally decreased time spent in screen time, whereas coefficients more than 1 denote proportionally increased time spent in screen time, relative to the reference category.
*P<0.05.
BMI, body mass index; GIS, geographic information system; MVPA, moderate-to-vigorous physical activity.

higher income (53.4% vs 43.9%, P=0.01) than those who did not. Thus, the final sample may not be representative of the populations of Nerima City and Kanuma City. The strengths of this study were its cross-sectional and prospective design and the utilisation of five subjectively and objectively measured environmental components, which could provide more confirmative evidence on this issue.

CONCLUSION

Activity-supportive neighbourhood environmental attributes appear to be related to higher levels of screen time cross-sectionally. Patterns of screen time might be maintained rather than changed over time under the same neighbourhood environments. Environmental interventions that promote physical activity may need to consider the potential negative health impact of screen time in Japan.

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