



Environmental predictors of objectively measured out-of-home time among older adults with cognitive decline

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ABSTRACT

Background: Older adults with cognitive decline are vulnerable to various health problems. Going out of home for longer time could be beneficial for their health. Identifying modifiable predictors is essential for developing effective strategies that would increase time spent out-of-home by older adults. This study examined social and physical environmental predictors of objectively measured out-of-home time spent among older adults with cognitive decline.

Methods: This study was a secondary analysis of a randomized controlled trial (n = 147). Out-of-home time per day was measured by a Global Positioning System at baseline and 1-year follow-up. Baseline data of social environment (living alone, social network [Japanese version of the Lubben Social Network Scale]), objective physical environment (road network distance from each home address to nearest supermarket store, convenience store, and public transportation), and demographic factors (gender, age, education, driving status, fear of falling) were examined as potential predictors.

Results: After adjusting main effects of allocation group, time of measures, and their interactive effect, a mixed model showed that younger age (p = 0.044), current driving status (p = 0.039), and stronger social network (p = 0.003) were predictors of out-of-home time. However, none of the physical environmental factors significantly predicted outdoor time.

Conclusions: The present study found that social network was a predictor of objectively measured out-of-home time among older adults with global cognitive decline. A sufficient social network might help increase out-of-home time among them. However, the influence of physical environment on out-of-home time might be small.

1. Introduction

Declines in cognitive functions are a common phenomenon among older adults. Shimada, Makizako et al. (2016) reported that 31.4% of community-dwelling older adults have mild or global cognitive impairments. Older adults with cognitive decline are more vulnerable to various health problems than healthier populations. They are at higher risk for dementia (Palmer, Wang, Bäckman, Winblad, & Fratiglioni, 2002), physical impairments (2016b, Buchman, Boyle, Leurgans, Barnes, & Bennett, 2011; Shimada, Makizako et al., 2016), and psychological distress (Vinkers, Gussekloo, Stek, Westendorp, & van der Mast, 2004).

To prevent onsets of further health problems among older adults with cognitive decline, going outside home more frequently could be

beneficial. Going out-of-home shares similar concepts with homebound status and life-space. When people go out home, they usually involve certain levels of physical, cognitive, and/or social activities. Compared with other health behaviors such as smoking cessation, control of food intake, and exercise, the notable point of going out-of-home is that no special knowledge, motivation, cost, or time are required. Older adults could incorporate going out-of-home into their daily lives more easily than other health behaviors. The health benefits of going out home more frequently among average or healthier older adults have been well reported (Fujita, Fujiwara, Chaves, Motohashi, & Shinkai, 2006; Inoue, Shono, & Matsumoto, 2006; Kono, Kai, Sakato, & Rubenstein, 2004; Shimada et al., 2010). Similarly to results found in healthier populations, some studies (Harada, Lee et al., 2017, 2018) have indicated that longer time spent out-of-home positively influences the

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health status of older adults with cognitive decline. Thus, increasing out-of-home time would contribute to health promotion among older adults with cognitive decline.

To develop effective strategies to increase out-of-home time among older adults with cognitive decline, it is essential to identify modifiable predictors of out-of-home time. Identifying them can highlight the target factors to effectively promote behavior change. In the research field of health behavior change, the ecological model (Sallis et al., 2006) asserts the importance of the environment's influence on health behaviors, because environmental factors can influence people's health behaviors for a longer time than individual factors can (Sallis et al., 2006). Review studies have confirmed the environmental determinants of various health behaviors, such as physical activity (Cerin et al., 2017), healthy eating (Brug, Kremers, van Lenthe, Ball, & Crawford, 2008), and smoking behaviors (Albertsen, Borg, & Oldenburg, 2006). Especially, among health behaviors, physical activity has been intensively examined in the framework of the ecological model, and it is affirmed that physical activity behaviors are determined by both social and physical environmental factors (Bauman et al., 2012).

Although various studies have identified determinants of homebound status and out-of-home behavior (Fujita et al., 2004; Ganguli, Fox, Gilby, & Belle, 1996; Jing, Wang, Zhang, Yao, & Xing, 2017; Murayama, Yoshie, Sugawara, Wakui, & Arami, 2012; Nakamura & Yamada, 2009; Negrón-Blanco et al., 2016; Smith, Chen, Clarke, & Gallagher, 2016; Todo et al., 2015), evidences about the environmental determinants of out-of-home behavior among older adults are still inconsistent. According to physical activity studies using an ecological model, out-of-home time among older adults would be influenced by both social and physical environmental factors. Living arrangements and social network might predict out-of-home time among social environmental factors. A study found that the four most common reasons for going out home among older adults, in order of importance, were the following: shopping, walking for exercise, social visit, and running errands (Tsai et al., 2016). Among these reasons, shopping, social visiting, and running errands would relate with living arrangements and social network; older adults who live alone would have more opportunities to go out home for shopping and running errands, while those who have an adequate social network would have more opportunities for visiting their friends and relatives. Nonetheless, the associations of these social environmental factors with out-of-home behavior are still inconclusive (Fujita et al., 2004; Ganguli et al., 1996; Jing et al., 2017; Murayama et al., 2012; Nakamura & Yamada, 2009; Negrón-Blanco et al., 2016; Todo et al., 2015). On the other side, regarding the physical environmental factors, while Japanese studies (Hirai et al., 2015; Murayama et al., 2012) have reported the associations of poor food accessibility and daily errands with homebound status among older adults, a previous study in the United States did not support these results (Smith et al., 2016). Inconsistent findings for environmental correlates of out-of-home behavior in previous studies would be derived from methodological limitations among them. One methodological limitation is that most studies were cross-sectional, and few have examined the social and physical environmental predictors by prospective design (Smith et al., 2016). Another limitation is that none of these studies have examined the environmental determinants of out-of-home time by using objective methods such as Global Positioning Systems (GPS: Harada, Lee et al., 2017, 2018; Wettstein et al., 2015) or home infrared sensors (Petersen, Austin, Mattek, & Kaye, 2015; Suzuki & Murase, 2010). To better understand the environmental influences on out-of-home time, prospective examinations of objective data are also necessary.

The purpose of the present study was to examine whether social and physical environmental factors were predictors of out-of-home time among older adults with cognitive decline.

2. Methods

2.1. Participants and procedures

In the present study, we conducted a secondary analysis of a community-based randomized control trial of exercise for older adults with global cognitive decline, which aimed to clarify the effect of an exercise intervention program on their further decline in cognitive functions. We are preparing to submit the main results of this trial as another manuscript; a protocol of this trial (ID: UMIN000013097) was registered on the UMIN Clinical Trials Registry website [<http://www.umin.ac.jp/ctr/index.htm>]. We also published several papers for the secondary analysis of this trial (Harada, Lee et al., 2017, 2018); the detailed procedures of this trial are described in these papers.

Participants of this trial were recruited from a sub-cohort of the National Center for Geriatrics and Gerontology-Study of Geriatric Syndromes (NCGG-SGS; Shimada, Tsutsumimoto et al., 2016) conducted in 2013 in the Midori Ward of Nagoya city, Aichi prefecture, Japan. Nagoya city is a typical urban city in Japan. Among those older adults enrolled in this sub-cohort, we sent the invitation letter for this trial to 709 eligible individuals who met the following inclusion criteria: 1) had global cognitive decline as reflected by scores from 21 to 24 on the Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975); 2) had normal walking speed as ≥ 1 m per second; 3) did not have serious health problems (e.g., stroke, Parkinson's disease, dementia); and 4) did not potentially participate in other intervention studies. Since this trial provided an exercise program, we excluded individuals who exhibited inadequate gait functioning or serious health problems due to the risk management. Among 709 individuals who received the invitation letter, 280 of them participated in the baseline assessments of this trial, which were conducted in May 2014, and were assigned to either the intervention ($n = 140$) or control ($n = 140$) group. We provided exercise programs once a week during 40 weeks (40 times in total) for the intervention group, and health education programs once every three months (three times in total) for the control group. Afterward, we conducted a follow-up assessment for both groups, which was performed in April 2015. Among the 280 participants, 26 individuals were removed from the follow-up assessment due to health problems ($n = 15$), withdrawal from participation ($n = 9$), and death ($n = 2$). In Nagoya City, the average temperatures were 19.5 °C in May 2014 and 15.2 °C in April 2015. Thus, the season was spring and it was not extremely hot or cold at both the baseline and follow-up assessments.

From a total of 280 participants, 194 met the inclusion criteria of providing GPS data for out-of-home time at baseline. Thus, for the cross-sectional examinations, the baseline data of 194 participants were analyzed in the present study. Among 194 individuals, 178 participated in the follow-up assessment. However, 31 of them did not meet the inclusion criteria of GPS data for the follow-up. Therefore, data of the 147 remaining participants were analyzed for the prospective associations.

Owing to the secondary analyses, the present study did not conduct a previous sample size calculation to detect the significant environmental predictors of out-of-home time.

The trial was approved by the Ethics Committee of the National Center for Geriatrics and Gerontology (No.637-3). Written informed consent was obtained from all participants. All procedures were conducted in accordance with the Helsinki Declaration.

2.2. Measures

2.2.1. Objective out-of-home time

The detailed methodology for the measurement of out-of-home time was reported in our previous articles (Harada, Lee et al., 2017, 2018). Briefly, out-of-home time was measured by GPS monitors (Globalsat DG-200 Data Logger: GlobalSat WorldCom Corporation: Taipei,

Taiwan). This device can record latitude and altitude every 30 s in normal connection conditions. We asked participants to carry the GPS at all times, except when sleeping, and to complete a diary for 14 consecutive days. They noted in their diary whether they wore the device all day or not.

We analyzed the data provided by this device according to the geographic information system (ArcGIS for Desktop 10.3: Esri Japan Incorporation: Tokyo, Japan). We operationally defined the home area as a 100-m radius from each home's representative point. Apart from a 100 m radius, we also examined narrower definitions of home area such as a 50 m radius. However, reasonable out-of-home times were not obtained using narrower definitions because 1) certain margins were required for some individuals living in large housing complexes and 2) the GPS monitors had measurement errors. Thus, we finally decided to employ the operational definition of home area as a 100 m radius. Next, out-of-home per day was calculated as the times when the individual left and returned to the home area. We defined a day to be eligible if participants 1) wore the device at least 10 h, 2) started and ended the day in the home area, 3) had no poor connection during the times when they left and returned to the home area, and 4) answered that they wore the device all day in their diary. Furthermore, we included the data of each individual who met these criteria for at least eight out of 14 eligible days. Then, we calculated for each participant the average daily out-of-home per day at the baseline and follow-up survey. The days when participants did not go out of home were also included in the calculations by coding them as zero.

2.2.2. Social environmental factors

Living arrangement (living alone or living with others: single item) and social network were measured as social environmental factors at baseline. We employed the short-form, Japanese version of the Lubben Social Network Scale (Kurimoto et al., 2011), developed by Lubben et al. (2006). This scale consists of six items, and higher scores represent a stronger social network. Kurimoto et al. (2011) established the test-retest reliability, as well as the construct and concurrent validity of the Japanese version of this scale.

2.2.3. Physical environmental factors

The present study measured road network distances (m) from each home address to the following three nearest destinations: supermarket store, convenience store, and public transportation (bus stop or train station). We calculated the distances by the geographic information system (ArcGIS for Desktop 10.3 Network Analyst software: Esri Japan Incorporation: Tokyo, Japan). Data of supermarket/convenience stores, bus stops, and train stations were obtained from a phone number database (*i-Taun-Pegi*, translated as “yellow page”), the *Kokudo-Suchi-Joho* download service (translated as “National Land Numerical Information”), and a map service website [MapFan Web (Increment P Corporation) <https://mapfan.com/>], respectively.

2.2.4. Demographic factors

Gender (men or women), age (years), education level (years spent in education), current driving status (yes or no), and fear of falling were included as demographic factors. Fear of falling was assessed by a single question: “Are you afraid of falling?” Participants answered this question in a 4-point Likert scale ranging from 1 (not at all) to 4 (very much).

2.3. Statistical analyses

2.3.1. Cross-sectional analyses

The present study conducted cross-sectional analyses at baseline for 194 individuals. Pearson's correlation coefficients were calculated for the associations among out-of-home time, social and physical environment variables, and demographic factors at baseline. Living alone (no = 0, yes = 1), gender (women = 0, men = 1), current driving

status (no = 0, yes = 1) were treated as dummy variables. Because fear of falling measured with a single item in a 4-point Likert scale has been treated as a continuous variable in previous studies (e.g., Harada, Park et al., 2017; Resnick et al., 2014), we also analyzed fear of falling as a continuous variable.

Afterward, we performed multiple regression analyses with out-of-home time as the dependent variable at baseline. The independent variables at baseline were: social environmental factors (living alone, social network), physical environmental factors (distance to supermarket store, convenience store, and public transportation), and demographic variables (gender, age, education, current driving status, and fear of falling). These variables were included in the model by the forced-entry method. Our study used variance inflation factors as indicators of multicollinearity.

Statistical significance was set at $P < 0.05$. The Statistical Package for the Social Sciences (SPSS) for Windows, version 21.0 (IBM Japan, Ltd., Tokyo, Japan), was used to accomplish the cross-sectional analyses.

2.3.2. Prospective analyses

This study included the data from 147 individuals for the prospective analyses. We performed a multiple linear mixed model with out-of-home time as the dependent variable at baseline and follow-up. For longitudinal data, mixed-random and fixed-effect regression models (also called mixed models) are more appropriate than ordinal regression models because the significance level in these models could be biased (Locascio & Atri, 2011). The fixed effects of social environmental, physical environmental, and demographic factors at baseline, and the time of measurement (0 = baseline, 1 = follow-up) were examined. Furthermore, because the present study was the secondary analyses of a randomized controlled trial, the main fixed effect of allocation group (0 = control group, 1 = intervention group) and the interactive fixed effect of allocation group with the time of measurement were also included in the model. Continuous variables were mean-centered prior to the analyses. This study treated the intercepts of individual differences as random effects. All variables were examined simultaneously.

The mixed model was performed using the “mixed” command of Stata statistical software, version 14 (StataCorp LLC, College Station, Texas, USA). Maximum likelihood estimation was used to fit the model. Statistical significance was set at $P < 0.05$.

3. Results

3.1. Characteristics of participants at baseline

Among the 194 participants, 2327 person-days were valid for out-of-home time at baseline. Among the 2327 valid person-days at baseline, 346 person-days (14.9%) were Sunday; 328 (14.1%), Monday; 329 (14.1%), Tuesday; 321 (13.8%), Wednesday; 327 (14.1%), Thursday; 340 (14.6%), Friday; and 336 (14.4%), Saturday. Thus, the proportions of the day of the week were equable. The number of person-days when the participants went out of home was 2115 (90.9%). The distribution of out-of-home time by person-days is shown in Fig. 1. On average, the participants went out of home 6.37 days per week (standard deviation, 0.87 days per week; range, 2.33–7 days per week).

Fig. 2 represents the distribution of average out-of-home time per day at baseline by participants. Average out-of-home time per day was 3:36:02. The distribution was not extremely skewed.

Descriptive statistics of demographic, and social and physical environmental factors at baseline are shown in Table 1. Among 194 participants, 110 (56.7%) were male and 84 (43.3%) were female; the mean age was 76.3 years old. Participants had an average of 11.9 years of education. A total of 126 individuals (64.9%) currently drove cars, and 13 (6.7%) lived alone. Mean distances to the nearest supermarket store, convenience store, and public transportation were 622.9 m,

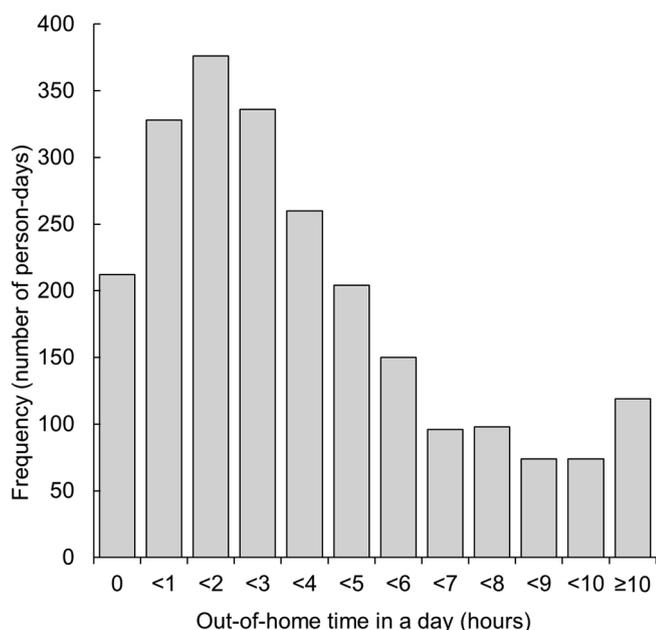


Fig. 1. Distribution of out-of-home time at baseline by person-days (total: 2327 person-days).

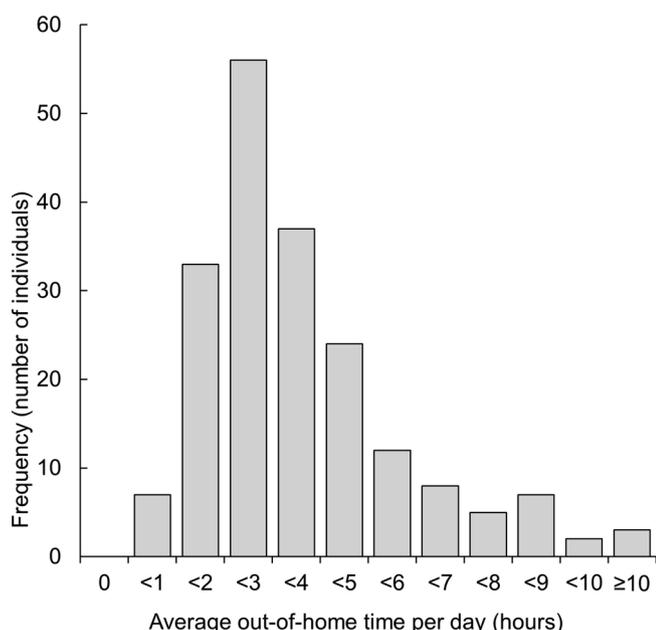


Fig. 2. Distribution of average out-of-home time per day at baseline by participants (total: 194 individuals).

455.1 m, and 264.5 m, respectively.

3.2. Cross-sectional associations of demographic, and social and physical environmental factors with out-of-home time per day at baseline

Table 2 shows Pearson’s correlations among out-of-home time, demographic, and social and physical environmental factors at baseline. Age, current driving status, living alone, and social network were significantly correlated with out-of-home time. On the other hand, no significant correlations were found between physical environmental factors and out-of-home time.

Results of the multiple regression analysis are presented in Table 3. The regressions from age, current driving status, living alone, and social network on out-of-home time were significant. All physical

Table 1 Descriptive statistics of demographics, and social and physical environmental factors at baseline (n = 194).

	Mean or %	SD	Range
Out-of-home time / day (time)	3:36:02	2:07:22	0:31:24 – 11:27:52
Demographic factors			
Gender (male)	56.7%	—	—
Age (years)	76.3	4.1	71 – 88
Education (years)	11.9	2.6	6 – 22
Current driving status (yes)	64.9%	—	—
Fear of falling (score)	2.5	1.0	1 – 4
Social environmental factors			
Living alone (yes)	6.7%	—	—
Social network (score)	17.4	5.2	5 – 29
Physical environmental factors			
Distance to supermarket store (meters)	622.9	287.9	128.6 – 1407.0
Distance to convenience store (meters)	455.1	226.6	0.0 – 982.9
Distance to public transportation (meters)	264.5	132.7	6.2 – 777.2

Note: SD, standard deviation.

environmental factors did not significantly correlate with out-of-home time.

3.3. Prospective associations of demographic, and social and physical environmental factors with out-of-home time per day at baseline

Table 4 shows the results of the mixed model for prospective associations of demographic, and social and physical environmental factors with out-of-home time. Younger age, current driving status, and stronger social network, as well as the time of measures, were significant predictors of out-of-home time. Contrary to cross-sectional analyses, living alone was not a significant predictor of out-of-home time. Furthermore, none of the physical environmental factors significantly predicted out-of-home time.

4. Discussion

The present study found that a stronger social network was a predictor of objectively measured out-of-home time among older adults with global cognitive decline. This result indicates that an adequate social network might contribute to preventing a decrease in going out-of-home time among this population. Concerning the potential mechanisms of the relationships between social network and out-of-home time, it is reasonable to consider that those older adults with adequate social networks have more opportunities to visit their friends and relatives than those with poor social networks. Social visit is the third most common reason for going out home among older adults (Tsai et al., 2016). Thus, social network might increase out-of-home time mediated by the frequency of social visit opportunities. However, in previous studies results concerning the influence of social network on homebound status and out-of-home behavior are inconsistent. A Chinese study reported that social network variables are not significantly associated with homebound status (Jing et al., 2017). In Japan, while Todo et al. (2015) did not found significant associations of social network with frequency of going out home, other studies have revealed that lack of social network is associated with lower frequency of going out home (Fujita et al., 2004; Nakamura & Yamada, 2009). One possible explanation for the inconsistent associations found in previous studies could be due to assessing out-of-home behavior and homebound status by simple and self-report methods. Previous studies (Fujita et al., 2004; Jing et al., 2017; Todo et al., 2015; Nakamura & Yamada, 2009) only measured self-reported weekly frequencies of going out home and did not consider the length of time spent out-of-home within the day. Therefore, the methodology of the present study could be more accurate in estimating the total amount

Table 2
Pearson's correlation coefficient among out-of-home time/day, demographics, and social and physical environmental factors at baseline. (n = 194).

	1	2	3	4	5	6	7	8	9	10
1. Out-of-home time/day	—									
Demographic factors										
2. Gender (male)	0.11	—								
3. Age	-0.30***	0.08	—							
4. Education	-0.02	0.16*	-0.05	—						
5. Current driving status (yes)	0.29***	0.56***	-0.19**	0.12	—					
6. Fear of falling	-0.09	-0.29***	0.04	-0.09	-0.27***	—				
Social environmental factors										
7. Living alone (yes)	0.18*	0.11	0.01	-0.06	0.11	0.02	—			
8. Social network	0.19**	-0.06	-0.05	0.21**	0.08	-0.11	-0.03	—		
Physical environmental factors										
9. Distance to supermarket store	0.09	0.16*	-0.07	-0.03	0.25***	-0.03	0.12	-0.02	—	
10. Distance to convenience store	-0.13	-0.02	0.11	0.15*	-0.13	-0.03	-0.04	0.02	0.02	—
11. Distance to public transportation	-0.06	0.07	-0.06	0.05	0.03	0.00	-0.11	-0.03	0.22**	0.17*

Note: *p < 0.05, **p < 0.01, ***p < 0.001.

Table 3
Multiple regression analysis for cross-sectional associations of demographics, and social and physical environmental factors with out-of-home time per day at baseline (n = 194).

	Standardized beta	p-value	VIF
Demographic factors			
Gender (female = 0, male = 1)	0.02	0.789	1.7
Age (years)	-0.26	< 0.001	1.1
Education (years)	-0.08	0.242	1.1
Current driving status (no = 0, yes = 1)	0.19	0.025	1.7
Fear of falling (score)	-0.02	0.831	1.1
Social environmental factors			
Living alone (no = 0, yes = 1)	0.15	0.028	1.1
Social network (score)	0.19	0.007	1.1
Physical environmental factors			
Distance to supermarket store (meters)	0.01	0.868	1.1
Distance to convenience store (meters)	-0.05	0.444	1.1
Distance to public transportation (meters)	-0.05	0.469	1.1

Note: VIF, variance inflation factor.
The dependent variable was out-of-home time/day.
Model fit: F(10, 183) = 4.97, p < 0.001 (R² = 0.21).

Table 4
Fixed effects in mixed model for prospective associations of demographics, and social and physical environmental factors with out-of-home time per day (n = 147).

	Estimated parameter (95%CI)	p-value
Demographic factors		
Gender (female = 0, male = 1)	-662.1 (-3061.3, 1737.1)	0.589
Age (years)	-235.7 (-465.3, -6.1)	0.044
Education (years)	-103.9 (-460.5, 252.6)	0.568
Current driving status (no = 0, yes = 1)	2569.9 (128, 5011.8)	0.039
Fear of falling (score)	-751 (-1703, 201)	0.122
Social environmental factors		
Living alone (no = 0, yes = 1)	2711.8 (-919.3, 6342.9)	0.143
Social network (score)	279.6 (93.8, 465.4)	0.003
Physical environmental factors		
Distance to supermarket store (meters)	0.4 (-2.8, 3.6)	0.799
Distance to convenience store (meters)	-1.7 (-5.8, 2.4)	0.421
Distance to public transportation (meters)	-1.4 (-8.5, 5.6)	0.694
Time of measures (baseline = 0, follow-up = 1)	-1703.0 (-2567.1, -838.9)	< 0.001

Note: The dependent variable was out-of-home time/day.
The main fixed effect of allocation group (0 = control, 1 = intervention) and the interactive fixed effect of allocation group with time of measures were adjusted.

of out-of-home time and thus be more sensitive to detect the individual differences of time spent out-of-home than previous studies. By measuring the time spent out-of-home objectively, this study advances previous findings regarding the associations of social network with out-of-home behavior and homebound status.

Although a cross-sectional analysis showed that those who lived alone were more likely to go out-of-home for a longer time than those who lived with others, the prospective analysis did not support this finding. Therefore, the present study could not obtain a clear conclusion about the influence of living arrangement on out-of-home time among older adults with cognitive decline. The smaller sample size of the living alone group (6.7%, n = 13 at baseline) might have limited the statistical power to detect the influence of living arrangements on out-of-home time. It can be expected that those older adults who live alone might have more opportunities to go shopping and run errands, and this fact might elevate the total time spent out-of-home among them. However, previous studies have reported that living arrangement was not significantly associated with homebound status (Ganguli et al., 1996; Murayama et al., 2012; Negrón-Blanco et al., 2016) or frequency of going out home (Todo et al., 2015; Nakamura & Yamada, 2009). Further studies based on larger sample sizes are required to confirm these findings more conclusively.

The present study did not find any significant associations of physical environmental factors with time spent out-of-home among older adults with cognitive decline. This result indicates that the influence of the physical environment on out-of-home time could be small among this population. However, this result is not consistent with previous Japanese studies which have shown that poor accessibility to non-residential places, such as restaurants and retail stores (Murayama et al., 2012), and longer distances to these facilities (Hirai et al., 2015) are associated with homebound status among older adults. One possible explanation concerning the differences between the present study and previous Japanese findings (Hirai et al., 2015; Murayama et al., 2012) is that the type of target community might cause such differences. While the present study targeted a typical urban area, Murayama et al. (2012) targeted a suburban area, and Hirai et al. (2015) targeted a rural area severely damaged by an earthquake. As shown in the descriptive statistics of Table 1, the absolute accessibility to shops and public transportation in our research area was good; the mean distances to these facilities among participants were 263.7–619.8 meters and the maximum distances were less than 1.5 km. Narrow variations in the accessibility to these facilities might have caused in the present study the null results regarding the association of accessibility to these facilities with out-of-home time.

Among the demographic factors, current driving status and younger age were significant predictors of longer time spent out-of-home among the participants. Similar to the present study, previous studies

(Amagasa et al., 2018; Marottoli et al., 2000) have also supported the importance of driving status for out-of-home behavior. These studies have shown that current drivers are more physically active than non-drivers (Amagasa et al., 2018), and that driving cessation can decrease out-of-home activities (Marottoli et al., 2000) among older adults. Regarding age, previous research has consistently revealed that older age is associated with homebound status (Ganguli et al., 1996; Jing et al., 2017; Murayama et al., 2012; Negrón-Blanco et al., 2016; Smith et al., 2016) and lower frequency of going out home (Fujita et al., 2004; Todo et al., 2015). Similarly, the present research provides strong evidence about the relationship between age and out-of-home behavior through objectively measured data.

The main strength of our study was the objective measurement of out-of-home time utilizing a prospective design. However, the present study had some limitations. First, the sample size was small, and the study was not based on a prior sample size calculation. Second, adherence to the GPS device was low; this could limit the internal validity of the study. Third, our operational definition of home area, a 100 m radius, could underestimate the amount of out-of-home time. Fourth, the present study was a secondary analysis of a randomized controlled trial. In the prospective analysis, this study statistically adjusted the potential effects of group allocation and its interactive effects over time. However, any potential bias might be found only in the secondary analysis. Larger studies using more representative samples are required to confirm our findings. Nonetheless, this study contributes to a better understanding of the environmental predictors of time spent out-of-home among older adults with cognitive decline.

In conclusion, the present study found that social network was a predictor of objectively measured out-of-home time among older adults with global cognitive decline. However, physical environmental factors did not significantly predict out-of-home time. As for the practical implications of our findings, strengthening the social network might be effective to increase out-of-home time among these older adults. Some interventional studies have succeeded to strengthen the social network among older adults by implementing intergenerational volunteering (Fujiwara et al., 2009) and event-based community programs (Harada, Masumoto et al., 2018). There is a possibility that providing such programs might indirectly increase out-of-home time mediated by the increase of social network. Based on our findings, further research on effective strategies to increase out-of-home time among older adults with global cognitive decline is expected.

Conflict of interests

The authors declare that they have no conflict of interests.

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