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Daily and longitudinal associations of out-of-home time with objectively measured physical activity and sedentary behavior among middle-aged and older adults

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Abstract This study examined the associations of time spent out of home with physical activity and sedentary behavior among middle-aged and older adults. A diary survey was conducted for 7 days with 157 adults to measure out-of-home time and working status. Time spent in sedentary behavior and levels of physical activity were measured using an accelerometer. After a year, 137 individuals from the original sample participated in a follow-up survey. From the daily analyses of 535 non-working days and 347 working days, multilevel models revealed that on non-working days, more out-of-home time was associated with less sedentary time and higher levels of physical activity at both within- and between-person levels. Longitudinal analyses of non-working days supported these results. However, on working days, similar associations were not revealed by daily or longitudinal analyses. These results suggest that increasing out-of-home time could contribute to increased physical activity and reduced sedentary behavior on non-working days.

Keywords Exercise · Health behavior · Healthy aging · Homebound persons · Sedentary lifestyle

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Introduction

The health benefits of physical activity (Kyu et al., 2016) and the health risks of sedentary behavior (Biswas et al., 2015) have been established. Current physical activity guidelines recommend that adults engage in physical activity (Haskell et al., 2007; World Health Organization, 2010) and reduce sedentary behavior (Department of Health, Physical Activity, Health Improvement and Protection, 2011; Australia's Department of Health, 2014) to promote health. With regard to the intensity of physical activity, current guidelines recommend moderate-to-vigorous intensity levels (Haskell et al., 2007; World Health Organization, 2010). In addition, light physical activity is now considered important for health promotion because light physical activity is associated with health outcomes independent of moderate-to-vigorous physical activity (Gando et al., 2010; Ku et al., 2018; Osuka et al., 2015). Step count is also widely accepted as a simple and easy-to-understand indicator of physical activity for public health and clinical applications (Tudor-Locke et al., 2011). However, people become less physically active (Inoue et al., 2011) and spend more time engaged in sedentary behavior (Harvey et al., 2015) as they age. Therefore, development of effective strategies to increase physical activity and reduce sedentary behavior among middle-aged or older populations is a public health priority.

To increase physical activity and reduce sedentary behavior among these populations, the promotion of going out of home for longer periods of time might be one potentially effective strategy. The ecological model of health behavior (Sallis et al., 2006) proposes that health behaviors are influenced at multiple levels, including individual, interposal, environmental, and policy levels. Within individual levels, previous studies have examined behavioral factors as the determinants of physical activity (Condello et al., 2017) and sedentary behavior (Chastin et al., 2015) among older adults. Going out of home would be one behavioral determinant of physical activity and sedentary behavior. Compared with other behavioral determinants such as exercising, the notable advantage of going out of home is that it neither requires any special knowledge, motivation, or time nor incurs any special cost. Thus, it may be easier to incorporate going out of home into individual's daily lives, than it would be to incorporate exercise. The concept of going out of home is similar to those of homebound status and life-space mobility used in the research area of gerontology. In the area of gerontology, the terms "going outdoors" (e.g., Tsai et al., 2016a, b) and "outdoor time" (e.g., Harada et al., 2017) are also used to refer to out-of-home behavior. The four most common reasons for going out of home among older adults are shopping, walking for exercise, paying social visits, and running errands (Tsai et al., 2016b). Similar to walking for exercise, the other three activities involve light-to-moderate physical activity. For example, when people go to such destinations by car, they have to walk from their parked car to their destination. In a building for shopping and errands, people normally spend larger amounts of time in walking or standing postures. With regard to social visits, the *2011 Compendium of Physical Activities* (Ainsworth et al., 2011) indicates that retreat/family reunion activities, involving sitting, relaxing, talking, and eating, correspond to light physical activity. The accumulation of these small amounts of active behaviors would elevate total amounts of physical activity. This accumulation also would contribute to decreased sedentary behavior in people who go out of home by replacing sedentary behavior at home (e.g., television viewing). For children, a systematic review (Gray et al., 2015) showed that time spent outdoor is associated with both increases in physical activity and decreases in sedentary behavior.

However, unlike in children, the evidence regarding associations of out-of-home time with physical activity and sedentary behavior among middle-aged and older adults remains insufficient. To establish the promotion of increasing out-of-home time as an effective strategy to change levels of physical activity and sedentary behavior, such evidence is essential. The Life-Space Mobility in Old Age (LISPE) project has shown that life-space mobility, which is a combined concept of spatial range, frequency and independence of travel behaviors, is associated with objectively measured physical activity and sedentary behavior among older adults in both cross-sectional (Tsai et al., 2015) and longitudinal (Tsai et al., 2016a) studies. However, the LISPE project did not examine the associations after adjusting for the potential effects of other daily behaviors such as exercise and household chores. Further longitudinal examinations are needed to strengthen the evidence. Except for the LISPE project, Beyer et al. (2018) showed cross-sectional associations of time spent in physical activities outside of buildings and sedentary behavior among adults. From cross-sectional examination, Harada et al., (2017) also revealed that more time spent out of the home is associated with higher amounts of step counts among older adults. However, previous studies (Beyer et al., 2018; Harada et al., 2017; Tsai et al., 2015, 2016a) did not examine within-person associations. The amount of physical activity and sedentary behavior varies each day within one person. It remains unclear whether such daily variations in these behaviors are explained by variations in out-of-home time within each individual. Examination at the within-person level can strengthen the previous evidence regarding associations of out-of-home time with physical activity and sedentary behavior.

To better understand the associations of out-of-home time with physical activity and sedentary behavior, the potential effects of other daily behaviors such as exercise and household chores should be adjusted. However, previous studies have not adjusted for these potential effects. One major reason for going out the home is walking for exercise (Tsai et al., 2016b). Household chores are major activities performed inside the home. On average, middle-aged and older adults engage in household chores for approximately 2 h per day (Statistics Bureau, Japanese Ministry of Internal Affairs and Communications, 2012). Most household chores involve low-to-moderate intensity levels of physical activity (Ainsworth et al., 2011). Thus, exercise and household time may confound the association of out-of-home time with physical activity and sedentary behavior.

Furthermore, the association of out-of-home time with physical activity and sedentary behavior may vary by working status. Previous studies have shown that patterns of physical activity and sedentary behavior differ between weekdays and weekend days (Davis et al., 2011; Evenson et al., 2015). In a working day, many workers usually spend larger portions of awake time working compared with other daily behaviors. Physical activity and sedentary behavior during working time account for approximately half of total daily time in each behavior (Clemes et al., 2014). It can be assumed that the influence of out-of-home time on physical activity and sedentary behavior would be more relevant in non-working days than in working days.

The present study aimed to examine both daily and longitudinal associations between time spent out-of-home, and levels of physical activity and sedentary behavior, among middle-aged and older adults. In particular, the present study hypothesized that more time spent out of the home would be associated with higher amounts of physical activity and lower amounts of sedentary behavior.

Methods

Participants and procedures

The present study targeted middle-aged and older married couples living in four areas located in Hyogo Prefecture, Japan: Chuo Ward of Kobe City; Takasago City; Miki City; and Shiso City. There are approximately 135 thousand people in Chuo Ward of Kobe City (4684 per km^2), 90 thousand people in Takasago City (2645 per km^2), 77 thousand people in Miki City (437 per km^2), and 37 thousand people in Shiso City (57 per km^2). From the official basic resident register of the four areas, 540 men aged 59, 64, or 69 in April of 2016 (135 men per area) and their 540 wives were randomly selected. The recruitment document was sent to 540 couples to invite them to participate in our accelerometer and diary survey for seven consecutive days. Of them, 79 couples (n = 158) agreed to participate in the survey. Book coupons worth 5000 Japanese yen were provided as incentives for each couple. The reason for recruiting couples was that the survey had other purposes; we examined spousal concordance of physical activity and sedentary behavior among couples, which was reported in another paper (Harada et al., in press).

After 1 year, we asked the 158 original participants (79 couples) to participate in a follow-up survey. Among them, 138 individuals (69 couples) agreed to participate. The content of the 1-year follow-up survey was the same as the baseline survey.

Informed consent was obtained from all individual participants included in the study. The present study received prior approvals (baseline survey, No. 209; 1-year follow-up survey, No. 286) from the Ethical Committee in the Graduate School of Human Development and Environment, Kobe University.

Measures

Physical activity and sedentary behavior

A triaxial accelerometer (HJA-750C, Active style Pro, Omron Healthcare Co., Ltd., Kyoto, Japan) was used to measure time spent in light physical activity, moderate-to-vigorous physical activity, sedentary behavior, and step counts. The algorithm of the accelerometer (HJA-750C) is identical to that of the older model (HJA-350IT), the validity of which was previously confirmed (Ohkawara et al., 2011). The HJA-350IT can more accurately estimate total energy expenditure in free-living days using the doubly labeled water method than the other types of accelerometers available in Japan (Murakami et al., 2016). The size of the device and data-download system differ between the newest (HJA-750C) and older model (HJA-350IT).

The period of the accelerometer survey was seven consecutive days. The participants were asked to wear the accelerometer on their waists all day, except when bathing and sleeping, and to live as normal. The monitor results were blinded, and individuals could not check their records themselves.

The epoch length of the accelerometer was set at 10 s. Non-wearing time was defined as any period of at least 60 min in which the accelerometer data were not recorded. Wearing time was calculated by subtracting non-wearing time from 24 h. An eligible day was defined as a day in which the accelerometer was worn for between 10 and 20 h. The inclusion criteria of wearing time as $\geq$ 10 h per day has been commonly employed in previous studies (Gorman et al., 2014). Furthermore, although we asked individuals to take off the accelerometer when sleeping, the data indicated that a few individuals did not. Thus, we also excluded days when wearing time was $\geq$ 20 h. Out of 1106 eligible days at baseline and 966 eligible days at follow-up, 16 days (1.4%) at baseline and 20 days (2.0%) at follow-up were deleted because wearing time was more than 20 h, and 72 days (6.5%) at baseline and 67 days (6.9%) at follow-up were deleted because wearing time was less than 10 h.

Following Pate et al. (2008), the present study defined moderate-to-vigorous physical activity as all activities involving $\geq$ 3 metabolic equivalents, the expression of the energy cost of physical activity, light physical activity as all activities involving 1.6 to 2.9 metabolic equivalents, and sedentary behavior as all activities involving $\leq$ 1.5 metabolic equivalents. Although the definition of sedentary behavior includes both the intensity and posture (Tremblay et al., 2017), the accelerometer does not estimate sedentary behavior by posture. Kurita et al. (2017) compared the sedentary time measured by the older model (HJA-350IT) of Active Style Pro and activPAL3. activPAL3 (PAL Technologies Ltd., Glasgow, UK) is also a triaxial accelerometer and can estimate sedentary time by both intensity and posture. Kurita et al. (2017) reported that Pearson's correlation coefficients for sedentary time measured by both accelerometers are 0.87 in working days and 0.83 in non-working days. Thus, the validity of Active Style Pro for estimating sedentary behavior is acceptable.

The time spent in sedentary behavior, light physical activity, moderate-to-vigorous physical activity, wearing time, and the step counts in a day, were calculated and analyzed in the present study.

Time spent out of the home, exercising, or engaged in household chores

Out-of-home, exercise, and household chore times were measured by the diary survey for seven consecutive days, the same period as for the accelerometer survey. The participants were asked to record the time (hours and minutes) they spent in each behavior before going to bed every day. If they did not engage in a behavior for any amount of time in a day, they were to record the amount of time engaged in the behavior as 0 min.

The present study defined out-of-home time as all times involving participants leaving their houses for any purpose except for taking out the trash and checking the mailbox. Japanese gerontology studies (e.g., Fujita et al., 2016; Harada et al., 2017; Kono et al., 2004) often use the term "outdoors." In the present study, the term "out of home" refers to the same concept. Because the time spent inside buildings other than the home (e.g., shops, friend's house, and restaurants) is also included in this concept, we determined that "out of home" would be more appropriate. The participants recorded total out-of-home time in a day in the diary.

Household chore time was defined as the total time for six activities: cooking meals, washing dishes, cleaning rooms, doing the laundry, caring for older adults, and caring for young children. We asked the participants to record time spent on each activity in the diary. From these data, we calculated the total household time in a day.

Although we did not provide a specific definition of exercise, we listed walking for exercise, calisthenics, and sports as examples of exercise. The participants recorded total time spent engaged in exercise activities in a day.

Working status

Working status was measured by the diary survey. Work was defined as what an individual did to earn money. We asked the participants to indicate whether they worked with an answer of "yes" or "no" for each day in the diary. If they answered "yes," they were asked to indicate total time spent working (excluding mealtime and breaks) and whether they commuted to work or worked from home. On working days, working time was subtracted from out-of-home time if the workplace was outside of the home.

Basic demographic and health factors

Information on gender, age, education (junior high/high school, beyond high school), and frailty (healthy, pre-frail/frail) were obtained as basic demographic and health factors by the questionnaire survey. The Kihon Checklist (Japanese Ministry of Health, Labour and Welfare, 2009; Arai & Satake, 2015) was employed to assess frailty. The Kihon Checklist was developed by the Japanese Ministry of Health, Labour and Welfare in 2005 to screen for frailty in older adults. The Kihon Checklist is composed of 25 items. Respondents answer each item by yes or no. Based on the pre-frailty/frailty criteria (Satake et al., 2016), the individuals were categorized into two groups: healthy and pre-frail/frail. The sensitivity and specificity of the Kihon Checklist for screening clinically diagnosed pre-frailty and frailty are 70.3 and 78.3% for pre-frailty, and 89.5 and 80.7% for frailty, respectively (Satake et al., 2016).

Analyses

Daily analyses

The present study conducted two analysis plans: daily analyses and longitudinal analyses. For daily analyses of the associations between out-of-home time with physical activity and sedentary behavior, one individual was excluded from the total number of participants (n = 158), because they did not have any valid data for the accelerometer variables. Baseline data without missing values were analyzed for 141 individuals with 535 days of non-working status (an average of 3.79 days per individual), and for 100 individuals with 347 days of working status (an average of 3.47 days per individual).

Multilevel models were used to examine these associations at both within- and between-person levels. Before stratified analysis, the present study confirmed whether working status was a moderator of the association of out-of-home time with physical activity and sedentary behavior variables by examining the interaction terms of working status with out-of-home time in the single-model analyses. If the interaction terms in the single models were significant, we conducted stratified analyses by working status. The present study developed four models with sedentary behavior time, light physical activity time, moderate-to-vigorous physical activity time, and step counts within each day set as the dependent variables. The independent variables were daily accelerometer wearing time, daily out-of-home time, daily household time, daily exercise time, working status (level 1, within-person level), overall accelerometer wearing time, overall out-of-home time, overall household time, overall exercise time, gender, age, educational background, and frailty (level 2, between-person level). In the single-model analyses, the interaction terms of working status with daily out-of-home time (level 1) and of working status with overall out-of-home time (cross-level) were also included as the independent variables. In the stratified analyses, while we excluded working status from the model, we added daily (level 1) and overall (level 2) working time as the independent variables for analyses in working day. The intercept for individual differences (level 2) was included as a random effect. Because the present study recruited spousal couples, the multilevel models also included couple as a random effect (level 3, couple level). All continuous variables at level 2 were mean-centered prior to the analyses. Categorical variables, which were treated as dummy variables, included: working status (non-working day = 1, working day = 1), gender (men = 0, female = 1), education (junior high/high school = 0, beyond high school = 1), and frailty (healthy = 0, pre-frail/frail = 1). Similar to previous studies (Conroy et al., 2013; Maher & Conroy, 2017), the overall behavior variables were calculated as each person's mean time or mean step count across 7 days for each behavior. Daily times for each behavior and daily step counts were calculated as the differences in each day's time or step counts from each person's overall time or counts. Thus, overall times or step counts for each behavior were used to determine the regression onto individual differences between participants, and daily times or step counts were used to determine the regression onto the daily differences within participants.

All multi-level analyses were performed using the *mixed* command of Stata version 14 (StataCorp LLC, College Station, Texas, USA). Maximum likelihood estimation was used to fit the model. Statistical significance was set at $p < 0.05$.

Longitudinal analyses

For the longitudinal analyses, the data of 137 individuals with valid data at both baseline and 1-year follow up were analyzed. Specifically, the baseline and 1-year follow-up data of 114 individuals were analyzed for non-working days, and 85 individuals were analyzed for working days.

Similar to daily analyses, multilevel models were employed for the longitudinal analyses. For longitudinal data, multilevel models (also called mixed models) are more appropriate than ordinal regression models because the significance level in ordinal models could be biased (Locascio & Atri, 2011). Because we assume that the associations of out-of-home time with physical activity would be on a daily basis, multilevel models examined synchronous (cotemporal) association between the two variables. Before stratified analysis, we examined the interaction terms of working status with out-of-home time on physical activity and sedentary behaviors by single-model analyses. Then stratified analyses were conducted. The dependent variables were average sedentary behavior time, average light physical activity time, average moderate-to-vigorous physical activity time, and average step counts per day. The independent variables were survey time (baseline = 0, follow-up = 1: level 1, within-person level), average accelerometer wearing time, average out-of-home time, average household time, average exercise time, gender, age, educational background, frailty (level 2, between-person level), and the interaction term of out-of-home time with survey time (cross-level). We also included the interaction terms of working status with average out-of-home time (cross-level) as the independent variables for the single-model analyses. In the stratified analyses, while we excluded working status from the model, we added daily (level 1) and average working time (level 2) as the independent variables for analyses in working day. We treated the intercepts for individual differences (level 2) and couple (level 3, couple level) as the random effects.

As we did for daily analyses, we used the *mixed* command of Stata version 14 (StataCorp LLC, College Station, Texas, USA) for multilevel analyses. Statistical significance was set at $p < 0.05$.

Results

Baseline characteristics of the participants

Among the 157 participants included in the present study, 79 (50.3%) were men, and 78 (49.7%) were women. The mean and standard deviation for age were 63.2 and 4.6 years, respectively, and the age range was 53–70 years old. Among them, 85 individuals (54.1%) had graduated from junior-high or high school, and 72 individuals (45.9%) from upper school; 81 individuals (51.6%) were of healthy status and 76 individuals (48.4%) were of pre-frail or frail status; 171 individuals (68.2%) were workers (61 men [mean age 64.0 years] and 46 women [means age 60.7 years]), and 50 individuals (31.8%) were non-workers (18 men [mean age 67.0 years] and 32 women [mean age 63.1 years]). Among workers (n = 107), average working days per week was 4.63 days.

The descriptive statistics and Pearson's correlation coefficients of the average time spent on each behavior and average step counts at baseline are shown in Table 1 for non-working days and in Table 2 for working days. On non-working days, average out-of-home time was significantly correlated with average sedentary behavior time, average light physical activity time, average moderate-to-vigorous physical activity time, and average step counts. However, on working days, average out-of-home time was not significantly correlated with any physical activity variables.

Table 1 Descriptive statistics and Pearson's correlation coefficient among accelerometer variables and daily behaviors on non-working days (n = 141)

		Descriptive statistics		Pearson's correlation coefficients						
		Mean (SD)	Range	1	2	3	4	5	6	7
1	Average sedentary behavior time	8:33:11 (1:53:59)	3:44:20–15:11:35	—						
2	Average LPA time	4:25:56 (1:21:09)	1:13:40–8:26:40	**− 0.45*****	—					
3	Average MVPA time	1:19:58 (0:35:17)	0:11:29–3:21:45	**− 0.56*****	**0.50*****	—				
4	Average step counts	5520.1 (2827.5)	293.5–14138.7	**− 0.34*****	**0.30*****	**0.77****	—			
5	Average accelerometer wearing time	14:19:07 (1:44:17)	10:01:30–19:18:30	**0.55*****	**0.46*****	0.12	0.12	—		
6	Average out-of-home time	4:40:10 (2:28:38)	0:00:00–11:00:00	**− 0.26****	**0.27****	**0.26****	**0.29****	0.01	—	
7	Average household time	2:41:18 (2:33:47)	0:00:00–14:46:40	− 0.11	**0.49*****	0.12	0.06	**0.29*****	− 0.02	—
8	Average exercise time	0:28:36 (0:38:09)	0:00:00–3:20:00	− 0.14	0.04	**0.34*****	**0.45*****	− 0.00	**0.17***	**− 0.18***

M mean, *SD* standard deviation, *LPA* light physical activity, *MVPA* moderate-to-vigorous physical activity

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Bold font represents significant correlations

Table 2 Descriptive statistics and Pearson's correlation coefficient among accelerometer variables and daily behaviors on working days (n = 100)

		Descriptive statistics		Pearson's correlation coefficients							
		Mean (SD)	Range	1	2	3	4	5	6	7	8
1	Average sedentary behavior time	7:46:43 (2:03:06)	3:18:08–12:03:30								
2	Average LPA time	5:19:43 (1:40:41)	1:52:28–10:10:57	**− 0.69*****							
3	Average MVPA time	1:45:14 (0:49:13)	0:29:21–4:21:56	**− 0.54*****	**0.51*****						
4	Average step counts	7904.2 (3819.2)	1933.7–20268.3	− 0.16	**0.21***	**0.71*****					
5	Average accelerometer wearing time	14:51:41 (1:35:10)	10:46:49–18:09:20	**0.28****	**0.43*****	**0.36*****	**0.38*****				
6	Average out-of-home time (except for work)	3:10:51 (1:43:50)	0:00:00–8:07:30	**0.24***	− 0.07	− 0.10	0.12	0.19			
7	Average household time	1:35:29 (1:52:22)	0:00:00–8:30:00	− 0.10	**0.28****	0.08	− 0.06	**0.21***	− 0.04		
8	Average exercise time	0:17:41 (0:29:54)	0:00:00–2:18:20	0.15	− 0.17	0.15	**0.38*****	0.10	**0.20***	− 0.09	
9	Average work time	6:28:59 (2:37:38)	0:53:20–14:00:00	− 0.19	0.14	0.04	0.04	− 0.09	− 0.18	**− 0.39*****	− 0.17

M mean, *SD* standard deviation, *LPA* light physical activity, *MVPA* moderate-to-vigorous physical activity

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Bold font represents significant correlations

Analyses of daily associations of out-of-home time with physical activity and sedentary behavior

The results of multilevel analyses by single models are shown in Table 3. Except overall out-of-home time with working status on step counts, all other interaction terms were significantly regressed on the dependent variables. Thus, the present study conducted further multilevel analyses stratified by working status.

Table 4 (non-working days) and Table 5 (working days) show the results of the stratified analyses. On non-working days, longer out-of-home time was significantly associated with shorter sedentary behavior time, longer light physical activity time, longer moderate-to-vigorous physical activity time, and a higher step count at both within- and between-person levels. Also at both within- and between-person levels, longer household time was significantly associated with lower sedentary behavior time and longer light physical activity time, whilst longer exercise time was significantly associated with lower sedentary behavior time, longer moderate-to-vigorous physical activity time, and a higher step count.

On working days, longer out-of-home time was significantly associated with shorter sedentary behavior time, longer light physical activity time, and higher amounts of step counts at the within-person level. However, in contrast to non-working days, these associations were not significant at the between-person level. The associations of household and exercise times with dependent variables were not consistent for within- and between-person levels.

Analyses of longitudinal associations of out-of-home time with physical activity and sedentary behavior

Table 6 shows the results of multilevel analyses by single models. The interaction terms of average out-of-home time with work status on sedentary behavior time, light physical activity time, and moderate-to-vigorous physical activity

Table 3 Fixed effects of multilevel models for daily associations of out-of-home time with physical activity and sedentary behavior on all days

	Sedentary behavior time		LPA time		MVPA time		Step counts	
	Parameter estimate (SE)	*p* value	Parameter estimate (SE)	*p* value	Parameter estimate (SE)	*p* value	Parameter estimate (SE)	*p* value
Within-person level								
Daily accelerometer wearing time	**0.64 (0.03)**	**< 0.001**	**0.29 (0.02)**	**< 0.001**	**0.07 (0.01)**	**< 0.001**	**0.08 (0.02)**	**< 0.001**
Daily out-of-home time	**− 0.17 (0.02)**	**< 0.001**	**0.14 (0.02)**	**< 0.001**	**0.03 (0.01)**	**0.001**	**0.07 (0.01)**	**< 0.001**
Daily household time	**− 0.21 (0.03)**	**< 0.001**	**0.17 (0.03)**	**< 0.001**	**0.04 (0.01)**	**0.002**	0.03 (0.02)	0.108
Daily exercise time	**− 0.38 (0.06)**	**< 0.001**	**0.11 (0.04)**	**0.010**	**0.26 (0.02)**	**< 0.001**	**0.47 (0.03)**	**< 0.001**
Working day	**− 5809.33 (432.36)**	**< 0.001**	**4111.11 (339.08)**	**< 0.001**	**1722.68 (174.95)**	**< 0.001**	**3001.61 (250.86)**	**< 0.001**
Daily out-of-home time × working day	**0.18 (0.04)**	**< 0.001**	**− 0.15 (0.03)**	**< 0.001**	**− 0.03 (0.02)**	**0.038**	**− 0.05 (0.02)**	**0.034**
Between-person level								
Overall accelerometer wearing time	**0.59 (0.08)**	**< 0.001**	**0.30 (0.06)**	**< 0.001**	**0.11 (0.03)**	**0.001**	**0.13 (0.04)**	**0.001**
Overall out-of-home time	**− 0.27 (0.08)**	**< 0.001**	**0.21 (0.06)**	**< 0.001**	0.05 (0.03)	0.091	0.06 (0.04)	0.087
Overall household time	− 0.19 (0.24)	0.424	− 0.17 (0.18)	0.363	**0.34 (0.10)**	**< 0.001**	**0.71 (0.12)**	**< 0.001**
Overall exercise time	− 0.07 (0.07)	0.314	0.09 (0.05)	0.085	− 0.03 (0.03)	0.376	− 0.02 (0.03)	0.565
Gender	**− 5274.71 (1183.88)**	**< 0.001**	**4034.94 (901.29)**	**< 0.001**	**1289.24 (473.38)**	**0.006**	556.37 (603.91)	0.357
Age	− 95.34 (106.26)	0.370	131.36 (76.63)	0.086	− 28.09 (42.93)	0.513	− 49.09 (49.92)	0.325
Educational background	**1727.61 (855.75)**	**0.044**	**− 1437.69 (629.24)**	**0.022**	− 366.67 (344.23)	0.287	104.75 (413.06)	0.800
Frailty	− 1075.14 (853.94)	0.208	963.28 (639.72)	0.132	91.08 (342.32)	0.790	**− 917.19 (424.35)**	**0.031**
Cross-level								
Overall out-of-home time × working day	**0.31 (0.06)**	**< 0.001**	**− 0.20 (0.05)**	**< 0.001**	**− 0.11 (0.03)**	**< 0.001**	− 0.06 (0.04)	0.091
Intercept	**34,778.26 (1014.84)**	**< 0.001**	**13,769.70 (754.82)**	**< 0.001**	**4221.65 (407.76)**	**< 0.001**	**5366.41 (500.96)**	**< 0.001**

Data of 930 days from 157 individuals were analyzed

The intercept for individual differences and couple were included as random effects

Working day (non-working day = 0, working day = 1), gender (male = 0, female = 1), education (junior high/high school = 0, beyond high school = 1), and frailty (healthy = 0, pre-frail/frail = 1) were treated as the dummy variables

LPA light physical activity, *MVPA* moderate-to-vigorous physical activity

Bold font represents significant associations

Table 4 Fixed effects of multilevel models for daily associations of out-f-home time with physical activity and sedentary behavior on non-working days

	Sedentary behavior time		LPA time		MVPA time		Step counts	
	Parameter estimate (SE)	p value	Parameter estimate (SE)	p value	Parameter estimate (SE)	p value	Parameter estimate (SE)	p value
Within-person level								
Daily accelerometer wearing time	**0.75 (0.03)**	**< 0.001**	**0.21 (0.03)**	**< 0.001**	**0.04 (0.02)**	**0.003**	**0.06 (0.02)**	**0.017**
Daily out-of-home time	**− 0.22 (0.02)**	**< 0.001**	**0.17 (0.02)**	**< 0.001**	**0.04 (0.01)**	**< 0.001**	**0.09 (0.01)**	**< 0.001**
Daily household time	**− 0.30 (0.03)**	**< 0.001**	**0.23 (0.03)**	**< 0.001**	**0.07 (0.01)**	**< 0.001**	**0.06 (0.02)**	**0.006**
Daily exercise time	**− 0.35 (0.05)**	**< 0.001**	**0.11 (0.04)**	**0.010**	**0.24 (0.02)**	**< 0.001**	**0.46 (0.04)**	**< 0.001**
Between-person level								
Overall accelerometer wearing time	**0.70 (0.07)**	**< 0.001**	**0.27 (0.05)**	**< 0.001**	0.03 (0.03)	0.366	0.03 (0.04)	0.460
Overall out-of-home time	**− 0.20 (0.05)**	**< 0.001**	**0.15 (0.04)**	**< 0.001**	**0.05 (0.02)**	**0.013**	**0.07 (0.03)**	**0.007**
Overall household time	**− 0.19 (0.06)**	**0.001**	**0.16 (0.04)**	**< 0.001**	0.03 (0.02)	0.228	0.04 (0.03)	0.217
Overall exercise time	**− 0.42 (0.19)**	**0.026**	0.1 (0.14)	0.498	**0.32 (0.07)**	**< 0.001**	**0.54 (0.10)**	**< 0.001**
Gender	**− 2262.30 (1134.77)**	**0.046**	**2164.86 (856.32)**	**0.011**	137.73 (441.59)	0.755	− 401.39 (576.02)	0.486
Age	− 93.30 (96.37)	0.333	125.59 (72.19)	0.082	− 31.19 (38.60)	0.419	− 29.77 (51.71)	0.565
Educational background	− 269.41 (820.94)	0.743	99.59 (616.82)	0.872	160.65 (325.33)	0.621	368.90 (431.68)	0.393
Frailty	− 83.15 (856.25)	0.923	338.27 (644.72)	0.600	− 228.37 (336.65)	0.498	− 757.88 (443.37)	0.087
Intercept	**32,084.04 (987.68)**	**< 0.001**	**14,661.14 (742.66)**	**< 0.001**	**4780.76 (389.70)**	**< 0.001**	**5965.38 (514.81)**	**< 0.001**

Data of 535 days from 141 individuals were analyzed

The intercept for individual differences and couple were included as random effects

Gender (male = 0, female = 1), education (junior high/high school = 0, beyond high school = 1), and frailty (healthy = 0, pre-frail/frail = 1) were treated as the dummy variables

LPA light physical activity, *MVPA* moderate-to-vigorous physical activity

Bold font represents significant associations

were significant. The interaction term on step counts was marginally significant ($p = 0.053$).

The results of stratified multilevel analyses are shown in Table 7 for non-working days and in Table 8 for working days. On non-working days, longer out-of-home time was associated with shorter sedentary behavior time, longer light and moderate-to-vigorous physical activity time, and greater amounts of step counts. The interaction terms of average out-of-home time with survey time on dependent variables were not significant. Furthermore, on non-working days, longer household time was associated with shorter sedentary behavior time, and longer light and moderate-to-vigorous physical activity time, and longer exercise time was associated with shorter sedentary behavior time, longer moderate-to-vigorous physical activity time, and greater amounts of step counts.

On working days, out-of-home time and household time were not significantly associated with any of the dependent variables. Longer exercise time on working days was associated with longer moderate-to-vigorous physical activity time and greater amounts of step counts.

Discussion

The main finding of the present study was that longer out-of-home time on non-working days was associated with increased physical activity and reduced sedentary behavior at both within- and between-person levels among middle-

Table 5 Fixed effects of multilevel models for daily associations of out-f-home time with physical activity and sedentary behavior on working days

	Sedentary behavior time		LPA time		MVPA time		Step counts	
	Parameter estimate (SE)	*p* value	Parameter estimate (SE)	*p* value	Parameter estimate (SE)	*p* value	Parameter estimate (SE)	*p* value
Within-person level								
Daily accelerometer wearing time	**0.69 (0.04)**	**< 0.001**	**0.23 (0.04)**	**< 0.001**	**0.08 (0.02)**	**< 0.001**	**0.12 (0.03)**	**< 0.001**
Daily out-of-home time (except for work)	**− 0.10 (0.03)**	**0.003**	**0.08 (0.03)**	**0.006**	0.03 (0.01)	0.062	**0.07 (0.02)**	**0.003**
Daily household time	**− 0.15 (0.07)**	**0.042**	**0.14 (0.06)**	**0.018**	− 0.01 (0.03)	0.861	− 0.01 (0.05)	0.884
Daily exercise time	**− 0.58 (0.12)**	**< 0.001**	**0.21 (0.10)**	**0.032**	**0.37 (0.05)**	**< 0.001**	**0.58 (0.08)**	**< 0.001**
Daily work time	**− 0.10 (0.03)**	**0.002**	**0.09 (0.03)**	**0.001**	0.02 (0.01)	0.119	**0.05 (0.02)**	**0.014**
Between-person level								
Overall accelerometer wearing time	**0.45 (0.12)**	**< 0.001**	**0.39 (0.09)**	**< 0.001**	**0.16 (0.05)**	**0.001**	**0.23 (0.06)**	**< 0.001**
Overall out-of-home time (except for work)	0.06 (0.10)	0.566	− 0.01 (0.08)	0.925	− 0.05 (0.04)	0.238	0.02 (0.05)	0.751
Overall household time	0.16 (0.15)	0.305	− 0.05 (0.12)	0.650	− 0.1 (0.07)	0.125	− 0.14 (0.08)	0.072
Overall exercise time	− 0.03 (0.34)	0.935	− 0.32 (0.26)	0.218	**0.36 (0.15)**	**0.014**	**0.88 (0.18)**	**< 0.001**
Overall work time	**− 0.24 (0.08)**	**0.002**	**0.19 (0.06)**	**0.001**	0.05 (0.03)	0.126	0.04 (0.04)	0.277
Gender	**− 9023.62 (1881.56)**	**< 0.001**	**6192.37 (1454.33)**	**< 0.001**	**2739.62 (818.90)**	**0.001**	**2120.03 (1037.42)**	**0.041**
Age	− 135.71 (165.69)	0.413	139.36 (124.08)	0.261	− 4.00 (68.53)	0.953	− 54.25 (77.16)	0.482
Educational background	**3022.17 (1245.42)**	**0.015**	**− 2265.22 (947.01)**	**0.017**	− 799.51 (527.81)	0.130	− 47.02 (625.02)	0.940
Frailty	− 1580.18 (1255.02)	0.208	1204.17 (960.74)	0.210	403.79 (538.20)	0.453	− 535.53 (653.53)	0.413
Intercept	**32,126.69 (1529.26)**	**< 0.001**	**16,202.59 (1172.25)**	**< 0.001**	**5123.57 (655.52)**	**< 0.001**	**6987.71 (806.41)**	**< 0.001**

Data of 347 days from 100 individuals were analyzed

The intercept for individual differences and couple were included as random effects

Gender (male = 0, female = 1), education (junior high/high school = 0, beyond high school = 1), and frailty (healthy = 0, pre-frail/frail = 1) were treated as the dummy variables

LPA light physical activity, *MVPA* moderate-to-vigorous physical activity

Bold font represents significant associations

aged and older adults. Longitudinal analyses supported these associations. These findings indicate that going out-of-home for longer periods of time on non-working days contributes to increases in physical activity and reductions in sedentary behaviors. To the best of our knowledge, this is the first study to examine daily and longitudinal associations of out-of-home time with objectively measured physical activity and sedentary behavior. Concordance of the daily and longitudinal analyses emphasizes the robustness of the findings. While previous studies (Gray et al., 2015) have indicated influences of longer time spent outdoor on physical activity and sedentary behavior among children, the studies remain limited for adults or older populations. The LISPE project (Tsai et al., 2015, 2016a)

Table 6 Fixed effects of multilevel models for longitudinal associations of out-of-home time with physical activity and sedentary behavior on all days

	Average SB time		Average LPA time		Average MVPA time		Average step counts	
	Parameter estimate (SE)	*p* value	Parameter estimate (SE)	*p* value	Parameter estimate (SE)	*p* value	Parameter estimate (SE)	*p* value
Within-person level								
Survey time	− 494.83 (396.73)	0.212	351.06 (308.32)	0.255	150.67 (154.44)	0.329	− 24.90 (208.33)	0.905
Working day	**− 4650.78 (567.94)**	**< 0.001**	**3436.82 (431.51)**	**< 0.001**	**1233.90 (227.04)**	**< 0.001**	**2368.35 (296.50)**	**< 0.001**
Between − person level								
Average accelerometer wearing time	**0.63 (0.05)**	**< 0.001**	**0.28 (0.04)**	**< 0.001**	**0.09 (0.02)**	**< 0.001**	**0.10 (0.03)**	**< 0.001**
Average out-of-home time	**− 0.12 (0.04)**	**0.006**	**0.11 (0.03)**	**0.001**	0.01 (0.02)	0.531	0.04 (0.02)	0.064
Average household time	**− 0.15 (0.05)**	**0.001**	**0.14 (0.04)**	**< 0.001**	0.02 (0.02)	0.307	0.00 (0.02)	0.857
Average exercise time	**− 0.40 (0.11)**	**< 0.001**	0.04 (0.08)	0.652	**0.35 (0.04)**	**< 0.001**	**0.54 (0.06)**	**< 0.001**
Gender	**− 3852.33 (958.78)**	**< 0.001**	**3152.36 (699.08)**	**< 0.001**	653.85 (416.37)	0.116	20.64 (517.79)	0.968
Age	− 68.46 (100.54)	0.496	107.87 (70.52)	0.126	− 40.97 (42.55)	0.336	− 48.08 (47.95)	0.316
Educational background	1085.57 (830.30)	0.191	− 669.58 (587.85)	0.255	− 430.42 (360.21)	0.232	− 17.07 (417.59)	0.967
Frailty	− 1256.65 (822.01)	0.126	955.30 (585.60)	0.103	301.24 (360.24)	0.403	− 462.73 (425.00)	0.276
Cross-level								
Average out-of-home × survey time	0.02 (0.05)	0.598	− 0.01 (0.04)	0.819	− 0.01 (0.02)	0.430	− 0.02 (0.02)	0.440
Average out-of-home × working day	**0.21 (0.06)**	**< 0.001**	**− 0.15 (0.04)**	**0.001**	**− 0.07 (0.02)**	**0.002**	− 0.06 (0.03)	0.053
Intercept	**33,984.58 (954.62)**	**< 0.001**	**13,953.92 (686.04)**	**< 0.001**	**4610.75 (407.53)**	**< 0.001**	**5836.39 (485.39)**	**< 0.001**

Data from 137 individuals were analyzed

The intercept for individual differences and couple were included as random effects

Survey time (baseline = 0, 1-year follow-up = 1), working day (non-working day = 0, working day = 1), gender (male = 0, female = 1), education (junior high/high school = 0, beyond high school = 1), and frailty (healthy = 0, pre-frail/frail = 1) were treated as the dummy variables

SB sedentary behavior, *LPA* light physical activity, *MVPA* moderate-to-vigorous physical activity

Bold font represents significant associations

has shown that life-space is cross-sectionally and longitudinally associated with objectively measured physical activity and sedentary behaviors among older adults. However, the project did not adjust for the potential confounding effects of daily behavioral factors such as household chores and exercise. Additionally, none of the previous cross-sectional studies (Beyer et al., 2018; Harada et al., 2017) have examined within-person associations. Thus, the present study contributes to a better understanding of the role of going out-of-home in promoting physical activity and reducing sedentary behaviors.

In terms of potential mechanisms for the associations of out-of-home time with physical activity and sedentary behavior on non-working days, it can be expected that people perform physically active behaviors and break their sedentary behavior when leaving their homes even if they use motor vehicles. Accumulating small amounts of activity when going out, such as a walk from one's parked car to the entrance of a building and walking inside of a building, might contribute to increases in total physical activity levels and decreases in sedentary behavior. Amagasa et al. (2018) revealed that among older adults, drivers are more physically active and spend less time in sedentary behavior than non-drivers. Amagasa et al. (2018) speculated that this could be because drivers have more opportunities to spend time out of the home than non-drivers. The findings and speculation by Amagasa et al. (2018) may

Table 7 Fixed effects of multilevel models for longitudinal associations of out-of-home time with physical activity and sedentary behavior on non-working days

	Average SB time		Average LPA time		Average MVPA time		Average step counts	
	Parameter estimate (SE)	*p* value	Parameter estimate (SE)	*p* value	Parameter estimate (SE)	*p* value	Parameter estimate (SE)	*p* value
Within-person level								
Survey time	− 328.61 (358.12)	0.359	134.9 (291.76)	0.644	200.67 (125.42)	0.110	146.80 (177.00)	0.407
Between-person level								
Average accelerometer wearing time	**0.72 (0.05)**	**< 0.001**	**0.25 (0.04)**	**< 0.001**	0.03 (0.02)	0.081	**0.06 (0.03)**	**0.011**
Average out-of-home time	**− 0.23 (0.04)**	**< 0.001**	**0.18 (0.03)**	**< 0.001**	**0.04 (0.02)**	**0.006**	**0.05 (0.02)**	**0.012**
Average household time	**− 0.31 (0.05)**	**< 0.001**	**0.23 (0.04)**	**< 0.001**	**0.08 (0.02)**	**< 0.001**	0.03 (0.02)	0.146
Average exercise time	**− 0.40 (0.11)**	**< 0.001**	0.04 (0.08)	0.625	**0.35 (0.04)**	**< 0.001**	**0.55 (0.05)**	**< 0.001**
Gender	− 1092.01 (1034.98)	0.291	**1617.35 (813.86)**	**0.047**	− 538.02 (428.90)	0.210	− 546.97 (542.33)	0.313
Age	− 33.81 (101.91)	0.740	79.62 (73.39)	0.278	− 57.66 (41.810)	0.168	− 47.30 (51.72)	0.360
Educational background	− 897.58 (855.96)	0.294	758.67 (636.96)	0.234	225.13 (358.32)	0.530	321.56 (442.83)	0.468
Frailty	− 828.10 (878.19)	0.346	644.78 (664.87)	0.332	196.16 (371.41)	0.597	− 247.21 (458.82)	0.590
Cross-level								
Average out-of-home time × survey time	0.01 (0.04)	0.757	0.00 (0.03)	0.976	− 0.01 (0.01)	0.591	0.00 (0.02)	0.931
Intercept	**32,203.88 (1118.95)**	**< 0.001**	**14,554.48 (856.38)**	**< 0.001**	**4935.81 (447.28)**	**< 0.001**	**5874.90 (571.55)**	**< 0.001**

Data from 114 individuals were analyzed

The intercept for individual differences and couple were included as random effects

Survey time (baseline = 0, 1-year follow-up = 1), gender (male = 0, female = 1), education (junior high/high school = 0, beyond high school = 1), and frailty (healthy = 0, pre-frail/frail = 1) were treated as the dummy variables

SB sedentary behavior, *LPA* light physical activity, *MVPA* moderate-to-vigorous physical activity

Bold font represents significant associations

be helpful to interpret the potential mechanisms of the present study.

On non-working days, the daily analyses of the present study also revealed the associations of more household time with less time in sedentary behavior and more time in light physical activity at both within- and between-person levels. These associations on non-working days were also confirmed by the longitudinal analyses. These results indicate that engagement in household chores for a longer period of time might contribute to increases in light physical activity and reductions in sedentary behavior. The compendium of physical activity (Ainsworth et al., 2011) shows that common household chores, such as cooking, washing dishes, and cleaning with light effort, are equal to light physical activity intensity levels. Engagement in household chores might replace sedentary behavior with light physical activity.

Almost all interaction terms of working status with out-of-home time on dependent variables were significant in both the daily and longitudinal analyses. Stratified by working status, clear and robust associations of out-of-home time with physical activity and sedentary behaviors were not found on working days. These results indicate that the influences of out-of-home time on physical activity and sedentary behavior would be more relevant on non-working days. Similar to out-of-home time, the associations of household and exercise time with physical activity and sedentary behaviors were not robust across daily and longitudinal analyses. As shown in the descriptive statistics in Table 2, the average working time per day was 6.5 h. As indicated by Clemes et al. (2014), work-related factors may have a predominant influence on levels of physical activity and sedentary behavior, and the influences of other factors

Table 8 Fixed effects of multilevel models for longitudinal associations of out-of-home time with physical activity and sedentary behavior on working days

	Average SB time		Average LPA time		Average MVPA time		Average step counts	
	Parameter estimate (SE)	*p* value	Parameter estimate (SE)	*p* value	Parameter estimate (SE)	*p* value	Parameter estimate (SE)	*p* value
Within-person level								
Survey time	− 446.75 (461.41)	0.333	408.86 (388.18)	0.292	22.95 (180.01)	0.899	− 215.64 (252.58)	0.393
Between-person level								
Average accelerometer wearing time	**0.78 (0.08)**	**< 0.001**	**0.15 (0.06)**	**0.015**	**0.08 (0.03)**	**0.013**	**0.11 (0.04)**	**0.015**
Average out-of-home time	− 0.01 (0.07)	0.924	0.03 (0.06)	0.670	− 0.03 (0.03)	0.338	0.04 (0.04)	0.366
Average household time	− 0.14 (0.1)	0.149	0.1 (0.08)	0.214	0.03 (0.04)	0.491	0.04 (0.06)	0.515
Average exercise time	− 0.1 (0.26)	0.701	− 0.21 (0.2)	0.303	**0.32 (0.11)**	**0.004**	**0.66 (0.15)**	**< 0.001**
Average work time	**− 0.25 (0.05)**	**< 0.001**	**0.16 (0.04)**	**< 0.001**	**0.08 (0.02)**	**< 0.001**	**0.07 (0.03)**	**0.016**
Gender	**− 6628.76 (1456.56)**	**< 0.001**	**4918.57 (1065.19)**	**< 0.001**	**1784.96 (681.78)**	**0.009**	981.5 (921.55)	0.287
Age	− 35.51 (164.43)	0.829	82.59 (112.18)	0.462	− 43.06 (74.93)	0.566	− 53.12 (83)	0.522
Educational background	**3474.78 (1287.11)**	**0.007**	**− 2156.81 (884.27)**	**0.015**	**− 1321.71 (606.7)**	**0.029**	− 492.39 (708.35)	0.487
Frailty	− 1458.37 (1259.51)	0.247	1098.97 (871.68)	0.207	468.23 (605.04)	0.439	− 335.54 (736.86)	0.649
Cross-level								
Average out-of-home time × survey time	0 (0.08)	0.960	0.03 (0.06)	0.672	− 0.03 (0.03)	0.362	− 0.07 (0.04)	0.097
Intercept	**30781.48 (1549.97)**	**< 0.001**	**17221.73 (1134.15)**	**< 0.001**	**6023.58 (703.21)**	**< 0.001**	**8390.04 (884.24)**	**< 0.001**

Data from 85 individuals were analyzed

The intercept for individual differences and couple were included as random effects

Survey time (baseline = 0, 1-year follow-up = 1), gender (male = 0, female = 1), education (junior high/high school = 0, beyond high school = 1), and frailty (healthy = 0, pre-frail/frail = 1) were treated as the dummy variables

SB sedentary behavior, *LPA* light physical activity, *MVPA* moderate-to-vigorous physical activity

Bold font represents significant associations

such as time spent out of home, household chores, and exercise might be relatively smaller on working days.

The examination of both daily and longitudinal data are the strengths of the present study. Concordance of the results from the daily and longitudinal analyses strengthens the robustness of the findings. The use of the accelerometer and the diary method are other strengths as they provide a combination of objective activity measurement, and details of activity type, on a day by day basis. However, the present study had several limitations. First, the sample was small. Second, the study has sampling bias. The mean daily step counts in the present study (5520.1 steps for non-working days and 7904.2 steps for working days) were not substantially different from a nationally representative dataset (7162 steps/day for men aged 60–69 years and 6559 steps/day for women aged 60–69 years; Inoue et al., 2011). Inoue et al., (2010) reported that the participants of a mail-based accelerometer survey are likely to have walking habits in their leisure time. Similarly, the participants in the present study, which were recruited by a comparable method, might be more motivated towards physical activity than the non-participants. Furthermore, the present study recruited married couples. In the multilevel models, concordance among couples were adjusted. However, this adjustment was only a statistical adjustment, and it is unclear whether the findings from our sample could generalize to people who are not married. Third, the present study did not record some potentially important qualitative aspects of out-of-home time, such as the purpose and/or the mode of transportation. Thus, further longitudinal examinations using larger and more representative samples with more detailed data on out-of-home time would be necessary to provide findings that are more definitive.

In conclusion, the present study found that in middle-aged and older adults, more out-of-home time on non-working days is associated with more physical activity and less sedentary behavior at both within- and between-person levels. As for the practical implications of these findings, the promotion of going out for longer periods of time might be an effective strategy to increase physical activity and decrease sedentary behavior on non-working days. From the values of the estimate parameters in the multilevel models (Table 4, 7), increase of out-of-home time for 1 h in a non-working day would be associated with decrease of sedentary behavior for 12–14 min, increase of light physical activity for 9–11 min, increase of moderate-to-vigorous physical activity for 2–3 min, and increase of 180–324 step counts. Further interventional studies would be necessary to confirm how these changes are practically significant compared with other strategies to increase physical activity and decrease sedentary behavior.

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Compliance with ethical standards

Conflict of interest Kazuhiro Harada, Kouhei Masumoto, Narihiko Kondo declare that they have no conflicts of interest.

Human and animal rights and Informed consent All procedures followed were in accordance with ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all individual participants included in the study.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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