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Cross-sectional associations of sedentary behaviour and physical activity on depression in Japanese older adults: an isotemporal substitution approach

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ABSTRACT

Objectives Reducing sedentary behaviour (SB) and increasing physical activity (PA) have been shown to be associated with decreased depression. However, there are yet few studies examining the potential benefits on older adults' depression, when SB is replaced with PA. This study aimed to examine the associations of objectively assessed SB, light-intensity PA (LPA) and moderate-to-vigorous PA (MVPA) with depression among a sample of Japanese older adults, and to explore impacts of substituting SB with PA on older adults' depression.

Design Cross-sectional analysis.

Setting General community.

Participants A total of 276 older adults aged 65–85 years living in Japan.

Main outcome measures Three behaviours including the average daily time spent in SB (≤1.5 METs); LPA (>1.5 to <3.0 METs) and MVPA (≥3.0 METs) per day were calculated by accelerometers. Depression was assessed using the Japanese version of the 15-item Geriatric Depression Scale (GDS-15).

Results Less SB (β=0.129, 95% CI 0.015 to 0.243) and more LPA (β=−0.138, 95% CI −0.265 to −0.011) were found to be significantly and negatively associated with the GDS-15 score in the single-activity model. The isotemporal substitution model found that replacing only 30 min per day of SB with the same amount of LPA to be significantly and negatively associated with the GDS-15 score (β=−0.131, 95% CI −0.260 to −0.002).

Conclusions These findings indicated that substituting even small amounts of SB with LPA may contribute to less depression in older adults. Potential favourable effects can be observed for replacing only 30 min per day of SB with LPA.

Strengths and limitations of this study

► The use of accelerometers to objectively measure participants' sedentary and active behaviours was the main strength of this study.
► We examined the impacts of substituting sedentary behaviour with physical activity on older adults' depression by using the isotemporal substitution approach.
► As a cross-sectional study, we were unable to infer a cause-and-effect relationship between sedentary behaviour, physical activity and depressive symptoms.

INTRODUCTION

Regular physical activity (PA), especially moderate-to-vigorous PA (MVPA) (eg, exercise, sports and brisk walking), has been found to be associated with less depression among older adults.[1 2] Recent studies have also demonstrated that sedentary behaviour (SB) (eg, television viewing, computer use, and sitting in cars) and light-intensity PA (LPA) (eg, housework, gardening, and casual walking) are closely related to depression: less SB[3] and more LPA[4] were found to be favourably associated with older adults' depression.

Several recent studies have examined how replacing one activity with another (eg, replacing SB with LPA or MVPA) can affect various health outcomes such as all-cause mortality and cardiovascular disease using the isotemporal substitution (IS) approach.[5 6] For example, a cross-sectional study found the reallocation of 30 min/day of SB with the equal time of sleep or LPA, or MVPA to be associated with better cardiovascular risk biomarkers.[5] Another prospective study including a large sample of middle-aged and older adults found that replacing SB with the same amount of standing, sleeping (only among low sleepers), and walking or MVPA was associated with the lowest mortality risk.[6] The IS approach enables researchers to simultaneously model a specific activity being performed and an activity being displaced in an equal time-exchange manner.[6] There are few previous studies examining the potential benefits on depression, when SB was replaced with LPA or MVPA.[7 8] For instance, a prospective study with 10 years follow-up among a

large sample of US women found that replacing 60 min/day of television viewing time with the same amount of fast walking was associated with a lower depression.[7] Another study examining association between objectively measured PA and depression demonstrated that replacing 30 min/day of SB with LPA was associated with a lower depression.[8] However, one of these studies used self-reported measures of PA and SB,[7] which are subject to recall bias (ie, lack of accuracy, validity, and reproducibility)[9] and two studies included middle-aged and older-aged people.[7 8] Hallgren *et al* suggested that further research is needed to better understand the complex relationships between PA, SB, and depression.[10] It is not clear yet how replacing SB with PA may affect depression among a total sample of elderly people, especially among Asian older sample.

Therefore, this study aims to examine the associations of objectively assessed SB, LPA, and MVPA with depression among a sample of Japanese older adults, and to explore impacts of substituting SB with PA on older adults' depression by using the IS approach.

METHODS
Participants and data collection
This study used cross-sectional data from a larger epidemiological study conducted in Matsudo city, Japan. A postal survey was sent to 3000 residents aged 65–85 years who were randomly selected from the registry of residential addresses. A total number of 349 participants (of 1250 people who responded to the postal survey) attended in a substudy, in which PA/SB was objectively calculated.

Measurements
Accelerometers (Active style Pro HJA-350IT, Omron Healthcare, Kyoto, Japan) were used to objectively measure participants' PA and SB. The detailed algorithm and validity of the accelerometer device have been described elsewhere.[11–13] The device evaluates the intensity of activity by metabolic equivalents (METs) using a built-in algorithm. A previous study, in which METs for household and locomotive activities were calculated, reported a linear relationship between filtered synthetic accelerations with PA intensity.[12] Participants were guided to wear the accelerometer on their waist for at least seven consecutive days—except when sleeping or during water-based activities. To be included in the study, participants needed to wear the accelerometer for ≥4 days (including one weekend day), with at least 10 hours/day of wear time each day.[14] Non-wear time was defined as at least consecutive 60 min of 0 count value per minute (cpm), with allowance for up to 2 min of some limited movement (<50 cpm).[14] The daily average time spent on SB (≤1.5 METs), LIPA (>1.5 to <3.0 METs) and MVPA (≥3.0 METs) were calculated. These MET levels have been used by previous studies examining functional decline among older adults.[15 16]

Depression was assessed using the Japanese language version of the 15-item Geriatric Depression Scale (GDS-15).[17] The GDS-15 questionnaire includes 15 questions about participants' feelings in the past week. For example, 'Do you often get bored? Yes/No'. The score ranges from 0 to 15: higher scores indicated stronger depression tendency. The GDS-15 has been widely used to assess depression symptom among older adults all over the world. In this study, the reliability of the GDS-15 (Cronbach's alpha) was 0.81.

The following individual-level variables were considered as covariates: gender, age, body mass index, physical function, marital status, and educational attainment. Body mass index was objectively calculated by measuring the participants' height and weight. Physical function was assessed using the Japanese language version of the Medical Outcomes Survey Short Form-8 questionnaire.[18]

Statistical analysis
We tested the assumption that replacing SB with PA on may contribute to better older adults' depression. First, we confirmed that there are linear associations between PA, SB, and depression score; and there was also no multicollinearity between the independent variables. And then, three multiple linear regression models including a single-activity, a partition, and an IS model were conducted to examine the associations of SB, LPA, and MVPA with depression. Since a 30 min was used as a unit for activity, the IS models assessed the effect of replacing a 30 min of one activity with the equal time of another activity. Several previous studies using IS model have examined the effects of replacing a 30 min[5 8] or a 60 min[6 7] unit of SB with equal time of LPA or MVPA on various health outcomes. From the viewpoint of feasibility, replacing 60 min a day may be difficult for older adults.[19 20] Therefore, we chose the replacing 30 min in this study. The single-activity model analysed each activity component separately (eg, SB only) without considering the other activity types, adjusting for total wear time and covariates. The model (in the case of SB) is shown as follows:

The GDS-15 score = (b0) SB + (b3) total wear time + (b4) covariates.

The partition model analysed all the activities simultaneously, without adjusting for total wear time. It is shown as below:

The GDS-15 score = (b0) SB + (b1) LPA + (b2) MVPA + (b4) covariates.

The coefficient for one type of activity represents the effect of increasing this type of activity while holding the other activities constant in this model. The model represents the effects of adding rather than substituting an activity type, because the total wear time is not included in the model (thus is not held constant).

The IS model assessed the effect of substituting one activity type with another for the equal amount of time (eg, replacing LPA with SB, by removing SB from the model). The IS model (in the case of omitting SB from the model) is shown as follows:

Table 1	Characteristics of study participants	
		n or M (SD), %
Gender		
Women	105	38.0%
Age (years)	74.4	5.3
Body mass index (kg/m^2)	23.5	3.2
Physical function	49.7	5.3
Marital status		
Married	228	82.6%
Educational attainment		
University, junior college, vocational school or higher level degree	109	39.5%
Total accelerometer wear time (min/day)	902.9	86.7
SB (min/day)	524.6	113.3
LPA (min/day)	328.8	101.3
MVPA (min/day)	50.0	32.8
GDS-15 score	2.8	3.0

SB, sedentary behaviour; LPA, light-intensity physical activity; MVPA, moderate-to-vigorous physical activity; GDS-15, 15-item Geriatric Depression Scale.

The GDS-15 score = (b1) LPA + (b2) MVPA + (b3) total wear time + (b4) covariates.

The coefficients b1 and b2 in this model represent the effect of a 30 min substitution of SB with one of the activity types (LPA or MVPA), while holding the other activity types and total wear time constant. For instance, b1 can be interpreted as the effect of replacing SB with LPA for 30 min, while holding MVPA and total wear time constant.

All analyses were conducted using IBM SPSS Statistics V.20.0 for Windows (IBM Japan) and the level of significance was set at p<0.05.

Patient and public involvement statement

Patients and public were not involved in developing the hypothesis, the specific aims or the research questions, nor were they involved in developing plans for design or implementation of the study.

RESULTS

Of 349 participants, data from 276 participants (171 men, 105 women) were analysed after excluding those with missing data; missing depression (4%) and covariates (0%–3.7%) and lacking valid PA accelerometer data (12.6%). There were no significant differences in the rate of gender and the mean of age between analysis sample and those with missing data.

Table 1 shows the characteristics of study participants. The mean number of valid days of participant's wearing accelerometer was 7.2 days (SD=0.9). On average, participants wore accelerometers for 15 hours/day. The mean proportion of SB, LPA, and MVPA times to total accelerometer wearing time were 58%, 36%, and 6%, respectively. Correlation coefficients were −0.68 between SB and LPA, −0.34 between SB and MVPA, and 0.21 between LPA and MVPA. Table 2 shows the results for the single activity, partition and IS models with adjusting for covariates. The single-activity model shows that LPA was significantly and favourably associated with the GDS-15 score (β=−0.138, p<0.05), and SB was significantly and positively associated with the GDS-15 score (β=0.129, p<0.05). The partition model showed no significant associations between all activities with the GDS-15 score. The IS model showed that a 30 min unit of SB replaced with LPA to be significantly and negatively associated with the GDS-15 score (β=−0.131, p<0.05).

DISCUSSION

This study examined how objectively measured SB, LPA and MVPA are associated with depression among Japanese older adults, and how replacing these behaviours may influence depression. Although many studies suggested that PA has favourable effects on depression in both clinical and non-clinical population,[21–23] there is currently no consensus regarding the optimal amount of PA needed

Table 2	The associations of SB, LPA and MVPA with depression					
	SB		**LPA**		**MVPA**	
	β	95% CI	β	95% CI	β	95% CI
Single-activity model	0.129	(0.015 to 0.243)*	−0.138	(−0.265 to −0.011)*	−0.173	(−0.530 to 0.184)
Partition model	0.101	(−0.031 to 0.233)	−0.030	(−0.184 to 0.124)	−0.011	(−0.390 to 0.367)
Isotemporal model						
Replace SB with	Dropped		−0.131	(−0.260 to −0.002)*	−0.113	(−0.473 to 0.247)
Replace LPA with	0.132	(0.003 to 0.261)*	Dropped		0.020	(−0.383 to 0.422)
Replace MVPA with	0.118	(−0.242 to 0.477)	−0.013	(−0.395 to 0.361)	Dropped	

All models adjusted for gender, age, body mass index, physical function, marital status, educational attainment, and total accelerometer wear time.
β=Regression coefficients correspond to a 30 min increment of each activity.
*P<0.05.
SB, sedentary behaviour; LPA, light-intensity physical activity; MVPA, moderate-to-vigorous physical activity.

to treat depression.[10] We found less SB and more LPA to be negatively associated with older adults' depression in a single-activity model (including total time held constant). Our findings are consistent with some recent studies that demonstrated the favourable effects of LPA or reducing SB on depression for older adults.[4 24 25]

In contrast with some previous studies,[26] we did not find any favourable effects of MVPA on depression in the three multiple linear regression models. This may be because of the age group (older adults), which was targeted in the current study. While relatively consistent effects of MVPA on depression among children and adults were reported by previous studies,[26] there are mixed findings among older adults.[27] For example, a randomised controlled trial study with a large sample aged 18–71 years reported that the mean reduction in depression scores were significantly larger in the physical exercise and internet-based cognitive–behavioural therapy groups compared with treatment as usual.[28 29] Furthermore, they compared the effects of different exercise intensities on post-treatment depression severity and found although there were no significant differences among light exercise, moderate exercise and vigorous exercise groups at post-treatment; the light exercise group reduced their depression score more than the moderate and vigorous exercise groups.[30] Jung *et al* found that LPA was favourably associated with preventing depressive symptoms among older adults, but MVPA was not.[27] Nevertheless, our findings showed that replacing SB with LPA had beneficial effects on older adults' depression. We found that replacing only 30 min of SB with the equal time of LPA during one day was associated with approximately 5% less depression score. Since our participants were relatively healthy, we did not consider the clinical meaning of decreasing depression score. However, a 5% reduction in depression score leads to 14 out of 62 people with a depression tendency (GDS score is over 5 point) return to normal range (GDS score is from 0 to 4 point). Currently, the evidence based for the prescription of different PA and exercise intensities for depression is weak.[30] For older adults including physical frail people, however, our results may suggest that it will be effective to reduce SB time and increase LPA that accounts for a large proportion of activities in a daily life in order to decrease depression. Among older adults, it may be more practical to increase 30 min of LPA per day compared with MVPA.

This study has some limitations. The cause-and-effect relationship between SB, PA, and depression cannot be inferred from a cross-sectional study. In addition, our findings may not be generalisable to the Japanese population; as relatively healthy, active, and well-educated older adults participated in this study. Thus, we suggest that future intervention studies, such as randomised controlled trial studies, using a larger sample size and including frailer individuals, are needed to provide a more definitive interpretation of the present findings. Furthermore, the context and type of SB was not assessed in this study. SB consists of different types: passive sedentary time (eg, television

viewing and just sitting) and mentally active sedentary time (eg, computer use and reading).[31 32] Several recent studies have shown that these different types of SB may be differently associated with health outcomes including mental health.[31 33] Such a coexistence of different types of SB may play a role in the observed associations in this study. Further research is needed to explore the effects of replacing different types of SB with LPA and MVPA on depression symptoms. In addition, previous PA levels and exercise participation of participants (i.e., the amount of PA in the past 12 months) were not considered in this study. It is likely that previous amount of PA may affect the current depression status.[34] The strength of this study is the use of accelerometers to objectively measure participants' SB and active behaviours.

CONCLUSION

Our findings indicated that replacing even small amounts of SB (e.g., watching television and sitting at a desk) with LPA (e.g., indoor housework and slow walking) are associated with less depression among older adults. Potential favourable effects were identified for replacing only 30 min per day of SB with LPA. These findings are useful in promoting mental health among older adults with better compliance, lower risk of injuries, and long-term sustainability.

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