Prospective relationship between objectively measured light physical activity and depressive symptoms in later life

Running title: Objectively measured light physical activity and depressive symptoms

Submission to *International Journal of Geriatric Psychiatry*

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Word count: 2,734 (without including tables and references); abstract: 245

Number of tables: 4

The authors declare no conflicts of interest

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Abstract

Background: The use of self-report measures of physical activity is a serious methodological weakness in many studies of physical activity and depressive symptoms. It is still equivocal whether light physical activity protects older adults from depressive symptoms.

Objective: This study aimed to explore whether objectively measured light physical activity, independent of sedentary and moderate-to-vigorous activity, is associated with a reduced risk of subsequent depressive symptoms in older adults.

Methods: This was a two-year prospective cohort study. A total of 285 community-dwelling older adults aged 65 or older were interviewed in 2012. A second wave of assessment was carried out in 2014 involving 274 (96.1%) participants. Time spent in physical activity at different intensities was assessed using tri-axial accelerometers. Depressive symptoms were measured using the 15-item Geriatric Depression Scale. Negative binomial regression models with adjustment for baseline depressive symptoms, accelerometer wear time, socio-demographic variables, lifestyle behaviors, and chronic disease conditions, were conducted.

Results: Time spent in moderate-to-vigorous and light physical activities were both inversely related to depressive symptoms at follow-up. Sedentary time was associated with an increased risk of subsequent depressive symptoms. When sedentary or moderate-to-vigorous activity were included in the multivariable adjusted regression models with light physical activity simultaneously, only light physical activity remained significant. Sensitivity analyses for assessing confounding and reverse causation provided further support for the stability of these findings.

Conclusion: Light physical activity, independent of sedentary and moderate-to-vigorous activity, is associated with a reduced risk of subsequent depressive symptoms in later life.

Key words: Exercise, Depression, Longitudinal, Accelerometer, Objective measure

Introduction

Depression is a common mental problem, characterized by sadness, diminished interest or pleasure, fatigue or loss of energy, disturbed sleep or appetite, feelings of worthlessness or inappropriate guilt, and poor concentration (American Psychiatric Association 2013). It is a leading cause of disability worldwide and is an important contributor to the overall global burden of disease (Ferrari, *et al.* 2013). A systematic review of depression in later life estimated a pooled prevalence for major depression of 7.2% and 17.1% for depressive symptoms (Luppa, *et al.* 2012). Although depression is less prevalent in older adults than in younger adults, it may lead to serious consequences such as increased risk of morbidity and mortality, decreased physical, cognitive and social functioning, and greater self-neglect (Blazer 2003; Fiske, *et al.* 2009). This underscores the need to identify correlates or determinants such as modifiable lifestyle behaviors that can prevent or delay the onset of depressive disorders among aging populations.

Systematic reviews and meta-analyses of prospective studies suggest that there is an inverse relationship between physical activity and depression/depressive symptoms in older adults (Mammen and Faulkner 2013). However, the use of self-report measures of physical activity is a serious methodological weakness in many studies. Although self-report instruments are easy to administer and are inexpensive, they may be subject to recall bias. Self-report questionnaires may be not sensitive to age, culture, and ethnicity. Additionally, these measures tend to have acceptable reliability (> 0.7) but only low to moderate validity as assessed against accelerometer assessments (Murphy 2009).

International physical activity guidelines recommend that older adults should do at least 150 minutes of moderate-intensity aerobic physical activity throughout the week or do at least 75 minutes of vigorous intensity aerobic physical activity throughout the week or an equivalent combination of moderate- and vigorous-intensity activity (World Health Organization 2010). This appears to imply that little or no health benefits can be derived from light physical activities (e.g. walking slowly, lifting lightweight objects, household chores, yoga, and Tai Chi etc.). However, these recommendations are mainly based on large-scale epidemiologic studies of self-reported physical activity in relation to all-cause mortality and cardiometabolic factors such as cardiovascular disease, type 2 diabetes, and measures of blood pressure, lipid, glucose and insulin (Lee and Shiroma 2014). They are not based on mental health outcomes. One cross-sectional study has demonstrated that objectively assessed light physical activity is associated with a reduced risk of depressive symptoms among older adults, but it did not adjust statistically for moderate-to-vigorous physical activities (Loprinzi 2013). To date, there have been no longitudinal studies examining whether objectively measured light physical activity, independent of moderate-to-vigorous physical activity, is prospectively related to a decreased risk of subsequent depressive symptoms at older ages.

To fill this gap in literature, our study explored whether objectively assessed light physical activity, independent of other intensities of physical activity, was prospectively associated with depressive symptoms among community-dwelling older adults in Taiwan over a 2-year follow-up period. We also included potentially confounding factors in multivariable analyses, and conducted sensitivity analyses to test for confounding and reverse causation.

Methods

Study design and sample

A total of 285 community-dwelling older adults aged 65 or older (mean age= 74.5 years, SD= 6.1 years) were recruited and assessed from August to October 2012 in Hunei District, Kaohsiung, which is the second largest city in Taiwan. Of the 14 villages in the district, approximate 20 participants were recruited from each community center at each village using quota sampling (national distribution of population according to sex and age in 2011) (Taiwan Ministry of Interior 2012). The data were collected through standardized household face-to-face interviews and accelerometry. Of the initial sample, 274 (96.1%) attended the second-wave interviews from May to July 2014 (mean follow-up time= 22.1 ± 1.5 months). All participants provided written consent at the time of enrollment. Ethical approval for this study was provided from National Taiwan University of Sport Institutional Review Board, Taiwan.

Measures

Depressive symptoms

The 15-item Geriatric Depression Scale (GDS) was utilized to assess depressive symptoms with a potential range of 0 to 15 (Brink, *et al.* 1982; Yesavage and Sheikh 1986). The Chinese version of this scale has demonstrated adequate reliability and validity among community-dwelling older adults in Taiwan (Liu, *et al.* 1997; Wong, *et al.* 2002). The Cronbach's alpha reliability coefficients for the 15-item GDS ranged between 0.74 and 0.84 in the two waves of data collection.

Time spent in physical activity at different intensities

Time spent in physical activity at different intensities was objectively measured using waist worn triaxial accelerometer monitors (GT3X+, ActiGraph, Pensacola, FL, USA) for 7 days. Participants were required to wear the sensor at least 10 hours of monitoring on at least 5 days (Buman, *et al.* 2010). Data were analyzed and scored using the ActiLife 6.2 software. Periods of 60 min of consecutive zero counts were considered as non-wearing time and were excluded from the analyses. Several physical activity parameters were then created, including time spent in sedentary behaviors (<100 counts/min), light physical activity (100–1951 counts/min), and moderate-to-vigorous activity (>1951 counts/min) (Gorman, *et al.* 2014), together with total physical activity energy expenditure (kcal/week). For descriptive purposes, the various physical activity categories were each divided into tertiles, but the primary analyses were conducted on continuously distributed variables.

Covariates

The following factors in the 2012 baseline survey were incorporated as covariates according to previous work (Mammen and Faulkner 2013): (i) socio-demographic factors: sex, age (< 75, 75+), educational attainment (no formal schooling, primary school, secondary school+), marital status (married/cohabitating, others), main source of income (from offspring vs. self [e.g. pension/savings]); (ii) lifestyle behaviors: smoker (current, never, or former smokers), alcohol consumption (yes vs. no), and; (iii) health status: body mass index (BMI) (<18.50, 18.50-23.99, 24-26.99, 27+) (Taiwan Department of Health 2003), number of chronic diseases (0, 1, 2+): Participants were presented with a list of chronic conditions (i.e. hypertension, stroke, diabetes, heart disease, cancer, chronic obstructive pulmonary disease (COPD), liver disease, renal disease, and arthritis) and were asked to indicate whether they have been diagnosed with each condition by a clinician. The total number of self-reported chronic conditions were then computed; difficulties with activities of daily living (ADLs, no difficulties at all vs. some or great difficulties); insomnia measured by the Athens Insomnia Scale (no vs. yes) (Chiang, *et al.* 2009); cognitive impairment assessed using the mini mental status examination (MMSE). Cut-off points of cognitive impairment were the scores of the MMSE < 14 for those with no formal schooling, and MMSE< 24 for those with primary school level or higher (Guo, *et al.* 1988); mean daily accelerometer wear time (Hamer, *et al.* 2014), and baseline depressive symptoms scores.

Data analysis

Descriptive statistics were used to describe the features of the study sample. Given the violation of normality, Mann Whitney U tests and Kruskal-Wallis tests were adopted to check for differences in depressive symptom scores in 2014 across levels of accelerometer-derived parameters (all in tertiles), and covariates. Variables with a *p* value less than 0.25 were included in the subsequent regression models for adjustment (Hosmer, *et al.* 2013).

To examine the crude correlations between objectively assessed physical activity parameters and subsequent depressive symptoms after controlling for accelerometer wear time, partial Spearman correlation coefficients between physical activity energy expenditure (kcal/week as a continuous variable), time (hours/day as a continuous variable) spent in physical activity at different intensities, and subsequent depressive symptoms were computed.

To assess the adjusted associations between physical activity parameters and subsequent depressive symptoms, multivariable negative binomial regression was conducted because the outcome variable was an over-dispersed count with a highly skewed distribution. All accelerometer-derived parameters were log-transformed before conducting regression analyses due to non-normality (Tudor-Locke, *et al.* 2011). Three separate wear time-adjusted regression models (single-factor models) for sedentary, light, and moderate-to-vigorous activity were conducted to assess the associations between each intensity categories and depressive symptoms. Then, two wear time-adjusted regression models (two-factor models) for moderate-to-vigorous and light activity, and sedentary and light activity respectively were fitted to examine the relationships in more detail. To avoid multi-collinearity, time spent in moderate-to-vigorous, light, and sedentary behaviors were not entered into the models at the same time because accelerometer wear time is equal to the sum of these behaviors.

Sensitivity analyses were carried out to evaluate confounding and reverse causation. Firstly, we considered the possibility that ADL difficulties might influence physical activity behaviors at baseline and subsequent depressive symptoms, so the negative binomial regressions were repeated after excluding the 13 participants with impaired ADLs. Secondly, we mitigated the potential impact of prodromal cognitive deterioration on physical activity and depressive symptoms at baseline by excluding participants with cognitive impairment (n= 34) at baseline (Guo *et al.* 1988).

Multicollinearity was checked using multiple linear regression (i.e., variance inflation factor value > 5 or tolerance value < 0.2) (Belsley*, et al.* 1980; de Vaus 2002), and the results indicate that this was not a problem in these regression models. All analyses were conducted using IBM SPSS 20.0 software and a p value < 0.05 was considered statistically significant.

Results

Characteristics of the sample

The differences in depressive symptoms at follow-up categorized by baseline characteristics are presented in Table 1. Individuals who had lower levels of depressive symptoms in 2014 were more likely to male, alcohol drinkers, and have mild or no comorbidities, cognitive impairment, or depressive symptoms at baseline (p<0.05). Overall, participants spent 8.72 ± (SD) 3.08

hour/day in sedentary activities, 3.75 ± 1.74 hour/day in light intensity activity, and 0.16 ± 0.62 hour/day in moderate-to-vigorous intensity physical activity. Participants with fewer depressive symptoms in 2014 had higher levels of total physical activity energy expenditure and spent more time in moderate-to-vigorous and light physical activity than those who were less active in 2012.

Table 1 here

Spearman's correlations between physical activity and subsequent depressive symptoms

Physical activity energy expenditure (ρ= -0.38) and time spent in moderate-to-vigorous (ρ= -0.24), and light physical activities (ρ= -0.30) were all inversely associated with subsequent depressive symptoms, whereas sedentary time (ρ= 0.27) was positively related to depressive symptoms ($p < 0.001$). Overall, the magnitude of associations between physical activity parameters and depressive symptoms were small-to-moderate.

Multivariable adjusted associations between physical activity and subsequent depressive symptoms

The multivariable adjusted regression (single-factor models) showed that participants who spent more time in physical activity at moderate-to-vigorous (Rate Ratio [RR] = 0.88, 95% CI= 0.79-0.98) or light intensities (RR = 0.63, 95% CI= 0.49-0.82) had fewer depressive symptoms at follow-up. In contrast, individuals engaging in more sedentary behaviors had higher levels of subsequent depressive symptoms (RR = 2.45, 95% CI= 1.16-5.15). (See Table 2)

Table 2 here

When moderate-to-vigorous physical activity and light physical activity were both included in the two-factor model, only light physical activity remained significant. Similarly, light physical activity was a stronger predictor of subsequent depressive symptoms than sedentary time in the second two-factor model. (See Table 3)

Table 3 here

Sensitivity analysis

The sensitivity analyses are detailed in Table 4. The association patterns for the single-factor models or the two-factor models were similar to those in Table 3 after excluding participants with ADL difficulties. Although the sample size quite markedly reduced after further excluding those with cognitive impairment, the patterns of associations did not alter very much. In each stage, greater light physical activity was associated with fewer depressive symptoms at follow-up.

Table 4 here

Discussion

This two-year study revealed that time spent in moderate-to-vigorous and light physical activities were both inversely related to depressive symptoms. In contrast, more sedentary time was associated with higher levels of subsequent depressive symptoms. Additionally, when sedentary or moderate-to-vigorous activity was entered into the multivariable adjusted regression models with light activity simultaneously, only light physical activity remained significant. These prospective results were verified even when adjusting for underlying covariates, including baseline depressive symptoms, chronic disease conditions, and accelerometer wear time. Sensitivity analyses for scrutinizing confounding and reverse causation provided further evidence for the stability of these findings.

Although self-report physical activity instruments are cost-effective, they are more reliable and valid for assessing moderate-to-vigorous intensity instead of light-intensity activities. Epidemiological studies based on self-reports have tended to focus on their measures of moderate-to-vigorous activities (Lee and Shiroma 2014). Unfortunately, the use of different self-report instruments may yield conflicting results (Teychenne, *et al.* 2008) and restrict the capacity to assess the relations between physical activity at different intensities and depressive symptoms (Mammen and Faulkner 2013).

There is currently no evidence on the longitudinal relationship between objectively measured light physical activity and depressive symptoms in older adults. The present study indicated that the associations were stronger for light activity than for moderate-to-vigorous activity. This supports earlier prospective work suggesting that light-intensity physical activity is a stronger predictor of mental well-being than moderate-to-vigorous physical activity in older adults (Buman *et al.* 2010). Compared with light activity, relatively fewer older people engage in moderate/vigorous activity. This might in part explain the weaker associations between moderate/vigorous activity and depressive symptoms. An alternative explanation is that light physical activity may be more beneficial for mental health because more discomfort and short of breath may be generated while engaging in moderate/vigorous physical activity (Hamer *et al.* 2014), especially in older people.

This is an observational study, so cannot establish causality. However, the beneficial effect of light physical activity on mental health in older populations has been observed in intervention studies as well. Several studies have been carried out, with the greatest improvements in mood being associated with light intensity exercise among older adults (Arent, *et al.* 2000). Another systematic review of randomized controlled trials in older adults suggested that two sessions per week of ‘light to moderate’ intensity each of a minimum of 45 min duration were more appropriate for improving older adults’ subjective well-being than more intense moderate-to-vigorous activity (Windle, *et al.* 2010). Given the problems of motivation and adherence to moderate-to-vigorous activity in older populations (Sparling, *et al.* 2015), light physical activity may be more feasible and help people achieve mental health benefits.

Sedentary behaviors are prevalent among older populations, and are increasingly regarded as a serious threat to healthy aging (de Rezende, *et al.* 2014). Our study showed that sedentary time is related to an increased risk of depressive symptoms, which is consistent with the findings from previous work (Teychenne, *et al.* 2010). We further assessed the independent associations of sedentary and light activity with depressive symptoms. The results revealed that light activity is a stronger correlate of depressive symptoms than sedentary behaviors. This highlights the importance of reducing sedentary behaviors by introducing light activity throughout the day for improving older adults' mental health.

To our knowledge, this is the first study documenting the prospective associations between objectively assessed light physical activity and depressive symptoms in older adults. Although this research was conducted adjusting for multiple potential confounders and included sensitivity analyses to address other influences on outcomes, it inevitably has some limitations. First, this study was based on community-dwelling older adults using a sex-age quota sampling and an excellent response rate on follow-up, but there may still be problems of sample representativeness. Compared with a previous study using the Taiwan National Health Interview Survey, we found there were no significant differences in terms of education level, but that participants in the current study had less cognitive impairment (Ku*, et al.* 2012), less difficulty in ADL and fewer chronic conditions (data not shown) (Chen*, et al.* 2012). Because inactivity and depressive symptoms may be less prevalent in this healthier subgroup of the population, potential selection bias may have led to underestimation of the association between physical activity and depressive symptoms. A well-designed longitudinal study using a nationally representative sample is warranted to verify this association and compare the effects of light physical activity on subsequent depressive symptoms among those with physical limitations, cognitive impairment, and multiple chronic conditions. Furthermore, this research cannot establish causality given that it is an observational study. The average amount of moderate-to-vigorous physical activity was small, and restricted variability may have limited the scope for identifying associations with depressive symptoms.

In sum, this study expands our understanding of how time spent in physical activity at different intensities is related to depressive symptoms in older adults. It presents evidence that light physical activity, independent of sedentary and moderate-to-vigorous activity, is associated with a reduced risk of subsequent depressive symptoms. This extends the existing evidence for the benefits of physical activity for disease prevention and improvement of mental well-being.

Acknowledgements

The authors declare no conflicts of interest and acknowledge funding support from Taiwan Ministry of Science and Technology (MOST 105-2628-H-018-001-MY2)

Conflict of interest: The authors do not have any conflict of interest to report.

Ethics statement: Ethics approval for this study was obtained from National Taiwan University of Sport Institutional Review Board, Taiwan (NTUPES-HSC-100-09).

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Table 1 Characteristics of participants in 2012 with depressive symptoms in 2014

Variables in 2012	n (%)	Depressive Symptoms in 2014 (Mean ± SD)	*p*-value[a]
Socio-demographic			
Sex			0.014
Male	125 (45.6)	2.02 (2.01)	
Female	149 (54.4)	2.83 (2.91)	
Age			0.085
< 75	156 (56.9)	2.29 (2.39)	
75+	118 (43.1)	2.69 (2.78)	
Education level			0.353
Secondary school+	48 (17.6)	1.79 (1.32)	
Primary school	113 (41.2)	2.45 (2.45)	
No formal schooling	113 (41.2)	2.76 (3.01)	
Marital status			0.645
Married	192 (70.1)	2.33 (2.28)	
Others	82 (29.9)	2.77 (3.12)	
Main source of income			0.187
Offspring	139 (50.7)	2.23 (2.24)	
Self (pension/savings)	135 (49.3)	2.70 (2.85)	
Lifestyle behaviors			
Total energy expenditures (kcal/week)			< 0.001
High	92 (33.6)	1.61 (1.61)	
Medium	91 (33.2)	2.25 (2.36)	
Low	91 (33.2)	3.54 (3.13)	
Moderate-to-vigorous PA (hour/day)			< 0.001
High	92 (33.6)	1.76 (1.82)	
Medium	88 (32.1)	2.26 (2.14)	
Low	94 (34.3)	3.34 (3.24)	
Light PA (hour/day)			<0.001
High	93 (33.9)	2.04 (2.47)	
Medium	91 (33.2)	2.16 (2.15)	
Low	90 (32.9)	3.20 (2.90)	
Sedentary time (hour/day)			0.528

Low	89 (32.5)	2.54 (2.76)	
Medium	92 (33.6)	2.33 (2.52)	
High	93 (33.9)	2.53 (2.45)	
Smoking			0.576
Current smoker	22 (8.0)	2.00 (1.60)	
Never smoker	238 (86.9)	2.49 (2.66)	
Former smoker	14 (5.1)	2.79 (2.26)	
Drinking			0.012
Yes	13 (4.7)	1.31 (1.49)	
No	261 (95.3)	2.52 (2.60)	
Health Status			
Body mass index			0.596
Underweight <18.5	11 (4.0)	2.55 (2.34)	
Normal 18.5-23.99	101 (36.9)	2.58 (2.41)	
Overweight 24-26.99	101 (36.9)	2.45 (2.84)	
Obese 27+	61 (22.2)	2.28 (2.44)	
Number of chronic diseases			0.019
0	118 (43.0)	1.94 (1.83)	
1	104 (38.0)	2.79 (2.66)	
2+	52 (19.0)	3.00 (2.49)	
Insomnia			0.058
No	225 (82.1)	2.28 (2.36)	
Yes	49 (17.9)	3.33 (3.24)	
Activities of daily living			0.003
No difficulty at all	261 (92.3)	2.37 (2.51)	
Some or great	13 (7.7)	4.31 (3.04)	
Cognitive impairment			0.001
No	240 (87.6)	2.30 (2.44)	
Yes	34 (12.4)	3.65 (3.14)	
Baseline depressive symptoms in 2012	274 (100.0)	ρ= 0.19[b]	0.001[b]

a: Mann Whitney U test or Kruskal-Wallis test

b: Spearman's correlation

Table 2 Multivariable adjusted regression of the single-factor models examining the independent effects of time spent in different intensities of physical activity at baseline on subsequent depressive symptoms (n=274)

Variables	Single-factor models[a]					
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Physical activity						
MVPA	0.88 (0.79-0.98)	0.021				
LPA			0.63 (0.49-0.82)	< 0.001		
Sedentary					2.45 (1.16-5.15)	0.019
Covariates						
Sex (male vs. female)	0.89 (0.65-1.21)	0.45	0.78 (0.56-1.06)	0.12	0.80 (0.58-1.10)	0.17
Age (<75 vs. 75+)	1.00 (0.74-1.36)	0.98	1.08 (0.80-1.47)	0.61	1.00 (0.74-1.34)	0.98
Income source (offspring vs. self)	0.94 (0.69-1.27)	0.67	0.99 (0.73-1.35)	0.97	0.97 (0.71-1.32)	0.85
Drinking (yes vs. no)	0.61 (0.28-1.35)	0.23	0.60 (0.27-1.33)	0.21	0.58 (0.26-1.29)	0.19
Number of diseases						
0 (vs. 2+)	0.72 (0.48-1.09)	0.12	0.89 (0.58-1.35)	0.57	0.80 (0.53-1.20)	0.28

1 (vs. 2+)	0.93 (0.61-1.40)	0.71	1.06 (0.70-1.60)	0.78	0.97 (0.65-1.47)	0.90
Insomnia (no vs. yes)	0.72 (0.49-1.05)	0.09	0.69 (0.47-1.02)	0.07	0.71 (0.48-1.05)	0.09
ADL difficulty (no vs. yes)	0.58 (0.29-1.17)	0.13	0.64 (0.32-1.27)	0.20	0.63 (0.32-1.26)	0.19
Cognitive impairment (no vs. yes)	0.83 (0.53-1.29)	0.40	0.85 (0.54-1.33)	0.48	0.81 (0.52-1.26)	0.35
Accelerometer wearing time	0.96 (0.91-1.01)	0.15	0.98 (0.93-1.04)	0.46	0.88 (0.81-0.95)	0.002
Baseline depressive symptoms	1.07 (1.00-1.14)	0.04	1.07 (1.00-1.13)	0.04	1.08 (1.01-1.14)	0.02

RR= rate ratio; MVPA= moderate-to-vigorous physical activity; LPA= light physical activity, ADL= activities of daily living

a: The three single-factor models represent the association of each intensity category (MVPA, LPA, and sedentary time) with depressive symptoms without mutual adjustment for other categories of activity

Table 3 Multivariable adjusted regression of the two-factor models examining the independent effects of time spent in different intensities of physical activity at baseline on subsequent depressive symptoms (n=274)

Variables	Two-factor models[a]			
	RR (95% CI)	*p*	RR (95% CI)	*p*
Physical activity				
MVPA	0.94 (0.84-1.05)	0.288		
LPA	0.67 (0.51-0.88)	0.004	0.66 (0.48-0.91)	0.011
Sedentary			1.20 (0.47-3.08)	0.703

RR= rate ratio; MVPA= moderate-to-vigorous physical activity; LPA= light physical activity

Covariates in two models: baseline depressive symptoms, sex, age, income, alcohol consumption, number of chronic diseases, activities of daily living, insomnia, and cognitive impairment

a: The two-factor models further adjusted for MPVA (or sedentary time) for LPA.

Table 4 Sensitivity analyses of the single-factor and two-factor regression models examining the independent effects of time spent in different intensities of physical activity at baseline on subsequent depressive symptoms

Physical activity	Single-factor models[a]		Two-factor models[b]			
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Stage 1: Excluding participants with ADL difficulties at baseline (n= 261)						
MVPA	0.88 (0.78-0.98)	0.018	0.93 (0.83-1.05)	0.239		
LPA	0.62 (0.47-0.82)	< 0.001	0.66 (0.50-0.88)	0.004	0.65 (0.47-0.91)	0.011
Sedentary	2.55 (1.18-5.49)	0.017			1.25 (0.48-3.27)	0.651
Stage 2: Excluding participants with ADL difficulties and cognitive impairment at baseline (n= 233)						
MVPA	0.89 (0.78-1.00)	0.040	0.95 (0.83-1.07)	0.375		
LPA	0.59 (0.43-0.80)	< 0.001	0.62 (0.44-0.86)	0.004	0.61 (0.40-0.92)	0.018
Sedentary	2.84 (1.25-6.41)	0.012			1.15 (0.38-3.46)	0.798

RR= rate ratio; MVPA= moderate-to-vigorous physical activity; LPA= light physical activity

Covariates in all models: baseline depressive symptoms, sex, age, income, alcohol consumption, number of chronic diseases, activities of daily living, insomnia, and cognitive impairment

a: The three single-factor models represent the association of each intensity category (MVPA, LPA, and sedentary time) with depressive symptoms without mutual adjustment for other categories of activity

b: The two-factor models further adjusted for MPVA (or sedentary time) for LPA.