

Effects of Marital Status and Physical Activity on Depressive Symptoms among Older Adults in South Korea

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Background: Depression in older adults is increasing worldwide with marital status and physical activity recognized as factors that influence depression among older adults. This study examines the association of marital status and physical activity with depressive symptoms in older adults.

Methods: This study employed data collected by the Korea National Health and Nutrition Examination Survey (KNHANES) in 2014, 2016, and 2018. The respondents comprised 4,134 individuals aged 65 years or older. The study used logistic regression to analyze the association of physical activity and marital status to depressive symptoms.

Results: Out of 4,134 respondents, 318 reported depressive symptoms. The study noted the risk of depressive symptoms was 1.39 times higher for those without a spouse than those with a spouse (women: odds ratio=1.39; 95% confidence interval=1.02-1.88). No association was found between physical activity and depressive symptoms. However, the risk of depressive symptoms was 1.75 times higher among physically active respondents without a spouse than those physically active with a spouse. In particular, the risk of depressive symptoms was approximately 2.57 times higher in physically active but spouseless men compared with the reference group, but the association is statistically nonsignificant.

Conclusion: Although the study does not confirm a significant association between physical activity and depressive symptoms in older adults, it verifies that marital status exerts an impact on depressive symptoms among older adults. Therefore, future studies should establish standards for physical activity and examine the effects of appropriate physical activity on depression among older adults.

Keywords: Depressive symptoms; Marital status; Physical activity; Older adults

INTRODUCTION

The prevalence of geriatric depression has continued to increase over time, with an estimated 13% of the older adult population suffering from geriatric depression [1]. Indeed, a significant proportion of older adults worldwide experience depressive symptoms [1]. With the growth of the older population in recent years, geriatric depression has become a major health concern among different ethnic groups [1,2]. Geriatric depression is strongly associated with increased mortality, suicidal thoughts, risk of chronic diseases, medical costs, and reduced quality of life [2,3]. While common in the older adults, depression is not a symptom of normal aging [4]. Depressive symptoms can be caused by grief associated with aging and marital status, including bereavement and/or loss of physical, social or cognitive functions [4,5]. Generally, geriatric depression is affected by a combination of physical and social factors.

Although medication and psychotherapy remain the primary treatments for depression, treatments targeting lifestyle behaviors are safer and more cost-effective [6]. In this respect, regular physical activity is a major behavioral factor in the prevention and treatment of depression. Indeed, research indicates a reduced prevalence of depression among older adults who regularly engage in physical activities compared with those who do not [7-9]. This is because physical activity involves psychological mechanisms, such as emotional function, which induce several neurochemical changes [10].

Marital status is also a major factor associated with depression in older adults [11]. Studies have shown that bereavement or divorce negatively affect the mental health of older adults, particularly among men, with loneliness often leading to depression [5,12,13]. Regardless of the differences between Eastern and

Western races or cultures, studies have uniformly observed a lower risk of depression among older adults living with their spouse [12-14].

The majority of studies have focused on the relationship between either marital status or physical activity and depressive symptoms [6-8]. However, few studies have investigated the effect of both physical activity and marital status on depressive symptoms in older adults. Therefore, this study examines various factors affecting geriatric depressive symptoms, namely, the combined state of physical activity and marital status, in older adults in South Korea.

METHODS

1. Study participants and database information

This study used cross-sectional raw data from the Korea National Health and Nutrition Examination Survey (KNHANES) of 2014, 2016, and 2018. The KNHANES is an epidemiological survey conducted by the Korea Centers for Disease Control and Prevention (KCDC) to monitor the health level, health behaviors, and nutrition of the South Korean population [15]. The present study was conducted after obtaining approval from the Institutional Review Board (IRB) of Eulji University (approval No. EUIRB2023-019). The survey was approved by the IRB of the KCDC (approval number 2013-12 EXP-03-05C for 2014, 2018-01-03-P-A for 2018). However, for the 2016 survey, the KNHANES was implemented without IRB review but in accordance with the Bioethics Act and Enforcement Rules. All participants signed an informed consent form attesting to their voluntary participation.

A total of 23,692 individuals participated in the 2014, 2016, and 2018 KNHANES. The KNHANES has assessed depressive symptoms using the self-administered Patient Health Questionnaire-9 (PHQ-9) biannually since 2014. This study initially included all

participants aged 65 years or older (n=4,871). However, after eliminating responses with missing data for marital status (n=37), physical activity (n=585), or PHQ-9 results (n=115), the sample comprised a total of 4,134 respondents.

2. Assessment of depressive symptom

Depressive symptoms were assessed using the PHQ-9, which is based on the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV) [16]. The PHQ-9 is a self-administered depressive symptom screening tool for measuring an individual's experience of major depressive symptom disorder in the two weeks prior [16]. The PHQ-9 comprises nine items rated on a four-point scale ranging from 0 ("never") to 3 ("nearly every day"). Item scores are summed to produce the total depressive symptom severity score, which ranges between 0-27 points, with 10 or more points defined as depressive symptoms [16]. The Korean version of the PHQ-9 shows high internal consistency, with a Cronbach's alpha of 0.86 [17].

3. Assessment of marital status and physical activity

Respondents' marital status was classified by "yes" (married) or "no" (unmarried, divorced, widowed, or separated).

Meanwhile, respondents' physical activity level was evaluated using the Global Physical Activity Questionnaire (GPAQ), which was developed by the World Health Organization (WHO) according to its physical activity guidelines [18]. Respondents were categorized into one of two groups: namely, active or inactive. The active group comprised those who performed at least 75 minutes of vigorous intensity aerobic activity per week, at least 150 minutes of moderate intensity physical activity per week, or a combination of moderate and vigorous intensity

activity (2 minutes of moderate intensity activity was considered equivalent to 1 minute of vigorous intensity activity); all others were classified as inactive.

4. Covariates

This study assessed the following covariates: gender, age (young-old: 65-74 years; old-old: ≥ 75 years), region (city/rural), education level (middle school or lower/high school or higher), occupation (yes/no), household income (discretized based on quartile), current smoking (yes/no), high-risk alcohol drinking (yes/no), self-rated health (good: fair, good, or very good; bad: poor or very poor). Current smoking was defined as having smoked 100 cigarettes or more (i.e., five packs) in their lifetime. High-risk alcohol drinking was defined as seven or more drinks for men and five or more for women twice or more per week. This study also assessed the number of chronic diseases (0, 1-2, or 3 or more) and type of chronic diseases, which were those investigated in the KNHANES, namely, dyslipidemia, diabetes, osteoarthritis, rheumatoid arthritis, asthma, hypertension, angina, myocardial infarction, stroke, and cancer. Cancer was defined as a participant currently having a diagnosis and treatment of any cancer type. The presence of each chronic disease was assessed by asking whether the participant had been diagnosed by a physician or was currently taking medication for the disease.

5. Statistical analysis

In terms of general characteristics, a chi-square test was used to assess differences by gender. The association between marital status, physical activity, and depressive symptoms was analyzed using odds ratios (ORs) and 95% confidence intervals (CIs) obtained using binary logistic regression analysis. This study also examined the combined association between marital status and physical activity and depressive symptom according to gender. All analyses were performed using

SAS software (ver. 9.4; SAS, Cary, NC, USA), with *p*-values <0.05 considered statistically significant.

RESULTS

Table 1 shows the prevalence of depressive symptoms by demographic characteristics and gender. Of the 4,134 older adults, 7.7% (n=318) had depressive symptoms. Regardless of gender, the prevalence of depressive symptoms was lowest among those who were married. Among those who were physically active, 6.3% (n=90) were depressed, while 8.4% (n=228) of those who were physically inactive were depressed. In terms of education level, 9.3% (n=282) of respondents had an education level below middle school, which increased to 11.6% (n=231) when stratified by women. Household income was divided into quartiles, prevalence of depressive symptom was highest among respondents in the first quartile, that is, the lowest income group, at 11.0% (n=214); when stratified by gender, 13.9% (n=167) of women in the first quartile had depressive symptoms.

Table 2 shows the results of the binary logistic regression analysis of the association between marital status, physical activity, and depressive symptom by gender, adjusted for age, education level, region, occupation, household income, current smoking, high-risk alcohol drinking, self-rated health, and chronic diseases. Results revealed a higher risk of depressive symptoms among older women who were not living with their spouse compared to those who were living with their spouse (OR=1.39; 95% CI=1.02-1.88). However, the association between physical activity and depressive symptoms was not statistically significant in either men (OR=1.03; 95% CI=0.61-1.74) or women (OR=0.91; 95% CI=0.66-1.26). In terms of household income level, older adults within the first (lowest income level) and second quartiles were 3.62, 2.56 times more likely to

experience depressive symptoms than those in the fourth quartiles (first quartile: OR=3.62, 95% CI: 1.80-7.27; second quartiles: OR=2.56, 95% CI=1.25-5.25). In respect to self-rated health, respondents who reported being in “bad” health showed higher risk of depressive symptoms than those reporting “good” health (OR=5.53; 95% CI=4.23-7.24). Older men affected by more than three chronic diseases had a higher risk of depressive symptoms than those who did not have any chronic diseases (OR=2.65; 95% CI=1.04-6.74).

Figure 1 summarizes the results of the analysis of the association between the combined factors of marital status and physical activity and depressive symptoms according to gender. This study used the combined categories of spouse and physical activity, spouse and physical inactivity, spouseless and physical activity, spouseless and physical inactivity, with spouse and physical activity as the reference group. Results showed a higher association between depressive symptoms and physically active but spouseless individuals (OR=1.75; 95% CI=1.10-2.81) compared to the reference group. Moreover, physically active but spouseless men had a higher risk of depressive symptoms physically active men who lived with their spouses, although not significantly (OR=2.57; 95% CI=0.98-6.71). However, combinations of marital status and physical activity were not significantly associated with depressive symptoms in women (see Appendix 1). Results confirmed that household income level had a significant effect on depressive symptoms in older adults; Appendices 2 and 3 presents the results of subgroup analysis by household income level. According to results, in the lowest income group, those not living with a spouse, women, and individuals with a low level of education had a higher risk of experiencing depressive symptoms.

Table 1. Demographic and socioeconomic factors according to depressive symptom

Variable	Depressive symptom														
	Total (n=4,134)					Men (n=1,812)					Women (n=2,322)				
	Yes (n=318)		No (n=3,816)		P	Yes (n=75)		No (n=1,737)		P	Yes (n=243)		No (n=2,079)		P
n	%	n	%	n		%	n	%	n		%	n	%		
Marital status															
Yes	163	5.8	2,652	94.2	<0.001	58	3.6	1,542	96.4	0.003	105	8.6	1,110	91.4	0.003
No	155	11.8	1,164	88.3		17	8.0	195	92.0		138	12.5	969	87.5	
Physical activity															
Active	90	6.3	1,334	93.7	0.02	25	3.3	729	96.7	0.14	65	9.7	605	90.3	0.44
Inactive	228	8.4	2,482	91.6		50	4.7	1,008	95.3		178	10.8	1,474	89.2	
Age															
65-74 yr	188	7.3	2,378	92.7	0.26	41	3.6	1,104	96.4	0.12	96	10.7	805	89.3	0.81
≥75 yr	130	8.3	1,438	91.7		34	5.1	633	94.9		147	10.3	1,274	89.7	
Region															
City	225	7.4	2,801	92.6	0.31	51	3.8	1,287	96.2	0.24	174	10.3	1,514	89.7	0.69
Rural	93	8.4	1,015	91.6		24	5.1	450	94.9		69	10.9	565	89.1	
Education level															
≤Middle school	282	9.3	2,755	90.7	<0.001	24	3.1	741	96.9	0.07	231	11.6	1,761	88.4	<0.001
≥High school	36	3.3	1,056	96.7		51	4.9	994	95.1		12	3.7	315	96.3	
Missing	5					2					3				
Occupation															
Yes	76	5.5	1,319	94.5	<0.001	53	5.1	986	94.9	0.06	54	8.7	569	91.3	0.22
No	242	8.8	2,495	91.2		22	2.9	750	97.1		189	11.1	1,509	88.9	
Missing	2					1					1				
Household income															
1 quartile	214	11.0	1,727	89.0	<0.001	47	6.4	689	93.6	<0.001	167	13.9	1,038	86.1	<0.001
2 quartiles	74	6.7	1,030	93.3		17	3.3	501	96.7		57	9.7	529	90.3	
3 quartiles	20	3.2	596	96.8		8	2.5	308	97.5		12	4.0	288	96.0	
4 quartiles	9	2.0	441	98.0		3	1.3	230	98.7		6	2.8	211	97.2	
Missing	23					9					14				
Current smoking															
Yes	27	7.1	354	92.9	0.70	15	4.5	318	95.5	0.74	12	25.0	36	75.0	<0.001
No	283	7.6	3,421	92.4		61	4.1	1,402	95.9		223	10.0	2,019	90.0	
Missing	49					17					32				
High-risk alcohol drinking															
Yes	4	2.5	154	97.5	0.70	4	2.8	140	97.2	0.38	-	-	14	100.0	0.20
No	310	7.9	3,638	92.2		71	4.3	1,584	95.7		239	10.4	2,054	89.6	
Missing	28					13					15				
Self-rated health															
Good	92	3.2	2,769	96.8	<0.001	25	1.8	1,352	98.2	<0.001	67	4.5	1,417	95.5	<0.001
Bad	226	17.8	1,046	82.2		50	11.5	385	88.5		176	21.0	661	79.0	
Missing	1					0					1				
Chronic diseases*															
0	32	4.7	648	95.3	<0.001	6	1.5	390	98.5	0.001	26	9.2	258	90.9	0.06
1-2	173	7.2	2,225	92.8		44	4.2	1,006	95.8		129	9.6	1,218	90.4	
≥3	113	10.7	943	89.3		25	6.8	341	93.2		88	12.8	602	87.2	

*Chronic diseases included dyslipidemia, diabetes, osteoarthritis, rheumatoid arthritis, asthma, hypertension, angina, myocardial infarction, stroke, cancer (stomach, liver, colon, breast, cervical, lung, thyroid, and other cancers).

Table 2. The associations between socioeconomic factors and depressive symptom

Variable	Depressive symptom					
	Total		Men		Women	
	OR	95% CI	OR	95% CI	OR	95% CI
Marital status						
Yes	1.00		1.00		1.00	
No	1.42	1.09-1.87	1.79	0.99-3.26	1.39	1.02-1.88
Physical activity						
Active	1.00		1.00		1.00	
Inactive	0.96	0.73-1.27	1.03	0.61-1.74	0.91	0.66-1.26
Gender						
Men	1.00		1.00		1.00	
Women	1.61	1.16-2.23	-	-	-	-
Age						
65-74 yr	1.00		1.00		1.00	
≥75 yr	0.74	0.57-0.97	1.05	0.63-1.75	0.67	0.49-0.92
Region						
Rural	1.00		1.00		1.00	
City	1.04	0.79-1.36	0.88	0.52-1.50	1.23	0.89-1.70
Education level						
≤Middle school	1.41	0.95-2.08	1.10	0.64-1.88	2.06	1.11-3.85
≥High school	1.00		1.00		1.00	
Occupation						
Yes	1.00		1.00		1.00	
No	1.21	0.90-1.62	1.32	0.76-2.28	1.13	0.80-1.60
Household income						
1 quartile	3.62	1.80-7.27	2.72	0.79-9.37	3.79	1.62-8.89
2 quartiles	2.56	1.25-5.25	1.94	0.55-6.88	2.78	1.16-6.66
3 quartiles	1.44	0.64-3.25	1.62	0.42-6.28	1.28	0.46-3.52
4 quartiles	1.00		1.00		1.00	
Current smoking						
Yes	1.16	0.73-1.84	0.96	0.52-1.76	1.82	0.88-3.77
No	1.00		1.00		1.00	
High-risk alcohol drinking						
Yes	1.89	0.67-5.33	1.24	0.43-3.57	-	-
No	1.00		1.00		1.00	
Self-rated health						
Good	1.00		1.00		1.00	
Bad	5.53	4.23-7.24	5.50	3.29-9.19	5.62	4.09-7.73
Chronic diseases*						
0	1.00		1.00		1.00	
1-2	1.13	0.75-1.70	2.18	0.91-5.24	0.84	0.52-1.35
≥3	1.21	0.78-1.86	2.65	1.04-6.74	0.85	0.52-1.41

Adjusted for age, education level, region, occupation, household income, current smoking, high-risk alcohol drinking, self-rated health, and chronic diseases.

OR, odds ratio; CI, confidence interval.

*Chronic diseases included dyslipidemia, diabetes, osteoarthritis, rheumatoid arthritis, asthma, hypertension, angina, myocardial infarction, stroke, cancer (stomach, liver, colon, breast, cervical, lung, thyroid, and other cancers).

DISCUSSION

This study examined the association between marital status, physical activity, and depressive symptoms in Korean older adults (i.e., aged 65 years or older) using KNHANES data from 2014, 2016, and 2018. Of the 4,134 older adults who participated in the KNHANES over the three years, 7.7% experienced depressive symptoms. Marital status, gender, income level, and self-rated health status are factors influencing depressive symptoms in older adults, with physically active but unmarried elderly adults exhibiting a higher risk of depressive symptoms than physically active married elderly adults. Indeed, contrary to expectations, this study did not find that physical activity had a significant effect on the risk of depressive symptoms in older adults. In terms of gender, a previous study found that women aged 60

years or older are at higher risk of depression than their male peers [19]. The risk of depression increases in adulthood due to gender-based stereotypes and inequalities between men and women [2,14]. The specific factors associated with depression may vary due to cultural differences. Certainly, Confucian culture may have a significant impact on depression mediated by gender inequality [14,20]. Among demographic characteristics, economic factors and education levels also affect depression, with low household income and education level increasing the risk of depression [21]. In general, highly educated people can alleviate depression because they have more opportunities to participate in various social activities, facilitated by greater awareness of and access to resources [21]. Stratified analysis was performed to confirm that household income level had a significant effect on depressive symptoms of

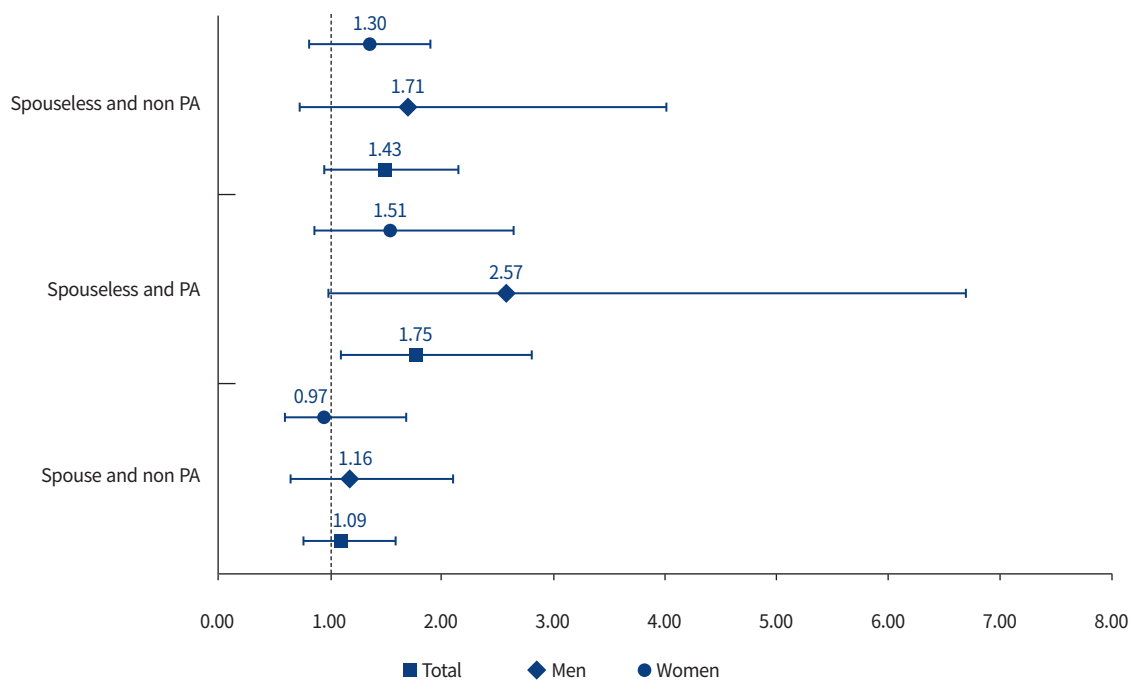


Figure 1. The associations between marital status with physical activity (PA) and depressive symptom by gender. Adjusted for age, education level, region, occupation, household income, current smoking, high-risk alcohol drinking, self-rated health, and chronic diseases.

those in the lowest income group (first quartile) (Appendices 2 and 3). Low-income groups are more vulnerable to depression due to various factors. Notably, financial difficulties can lead to stress, which can contribute to the development of depression [21]. Government intervention to improve the living standards and quality of life of low-income individuals is crucial due to the vulnerability of this group to poverty, social isolation, and inadequate access to resources, which can negatively impact their mental and physical health.

This study found that older adults with poor self-rated health and/or chronic diseases had a higher risk of depressive symptoms. The association between poor self-rated health and depressive symptoms was observed in both older males and females. Previous studies reported that self-rated health was a major predictor of depression in older adults [22]. In older adults, self-rated health status can affect mental health along with symptoms such as longstanding illness, anxiety, and depression [22]. In other words, how an older adult perceives their own health can have a significant impact on their mental well-being, underscoring the importance of addressing both physical and mental health in this demographic.

Results revealed that marital status affected geriatric depressive symptoms more than physical activity. Analysis of the combined association between marital status and physical activity and depressive symptoms showed that individuals living alone and performing physical activity had a 1.75-fold higher risk of depressive symptom than the reference group. There are several reasons why older adults who live alone (i.e., without a spouse) and exercise may still experience depression. One possible reason is that physical activity alone may not be sufficient to alleviate the complex and multifaceted causes of depressive symptoms in older adults. Although regular physical activity is known to have a positive effect on mental health [7,8], it may not

fully address the emotional and psychological factors that cause depression, such as social isolation, loss of purpose, and unresolved emotional issues [7]. This suggests that the factors that induce depressive symptom in older adults are influenced more by marital status than physical activity. In this study, when stratified by gender, results showed that physically active but spouseless men were 2.67 times more likely to experience depressive symptoms than their peers in the reference group, although this was not statistically significant. However, although not significant, this finding needs to be discussed in view of the existing literature. Previous studies showed that older spouseless men are at higher risk of depressive symptom than older spouseless women [12,13]. It is well known that older adults who feel loneliness or live alone (i.e., unmarried, divorced, widowed, or separated) are more prone to depressive symptoms than those who do not [11]. Social isolation and loneliness also limit physical activity and cause prolonged sedentary behavior [23]. According to Jang et al. [14], husbands receive more physical and emotional support from their wives. Furthermore, as is typical in patriarchal Oriental family cultures, older Korean men tend to be more reliant on their spouses after retirement, and thus suffer more grief if and when they are separated from their spouses [14]. As such, in order to ease depressive symptoms among older adults in Korea, it is necessary to improve awareness of fixed gender roles and facilitate access to social activities [5].

Although this study found no association between physical activity and depressive symptoms, numerous studies have reported that participation in regular physical activity—such as aerobics and flexibility exercises—are effective lifestyle interventions to prevent or alleviate depression in older adults [6,7,24]. This is since physical activity enables social support, such as communication with people and enhanced friendships, along with the promotion of psychological stability and

health [6]. According to Wen et al. [25], low levels of exercise—defined as 15 minutes per day or 90 minutes per week at moderate intensity—were beneficial for preventing disease. Therefore, exercise intensity and duration for this age group should be continuously examined to further support policies aimed at preventing depression and all-cause mortality [8]. However, in this study, physical activity criteria targeting only the elderly could not be applied. Therefore, there were not many respondents (older adults over the age of 65 years) who could satisfy the physical activity standards of general adults. As this study could not confirm the relationship between physical activity and depressive symptom in older adults, future studies using appropriate physical activity criteria targeting only the elderly should be conducted.

This study had several limitations. First, although three years of data were collected, the sample size was relatively small. In this study, the sample did not contain enough older adults with high-risk alcohol drinking, preventing any insights from being drawn. Second, as this is a cross-sectional study, it cannot prove any causal effect of marital status or physical activity on depressive symptoms. Third, there are not globally recognized or verified standards for physical activity for older adults, and thus could not be applied. Fourth, the KNHANES is a self-reporting survey of the general population in South Korea; collected data are based on subjective answers and limited quantitative measurements.

These limitations notwithstanding, this study has several strengths. First, the KNHANES is a relatively large national community-based survey. Second, this study found that older adults living without spouse have a higher risk of depressive symptoms. Third, as the selected independent variables have a simple intuitive meaning, the results can be used as basic data to encourage social participation in the prevention of depression among older adults.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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Appendix 1. The association between marital status and physical activity (PA) with depressive symptom by gender

Variable	Depressive symptom					
	Total		Men		Women	
	OR	95% CI	OR	95% CI	OR	95% CI
Combination						
Spouse and PA	1.00		1.00		1.00	
Spouse and non-PA	1.09	0.76-1.58	1.16	0.64-2.10	0.97	0.60-1.56
Spouseless and PA	1.75	1.10-2.81	2.57	0.98-6.71	1.51	0.86-2.63
Spouseless and non-PA	1.43	0.95-2.14	1.71	0.73-4.01	1.30	0.81-2.09

Adjusted for age, education level, region, occupation, household income, current smoking, high-risk alcohol drinking, self-rated health, and chronic diseases.

OR, odds ratio; CI, confidence interval.

Appendix 2. The association between marital status and physical activity with depressive symptom by household income

Variable	Depressive symptom							
	1 quartile		2 quartiles		3 quartiles		4 quartiles	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Marital status								
Yes	1.00		1.00		1.00		1.00	
No	1.70	1.22-2.34	1.12	0.62-2.01	0.92	0.29-2.90	-	-
Physical activity								
Active	1.00		1.00		1.00		1.00	
Inactive	0.90	0.64-1.28	1.17	0.67-2.10	0.84	0.31-2.30	0.38	0.09-1.63
Gender								
Men	1.00		1.00		1.00		1.00	
Women	1.56	1.03-2.36	1.70	0.89-3.24	1.34	0.43-4.21	2.59	0.49-13.75
Age								
65-74 yr	1.00		1.00		1.00		1.00	
≥75 yr	0.63	0.45-0.86	1.10	0.62-1.96	1.83	0.65-5.14	0.64	0.07-6.11
Region								
Rural	1.00		1.00		1.00		1.00	
City	1.01	0.73-1.41	2.00	1.03-3.92	0.83	0.28-2.50	0.18	0.04-0.86
Education level								
≤Middle school	1.97	1.05-3.71	1.08	0.55-2.11	1.46	0.46-4.60	1.22	0.26-5.70
≥High school	1.00		1.00		1.00		1.00	
Occupation								
Yes	1.00		1.00		1.00		1.00	
No	1.07	0.74-1.54	1.61	0.88-2.95	1.97	0.41-3.51	1.02	0.23-4.58
Current smoking								
Yes	1.38	0.80-2.36	0.32	0.07-1.39	3.35	0.77-14.59	-	-
No	1.00		1.00		1.00		1.00	

(Continued on next page)

Appendix 2. Continued

Variable	Depressive symptom							
	1 quartile		2 quartiles		3 quartiles		4 quartiles	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
High-risk alcohol drinking								
Yes	1.22	0.41-3.61	-	-	-	-	-	-
No	1.00		1.00		1.00		1.00	
Self-rated health								
Good	1.00		1.00		1.00		1.00	
Bad	6.10	4.31-8.63	4.77	2.82-8.09	6.37	2.38-17.03	3.29	0.79-13.63
Chronic diseases*								
0	1.00		1.00		1.00		1.00	
1-2	1.08	0.64-1.81	1.21	0.51-2.85	0.83	0.21-3.24	1.75	0.19-16.09
≥3	1.11	0.64-1.92	1.64	0.67-4.00	0.81	0.17-3.76	2.00	0.16-25.39

OR, odds ratio; CI, confidence interval.

*Chronic diseases included dyslipidemia, diabetes, osteoarthritis, rheumatoid arthritis, asthma, hypertension, angina, myocardial infarction, stroke, cancer (stomach, liver, colon, breast, cervical, lung, thyroid, and other cancers).

Appendix 3. The association between combined marital status and physical activity (PA) with depressive symptom by household income

Variable	Depressive symptom							
	1 quartile		2 quartiles		3 quartiles		4 quartiles	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Combination								
Spouse and PA	1.00		1.00		1.00		1.00	
Spouse and non-PA	1.75	1.04-2.95	1.19	0.60-2.40	0.95	0.30-3.04	0.38	0.09-1.63
Spouseless and PA	2.54	1.39-4.64	1.18	0.42-3.31	1.24	0.19-7.88	-	-
Spouseless and non-PA	1.75	1.04-2.95	1.31	0.56-3.10	0.76	0.16-3.56	-	-

Adjusted for age, gender, education level, region, occupation, current smoking, high-risk alcohol drinking, self-rated health, and chronic diseases.

OR, odds ratio; CI, confidence interval.