

Original Research

Gender difference in the relationships between behavioral risk factors and depression in older Korean adults

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Abstract

Background: Gender difference regarding the relationship between lifestyle choices and depression is unclear in Korea. This study investigated the relationship between behavioral risk factors and depression by gender in older Korean adults. **Methods:** The data used in the current study were obtained from 5024 participants aged 60 years and older (56% women) of the sixth and seventh editions of the Korea National Health and Examination Survey (KNHANES). The main outcome was depression, which was assessed using the Patient Health Questionnaire (PHQ)-9. Exposures included smoking, at-risk alcohol consumption, physical inactivity, and inadequate sleep. Body mass index (BMI), household income, educational background, marital status, and number of existing diseases were included as covariates. **Results:** Depressed persons were older ($p = 0.003$), had lower income ($p < 0.001$), lower marital status ($p = 0.021$), lower education ($p < 0.001$), lower smoking ($p = 0.003$), higher rates of physical inactivity ($p = 0.009$) and inadequate sleep ($p = 0.011$), and higher number of existing diseases ($p < 0.001$) compared with not depressed persons. Regression analysis showed that depression was significantly associated with sex ($p < 0.001$), BMI ($p < 0.001$), income ($p < 0.001$), education ($p = 0.001$), smoking ($p = 0.033$), physical inactivity ($p = 0.021$), inadequate sleep ($p < 0.001$), and number of existing diseases ($p < 0.001$). Generalized linear regression analysis showed a significant interaction between gender and number of unhealthy behaviors on the PHQ-9 score ($p = 0.004$), such that depression risk was significantly associated with clustered unhealthy behaviors in women only. **Conclusions:** The current findings showed that physical inactivity and inadequate sleep were independent predictors for depression in women, with no such relationship in men.

Keywords: Major depressive symptom; Healthy lifestyles; Physical activity; Insomnia; Koreans

1. Introduction

Major depressive disorder (MDD) is a common mental illness affecting 300 million people worldwide [1] and is a major contributor to the overall global burden of disease [2]. A noticeable feature of mental disorders is that women are twice as likely to experience depression than men [3,4]. Furthermore, MDD is the leading cause of disability globally in women [2], implying a gender-based health disparity for this mental illness [5].

Etiologically, depression is associated with behavioral risk factors, such as smoking [6], physical inactivity [7], heavy alcohol intake [8], and sleep deprivation [9]. Health conditions [10] and socioeconomic status [11] are additional risk factors for mental illness. In addition, the associations of lifestyle risk factors with prevalence and incidence of depression have been observed in cohort studies involving different populations [12,13].

In South Korea, MDD is the second most common mental illness after alcohol and nicotine abuse [14] and is a major contributor to disability in older adults [15]. The total economic burden of depression was estimated as 4,049 million USD in 2005 [16] and 1.331 billion USD in 2012 [17]. South Korea has the highest suicide rate at 23 deaths per 100,100 persons among the Organization for Economic Co-operation and Development countries [18]. Depression

is more closely correlated with a higher rate of suicide in older adults rather than in young adults or in men rather than in women [19].

Like in other countries, the similar associations between lifestyle risk factors and depression were reported from population-based studies in South Korea. For example, the findings from the 2017 Korea Community Health Survey involving 224,868 participants aged 19 years and older showed that no smoking, not belonging to high-risk drinking group, and walking frequently were associated with a lower risk of depression in Korean men and women [20]. Interesting enough, however, the relationships are gender-specific; women are more likely to suffer from depression [4] and have a higher prevalence of depression than men [14]. Furthermore, having an active or a passive healthy lifestyle was negatively associated with depressive symptoms in women, but such a relationship was not observed in men [21], implying that being female is a risk factor of depression.

Together, the findings from previous studies suggest that gender difference may exist in the roles of lifestyle risk factors in relation to depression. Yet, the role of gender as a moderator in determining the relationships are unclear in Korean populations. Therefore, the aim of this study was to investigate gender difference in the relationship between



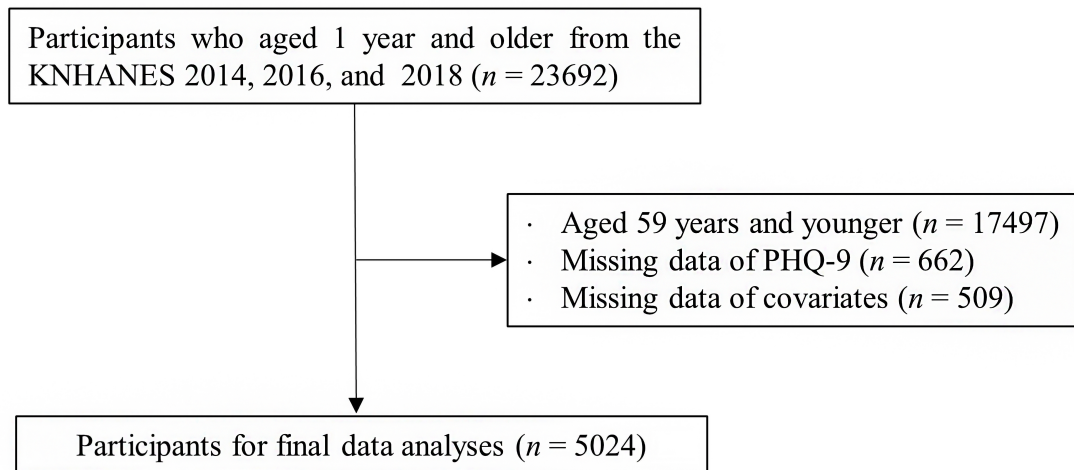


Fig. 1. Flow chart of selection for the study participants.

behavioral risk factors-smoking, at-risk alcohol consumption, and inadequate sleep- and depression risk in older Korean adults.

2. Material and methods

2.1 Data source and study participants

Fig. 1 represents a flow chart of selection for study participants. In brief, we initially selected respondents aged 1 year and older ($n = 23,692$) from the sixth and seventh Korea National Health and Examination Survey (KNHANES) in 2014, 2016, and 2018, a nationwide survey designed to assess health and nutritional status in the Korean population. We then excluded participants aged 59 years and younger ($n = 17,497$). Additionally, we excluded those without Patient Health Questionnaire (PHQ)-9 data ($n = 662$) as well as those with covariates and others ($n = 509$). Consequently, the remaining 5024 participants (2835 women/56%) were included in final data analyses. A detailed description of the KNHANES study design is available elsewhere [22].

2.2 Variables

2.2.1 Patient Health Questionnaire-9

MDD was assessed using the Korean version of PHQ-9, a self-reported version of the PRIME-MD diagnostic instrument for major depressive disorders [23]. Each of the nine items of PHQ-9 was scored corresponding to the Diagnostic and Statistical Manual of Mental Disorders criteria as “0” (not at all) to “3” (nearly every day). MDD was defined as having a PHQ-9 score of ≥ 10 . The cutoff value of 10 for screening MDD using the Korean version of PHQ-9 was previously tested and validated [24].

2.2.2 Behavioral risk factors

Behavioral risk factors included in this study were past/current smoking, at-risk alcohol consumption, physi-

cal inactivity, and inadequate sleep. Smoking status was dichotomized as non-smokers and smokers (past and current). At-risk alcohol intake was defined as having seven glasses or more (five or more for women) of alcohol per occasion two or more times per week [25]. Physical inactivity was defined as not participating in at least 150 minutes of moderate physical activity (PA) per week or 75 minutes of vigorous PA or a combination of moderate and vigorous PA (<https://www.who.int/news-room/fact-sheets/detail/physical-activity>). Inadequate sleep was defined as less than 7 hours of sleep per night or use of hypnotic medications [26].

2.2.3 Covariates

Age (continuous), gender (categorical: male or female), body mass index (quantitative), education (categorical: elementary school or lower, middle or high school, university or higher), income (quantitative), and marital status (categorical: yes or no) were included as covariates. Body mass index (BMI) was calculated as weight divided by height squared (kg/m^2).

2.3 Statistics

Normality of the data distribution was confirmed with QQ plotting, and the absence of multi-collinearity was assessed by the variance of inflation factor (VIF). Descriptive statistics were performed using the Student’s *t*-test and Chi-square test for continuous and categorical variables, respectively, which are presented as the mean and standard deviation (SD) and number (*n*) and percentage (%), respectively. Linear regression was used to assess the relationship between PHQ-9 scores and other variables. Multivariate logistic regression was performed to estimate the odds ratios (ORs) and 95% confidence intervals (CIs) of depression by number of lifestyle risk factors (from low to high) before and after adjusting for covariates. A generalized lin-

Table 1. Description of study participants.

	Men (n = 2189)	Women (n = 2835)	Total (n = 5024)	Effect size	<i>p</i> value
Anthropometrics					
Age (year)	69.8 ± 6.3	69.8 ± 6.4	69.8 ± 6.4	-0.001	0.979
BMI (kg/m ²)	23.9 ± 3.0	24.4 ± 3.2	24.2 ± 3.1	-0.185	<0.001
PHQ-9 score	1.9 ± 3.4	3.2 ± 4.4	2.6 ± 4.1	-0.308	<0.001
Socioeconomic status					
Income (10,000 won/month)	284.6 ± 283.2	242.7 ± 271.2	261.0 ± 277.2	0.152	<0.001
Marital status, n (%)					
Having a spouse	2169 (99.1)	2811 (99.2)	4980 (99.2)	0.004	
Having no spouse	20 (0.9)	24 (0.8)	44 (0.9)		0.800
Education, n (%)					
Elementary	643 (29.4)	1675 (59.1)	2318 (46.1)	0.308	<0.001
Middle/high	1083 (49.5)	948 (33.4)	2031 (40.4)		
College	463 (21.2)	212 (7.5)	675 (13.4)		
Health behaviors					
Smoking, n (%)	1737 (79.4)	165 (5.5)	1893 (37.7)	0.756	<0.001
At-risk alcohol intake, n (%)	339 (15.5)	85 (3.0)	424 (8.4)	0.223	<0.001
Physical inactivity, n (%)	1856 (84.8)	2634 (92.9)	4490 (89.4)	0.131	<0.001
Insufficient sleeping, n (%)	783 (35.8)	1189 (41.9)	1972 (39.3)	0.063	<0.001
Number of chronic diseases					
0	565 (25.8)	473 (16.7)	1038 (20.7)	-0.284	<0.001
1	700 (32.0)	797 (28.1)	1497 (29.8)		
≥2	924 (42.2)	1565 (55.2)	2489 (49.5)		

BMI, body mass index; PHQ, Patient Health Questionnaire. Effect sizes represent Cramer's V size and Cohen's D values for chi-square and ANOVA tests, respectively.

ear model was used to test the interaction between number of unhealthy behaviors and gender for depression risk. Statistical significance was defined as $p < 0.05$. All statistical analyses were conducted using PASW SPSS WIN 27.0 (SPSS Inc., Chicago, IL, USA).

3. Results

Table 1 presents the characteristics of the study participants by gender. Men had lower BMI ($p < 0.001$) and lower depression rate ($p < 0.001$), higher income ($p < 0.001$), higher educational background ($p < 0.001$), higher rates of smoking ($p < 0.001$) and at-risk alcohol consumption ($p < 0.001$), lower PHQ-9 score ($p < 0.001$), lower physical inactivity ($p < 0.001$), lower insufficient sleeping ($p < 0.001$), and lower number of existing diseases ($p < 0.001$) compared with women.

Table 2 presents the characteristics of the study participants by whether they were depressed or not. The prevalence of depression was 7.0% in total (4.1% in men and 9.3% in women, $p < 0.001$). Depressed individuals were older ($p = 0.003$) and weighed less ($p = 0.014$) than not depressed individuals. Depressed individuals had lower income ($p < 0.001$), lower marital status ($p = 0.021$), lower educational background ($p < 0.001$), lower smoking ($p =$

0.003), higher physical inactivity ($p = 0.009$), higher insufficient sleeping ($p = 0.011$), and higher number of existing diseases ($p < 0.001$) compared to not depressed individuals. No significant differences in BMI ($p = 0.063$) and at-risk alcohol consumption ($p = 0.875$) were found between depressed and not depressed individuals.

Table 3 presents the outcomes of multivariate linear regression for depression. Sex ($p < 0.001$), BMI ($p < 0.001$), household income ($p < 0.001$), educational background ($p = 0.001$), smoking ($p = 0.033$), physical inactivity ($p = 0.026$), inadequate sleeping ($p < 0.001$), and number of existing diseases ($p < 0.001$) were significant determinants of depression.

Table 4 presents the odds for depression according to number of unhealthy lifestyles. In total, two and three or more unhealthy behaviors had a higher risk for depression (OR = 1.355; $p = 0.016$ and OR = 1.850; $p = 0.002$, respectively) compared to one or less unhealthy behavior (OR = 1) only after adjustments for age, sex, BMI, income, marital status, education, and number of existing diseases. In men only, two and three or more unhealthy behaviors had a higher risk for depression (OR = 2.189; $p = 0.033$ and OR = 2.396; $p = 0.021$, respectively) compared to one or less unhealthy behavior (OR = 1). The increased ORs were

Table 2. Description of study participants by the presence of depression.

	Depression		Total	<i>p</i> value
	Depressed (<i>n</i> = 353)	Not depressed (<i>n</i> = 4671)	(<i>n</i> = 3700)	
Anthropometrics				
Male, <i>n</i> (%)	90 (4.1)	2099 (95.9)	353 (7.0)	<0.001
Females, <i>n</i> (%)	263 (9.3)	2572 (90.7)	4671 (93.0)	
Age (year)	70.7 ± 6.4	69.7 ± 6.4	69.8 ± 6.4	0.003
BMI (kg/m ²)	23.9 ± 3.3	24.2 ± 3.1	24.2 ± 3.1	0.063
PHQ-9 score	14.4 ± 3.9	1.7 ± 2.3	2.6 ± 4.1	<0.001
Socioeconomic status				
Income (10,000 won/month)	138.7 ± 161.8	270.2 ± 281.9	261.0 ± 277.2	<0.001
Marital status, <i>n</i> (%)				0.021
Having a spouse	346 (98.0)	4634 (99.2)	4980 (99.1)	
Having no spouse	7 (2.0)	37 (0.8)	44 (99.2)	
Education, <i>n</i> (%)				<0.001
Elementary	226 (64.0)	2092 (44.8)	2318 (46.1)	
Middle/high	109 (30.9)	1922 (41.1)	2031 (40.4)	
College	18 (5.1)	657 (14.1)	675 (13.4)	
Health behaviors				
Smoking, <i>n</i> (%)	107 (30.3)	1786 (38.2)	1893 (37.7)	0.003
At-risk alcohol intake, <i>n</i> (%)	29 (8.2)	395 (8.5)	424 (8.4)	0.875
Physical inactivity, <i>n</i> (%)	330 (93.5)	4160 (89.1)	4490 (89.4)	0.009
Insufficient sleeping, <i>n</i> (%)	161 (45.6)	1811 (38.8)	1972 (39.3)	0.011
Number of chronic diseases				
0	40 (11.3)	998 (21.4)	1038 (20.7)	<0.001
1	82 (23.2)	1415 (30.3)	1497 (29.8)	
≥2	231 (65.4)	2258 (48.3)	2489 (49.5)	

BMI, body mass index; PHQ, Patient Health Questionnaire.

Table 3. Linear regression analysis for the determinants of depression.

Variables	beta	95% CI	<i>p</i> value	VIF
Age	-0.001	-0.019–0.018	0.951	1.213
Gender	1.229	0.879–1.579	<0.001	2.533
BMI	-0.150	-0.141–0.069	<0.001	1.062
Income	-0.001	-0.002–0.001	<0.001	1.181
Marital status	0.579	-0.596–1.573	0.334	1.007
Education	-0.290	-0.467–0.112	0.001	1.293
Smoking	0.379	0.031–0.726	0.033	2.387
At-risk alcohol intake	0.307	-0.109–0.722	0.148	1.120
Physical Inactivity	0.415	0.049–0.781	0.026	1.072
Inadequate sleep	0.436	0.212–0.660	<0.001	1.009
Diseases	0.645	0.500–0.790	<0.001	1.097

CI, confidence interval; VIF, variance inflation factor; BMI, body mass index.

no longer significant when adjusting for all covariates. In women only, two and three or more unhealthy behaviors had a higher risk for depression (OR = 1.305; *p* = 0.048 and OR = 2.705; *p* < 0.001, respectively) compared to one

or less unhealthy behavior. The increased OR for three or more unhealthy behaviors (OR = 2.333; *p* = 0.002) for all covariates except for sex.

Table 4. Odds ratios (ORs) and 95% confidence intervals (CIs) of depression according to number of lifestyle risk factors.

Predictors	Model 1		Model 2	
	OR (95% CI)	<i>p</i> value	OR (95% CI)	<i>p</i> value
Total				
≤1	1 (reference)		1 (reference)	
2	1.105 (0.783–1.398)	0.408	1.355 (1.033–1.734)	0.016
≥3	0.992 (0.716–1.374)	0.960	1.850 (1.262–2.711)	0.002
Men only				
≤1	1 (reference)		1 (reference)	
2	2.189 (1.063–4.507)	0.033	1.868 (0.896–3.897)	0.096
≥3	2.396 (1.138–5.045)	0.021	2.024 (0.948–4.322)	0.068
Women only				
≤1	1 (reference)		1 (reference)	
2	1.305 (1.002–1.700)	0.048	1.264 (0.966–1.652)	0.087
≥3	2.705 (1.609–4.546)	<0.001	2.333 (1.369–3.976)	0.002

Model 1: unadjusted; Model 2: adjusted for age, gender (in total), body mass index, income, marital status, education, and number of existing diseases.

Fig. 2 illustrates the significant interaction between unhealthy lifestyles and gender on depression risk ($p = 0.004$). There was an incremental linear trend in PHQ-9 score according to incremental number of unhealthy behaviors in women but not in men, indicating that women were more likely to suffer from depression associated with accumulated unhealthy behaviors than men.

4. Discussion

In this cross-sectional study involving 5024 older Korean men and women, we examined the relationship between unhealthy behaviors and depression. We found that socio-demographics (i.e., sex, BMI, household income, and education) and unhealthy behaviors (i.e., smoking, physical inactivity, inadequate sleep, and number of existing diseases) were significantly correlated with depression risk. Novel to this study's findings was that clustering of unhealthy behaviors was positively and independently associated with increased depression risk in women, but no such relationship was found in men.

In accordance with the current findings of this study, an association between lifestyle risk factors and depression is present in the literature. In a cross-sectional study involving 1154 respondents to the online-based surveys, Silva *et al.* [27] examined the relationships between anxiety, depression, and stress with PA during the COVID-19 outbreak and found that individuals without regular PA had an increased risk for anxiety, depression, and stress symptoms compared to regular PA participants. By analyzing data obtained from the UK Biobank sample ($n = 84,860$), Sarris *et al.* [28] showed that depression at baseline was inversely associated with healthy lifestyles, including physical activity, healthy diet, and optimal sleep duration, but

positively associated with screen time and tobacco smoking. Sleep disturbances were also significantly correlated with subsyndromal depression, brief depressive episodes, and depressive episodes in low- and middle-income countries [29]. In addition, the association between sleep disturbances and depression was also observed in Chinese populations [30], Japanese elderly persons [31], and older Korean adults [32].

Gender difference observed in the current study is in agreement with previous findings from the Korea Longitudinal Study of Aging (KLoSA). Based on the 2012 KLoSA data, Park and Kim [21] found that adopting an active or passive healthy lifestyle was inversely associated with depressive symptoms in older Korean women, but such a relationship was not observed in older Korean men. In the same 2012 KLoSA data, Kim and Lee [33] also found that living alone was another independent predictor of depression in older Korean women but not in older Korean men. In addition, gender differences in these relationships may also be associated with gender-specific risk profiles for depression. In a systematic review study involving three ongoing population-based cohort studies in Germany, for example, Daniëlle *et al.* [34] showed that internal risk factors such as loneliness, social isolation, and low social support were significantly associated with an increased risk of depression in women. By contrast, external risk factors such as myocardial infarction and stroke were associated with mental illness in men. Gender-specific risk profiles for depression were observed in Asian countries. In a seven-year follow-up study involving middle-aged and older Japanese adults, Tanaka *et al.* [12] showed that having a chronic disease and physical inactivity were major risk factors for men, while poor perceived health and obesity were major risk factors for depression in women. In the Korean Community Health

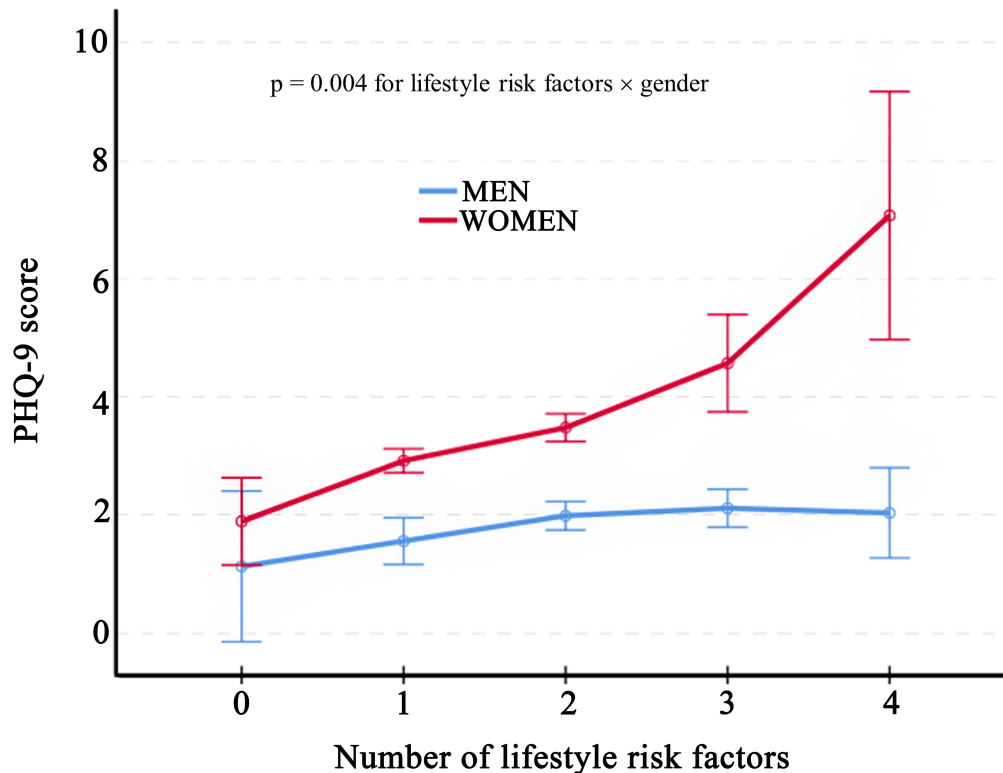


Fig. 2. The relationships between lifestyle risk factors (i.e., smoking, at-risk alcohol consumption, inadequate sleep, physical inactivity) and depression by gender.

Survey data, Jang *et al.* [20], found that not walking was the strongest predictor of depression for men, and smoking was the strongest predictor of depression for women. By analyzing data obtained from the 2006 KLoSA, Back and Lee [35] showed that household net worth was inversely associated with depressive symptoms in older Korean men, whereas education and income was inversely associated with depressive symptoms in older Korean women. Thus, a well-designed longitudinal study will be necessary to examine the effects of gender-specific profiles for depression on the relationships between unhealthy behaviors and depression in older Korean adults.

Several explanations can be given for gender difference in the relationship between unhealthy behaviors and depression. First, daily PA may be an explanation for such gender differences. Although levels of daily PA are likely to decline as people age, irrespective of gender, older women remain less engaged in PA than older men [36], mediating a positive association between unhealthy behaviors and depression in women. Second, sleep disturbance may be another explanation for gender difference in the relationship. Strong evidence linking sleep disturbance to depression exists in the literature. Sleep disturbances such as insomnia and hypersomnia are the most prominent symptoms among depressed patients, with a stronger prevalence in females [37]. Third, there are other potential factors for gender differences in these relationships, including socio-economic

status [20], social factors [20], nutritional adequacy [38], and others [39]. Lastly, biological factors such as cholesterol, cytokines, and appetite regulating hormones are also involved in the gender differences of the relationships between behavioral risk factors and depression [34], which remain to be further investigated in future studies.

This study has limitations. First, the cross-sectional nature of the study limits any causal explanation for the relationship between unhealthy behaviors and depression. Second, bi-directional relationships between unhealthy behaviors and depression are possible; that is, depression may result in unhealthy behaviors [40]. The causality of these relationships remains to be confirmed in a longitudinal cohort study. Third, sleep quality in addition to sleep quantity plays an important role in determining physical, cognitive, and psychological health and changes with normal aging [41]. Sleep quality in relation to MDD risk should be further investigated. Fourth, the relationship between behavioral risk factors and depression may be mediated by other factors, such as, socio-economic and social factors, nutritional status and others [35–40], which needs to be further addressed in a future study. Lastly, although the accuracy of the PHQ-9 score for screening MDD was previously tested and validated in Korean elderly populations [24], it is a subjective screening test and not cover all depression criteria. Therefore, a possibility of making type II error cannot be ruled out completely.

5. Conclusions

In this cross-sectional study, we examined gender difference in the relationship between lifestyle risk factors and depression in 5024 older Korean adults aged 60 years and older. We found that depression was significantly correlated with sex, BMI, income, education, smoking, physical inactivity, inadequate sleep, and number of existing diseases. Novel to this study was that depression was significantly associated with clustered behavioral risk factors in women only. The current findings of this study suggest that a healthy lifestyle intervention targeted at physical inactivity and inadequate sleep should be promoted, especially for depressed older women.

Author contributions

HK and HH contributed to conception and design, data analyses, data interpretation, and writing of the manuscript. SK, JK and JG contributed to statistical analyses, data interpretation, and preparation of the manuscript. All authors have read and agreed to the published version of the manuscript.

Ethics approval and consent to participate

The Institutional Review Board of Korea Centers for Disease Control and Prevention reviewed and approved the KNHANES VI (2013-07CON-03-4C and 2013-12EXP-03-5C) and VII surveys (2018-01-03-P-A) in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

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Conflict of interest

The authors declare no conflict of interest.

Data availability statement

Data can be accessible upon request to corresponding author (hkang@skku.edu).

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