Observational Study

Medicine®

OPEN

Relationship between obesity and depression in Korean adults

Korea National Health and Nutrition Examination Survey 2014

Soo Min Hong, MD[a], Yang-Im Hur, MD, PhD[b,*]

Abstract

Previous studies on the relationship between obesity and depression have produced conflicting results. And only a limited number of studies have been conducted in Asians, and few large-scale nationwide studies have been conducted in Korean populations.

We investigated the relationship between obesity and depression in Korean adults using data from a population-based sample from the 2014 Korea National Health and Nutritional Examination Survey (KNHANES) by cross-sectional study.

In total, 4026 subjects (1692 men, 2334 women) aged 19 to 69 years participated in the 2014 KNHANES. Current depression was defined as a score ≥10 on the 9-item Patient Health Questionnaire. Height and weight were measured and the body mass index (BMI) was calculated. The participants were asked to complete questionnaires about socio-demographic factors and disease comorbidities, and health-related behaviors. The chi-squared test and multivariate logistic regression analyses were performed to examine the relationship between obesity and depression.

Depression was diagnosed in 5.7% of the study participants (3.9% of men, 7.0% of women). According to body weight status, there was a significant difference in the prevalence of depression (underweight: 16.2%, normal weight: 5.5%, overweight: 4.3%, obese [BMI ≥30]: 6.9%). Compared with the normal weight group, the underweight group had a higher adjusted odds ratio (OR) for depression (OR = 3.27, 95% confidence interval [CI]: 1.22, 8.75 in men; OR = 2.00, 95% CI: 1.12, 3.57 in women). Overweight (OR = 0.60, 95% CI: 0.32, 1.13) and obese (OR = 0.62, 95% CI: 0.17, 2.27) men had lower ORs for depression, but this trend was not significant. Compared with normal weight women, obese women had higher adjusted ORs for depression (OR = 1.75, 95% CI: 0.79, 3.88), while overweight women had lower ORs for depression (OR = 0.90, 95% CI: 0.56, 1.45), but these trends were not significant.

This study shows differences in the risk of depression depending upon body weight status. Being underweight was correlated with a high risk of developing depression in both men and women, but obesity cannot be ruled out as a risk factor for this condition.

Abbreviations: BMI = body mass index, CI = confidence interval, KNHANES = Korea National Health and Nutrition Examination Survey, OR = odds ratio, PHQ-9 = patient health questionnaire-9.

Keywords: body mass index, depression, obesity

1. Introduction

The worldwide prevalence of obesity is increasing annually. According to a 2014 World Health Organization (WHO) report, 39% of adults over 18 years of age (>1.9 billion) were overweight and 13% (>600 million) were obese.[1] As the prevalence of obesity increases, obesity-related diseases such as hypertension and dyslipidemia will frequently arise.[2] Obesity contributes to other comorbidities and depression is one of the most common psychiatric disorders related to obesity.[3] Obesity and depression contribute to the global burdens of economic costs, morbidities, and mortalities.[4,5] These conditions correlate with many complications such as cardiovascular diseases and diabetes mellitus.[6,7]

Previous studies on the relationship between obesity and depression had contradictory outcomes.[8–10] Some studies reported that obese people also tend to have depression,[11–14] but other studies did not support this conclusion in all subjects.[15–20] Several studies found no relationship between obesity and depression,[21,22] whereas others reported a positive relationship between obesity and depression in women but not in men.[23,24] Obesity and depression have a reciprocal relationship.[25] Several factors can affect the relationship between obesity and depression such as sex, age, and ethnic differences. Recent research that examined the longitudinal association between obesity and depression reported that a higher body mass index (BMI) tended to cause depression and vice versa.[26,27] Interestingly, the same results were obtained in twin cohort studies.[28]

However, only a limited number of studies have been conducted in Asians, and there have been few large-scale, nationwide studies in the Korean population. The prevalence of obesity is also increasing in Korea, from 28.7% of adults over 20 years of age in 2006 to 32.4% in 2015.[29] The aim of this study

Editor: Massimo Tusconi.

This work was supported by a 2016 Inje University research grant.

The authors declare no conflict of interest.

[a] Department of Internal Medicine, [b] Department of Family Medicine, Seoul Paik Hospital, Inje University College of Medicine, Seoul, Republic of Korea.

[*] Correspondence: Yang-Im Hur, Department of Family Medicine, Seoul Paik Hospital, Inje University College of Medicine, Seoul 100032, Republic of Korea (e-mail: yangimhur@gmail.com).

Medicine (2017) 96:52(e9478)

Received: 30 May 2017 / Received in final form: 28 November 2017 / Accepted: 5 December 2017

http://dx.doi.org/10.1097/MD.0000000000009478

was to investigate the relationship between obesity and depression in Korean adults using data from a population-based sample of the 2014 Korean National Health and Nutritional Examination Survey (KNHANES).

2. Methods

2.1. Study population

This study used data of the Sixth Korea National Health and Nutrition Examination Survey (KNHANES VI-2), 2014. The KNHANES is a nationwide population-based survey of the health and nutritional status of Koreans conducted by Korea Centers for Disease Control and Prevention (KCDC). A stratified multistage clustered probability design was used to sample noninstitutionalized Korean. The KNHANES consists of 3 parts: a health interview, behavioral and nutritional surveys, and a medical examination. Additional details regarding the study design and methods have been reported elsewhere.[30] The study enrolled conducted in adults aged ≥19 years who participated in the KNHANES VI-2 health survey and underwent medical examination. We selected 4026 of a total of 7550 subjects (1692 men, 2334 women), excluding the following: age <19 or >70, height and weight not measured, PHQ-9 survey not answered, pregnant women, and those undergoing treatment for depression. All of the participants provided informed consent before data collection, and the survey was approved by the KCDC Bioethics Committee (Approval Numbers: 2013-12EXP-03-5C in 2014) and the Institutional Review Board of Seoul Paik Hospital of Inje University (Institutional Review Board No. PAIK 2017-02-005).

2.2. Measurements

2.2.1. Anthropometric measurements. Height was measured in centimeters and weight was measured in kilograms using a digital scale. BMI was calculated as the person's weight in kilograms divided by the square of the height. We classified the subjects as underweight (BMI <18.5), normal weight (BMI between 18.5 and 25.0), overweight (BMI between 25.0 and 29.9), and obese (BMI >30.0) according to WHO standards.[31] We included a separate "above overweight" group (BMI >25) considering that the typical BMI cut-off for obesity in Asia is 25.[32] In this study, the waist was measured down to 0.01 cm with a non-elastic measuring tape to avoid pressing the subject's skin, with the subject in the exhaled state after marking the subject's sides between the lowest rib and the top of the iliac crest with a pen.

2.2.2. Depression outcomes. KNHANES 2014 used the PHQ-9 depression-screening test.[33] PHQ-9 is a self-reported screening test method, which was developed by Dr. Spitzer for the primary care evaluation of mental disorders.[34] The PHQ-9 is used as both a measurement of depressive symptomology and a diagnostic instrument for Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV) depressive disorders.[35] It includes 9 items pertaining to the DSM-IV criteria for major depressive disorder (MDD)[36]: anhedonia; depressed mood; trouble sleeping; feeling tired; change in appetite; guilt, self-blame, or worthlessness; trouble concentrating; feeling slowed down or restless; and thoughts of being better off dead or hurting oneself.[37] Each item is rated on a 4-point scale from 0 to 3 (0 = never; 1 = several days; 2 = more than half the time; and 3 = nearly every day) during the 2 weeks prior to and including the day of survey completion. The overall scores range from 0 to 27 and are categorized as: 1 to 4, no depression; 5 to 9, mild depression; 10 to 14, moderate depression; 15 to 19, moderately severe depression; and 20 to 27, severe depression.[37] The Korean version of the PHQ-9 set the cut-off values at 10, so that the sensitivity was 81.8% and the specificity was 89.9%, and the values of Cronbach α was 0.852.[38] The Korean version was reported to be better than the Self-Rating Depression Scale and the Beck Depression Inventory.[38] This study considered a total score of 10 or more as indicative of depression.

2.2.3. Potential risk factors. Variables associated with obesity or depression in previous studies were selected as potential risk factors.[39,40] The education level, occupation, and disease factors of participants of the health survey were obtained by interview, and health behaviors including smoking, drinking alcohol, physical activity, and mental health were obtained by questionnaire. The subjects were divided into the following age groups: 20s, 30s, 40s, 50s, and 60s. Household income was calculated by dividing total monthly income by the number of family members, who then were categorized into 4 groups according to quartile. Residential areas were classified as urban or rural. Education level was categorized as elementary (≤6 years), junior high (≤9 years), senior high (10–12 years), or college (≥13 years). Marital status was classified as married (spouse/cohabitation), single (never married), or other (separated/divorced/widowed). Comorbidities included diagnoses of hypertension, dyslipidemia, stroke, myocardial infarction, angina, arthritis, asthma, diabetes, renal failure, or liver cirrhosis. Cancer diagnoses were categorized by type such as stomach, liver, colon, breast, lung, uterine, cervical, and thyroid cancers. Smoking status was categorized as current smoker (>100 cigarettes during whole life), ex-smoker, or non-smoker. For alcohol use, subjects were categorized as drinkers if they had drunk alcohol at least once a month for the last 12 months, or non-drinkers. Periodic physical activity was categorized according to the performance of mid-intensity activity (at least 2.5 hours per week) and high-intensity activity (at least 1 hour, 15 minutes per week), with 1 minute of high-intensity activity equivalent to 2 minutes of mid-intensity activity. Stress perception was categorized as low or high.

2.2.4. Statistical analysis. We performed all of the analyses for all participants together and then also separately for men and women. We used the independent *t* test and chi-squared test to analyze differences according to sex. Continuous variables were expressed as means ± standard errors and nominal variables as frequencies and percentages (standard error). The simple relationships between BMI groups and various factors were examined using the chi-squared test. We applied logistic regression analyses to estimate the odds ratios (ORs) and 95% confidence intervals (CIs) between BMI groups and depression. The included covariates were age, education level, household income, residential area, marital status, comorbidities, smoking, alcohol drinking, and stress perception those had significant relationship with obesity or depression. Crude ORs were obtained to evaluate the unadjusted relationships between obesity and depression, and then 2 sets of models were applied. The first model used several socio-demographic variables to account for well-known risk factors. Specifically, we included age, education level, household income, residential area, and marital status. The second model used disease- and health-related variables such as comorbidities, smoking, alcohol drinking, and stress perception. Missing values of confounders were excluded

in all analyses. All statistical analyses were performed using PASW SPSS ver.18.0 software (SPSS, Chicago, IL). We considered the variables with P values $<.05$ as statistically significant.

3. Results

3.1. Baseline characteristics

Among a total of 4026 cases, 1692 (42.0%) were men and 2334 (58.0%) were women. The average age was 46.21 ± 13.96, the average BMI was 23.63 ± 3.44, and the average PHQ-9 score was 2.70 ± 3.60. The ratio of overweight subjects was 26.3%, and of obese subjects was 4.3%. The total number of cases with PHQ-9 scores >10 was 5.7%, with 3.9% men and 7.0% women, thus women had a higher rate of depression ($P < .001$). Other variables, excluding residential area, comorbidities, and cancer, showed significant differences between men and women (Table 1). Tables 2 and 3 show the baseline socio-demographic characteristics of men and women according to BMI groups. The normal weight group had a higher ratio of greater household income, and the overweight and obese groups had higher ratios of mid-level household income. The ratio of alcohol drinkers was higher in the overweight group (Table 2). Women BMI groups showed significant differences in all of the factors, excluding cancer diagnosis, alcohol drinking habit, and exercise status (Table 3). The underweight and normal weight groups had higher education and income levels, and a greater incidence of living in urban areas. The underweight group had significantly higher rates of being single and current smokers, and had higher stress levels. PHQ-9 depression prevalence was highest in the underweight group in both men (18.6%) and women (15.5%) (Tables 2 and 3).

3.2. Bivariate analyses

A significantly lower prevalence of depression based on the PHQ-9 assessment was found for aged 40–49 years, education level above college, high household income, and married subjects. A significantly higher prevalence of depression was found for current smokers ($P = .02$), and with those subjects reporting high stress levels ($P < .001$). Alcohol drinking and regular exercise had no associations with depression (Table 4).

3.3. Multivariate analyses

Underweight men had a higher risk of depression (OR: 5.71, 95% CI: 2.48, 13.15) than normal weight men. Lower ORs of depression were found for overweight men (OR = 0.76, 95% CI: 0.12, 1.35) and obese men (OR = 0.95, 95% CI: 0.29, 3.14) than normal weight men, although this was not statistically significant (Table 5). Higher depression ORs were found in underweight (OR = 2.65, 95% CI: 1.61, 4.35) and obese women (OR = 1.55, 95% CI: 0.76, 3.16) than in normal weight women; however, this was significant only among underweight women. The depression OR of overweight women was low (OR = 0.90, 95% CI: 0.58, 1.38), but was not significant (Table 5). The abovementioned results among men and women were maintained even after adjustments were made in models 1 and 2. The depression OR of the underweight group was significantly high in both men (OR = 3.27, 95% CI: 1.22, 8.75) and women (OR = 2.00, 95% CI: 1.12, 3.57) even after adjusting for age, education level, household income, residential area, marital status, comorbidities, smoking, alcohol drinking, and stress perception (Table 5).

4. Discussion

We investigated the relationship between obesity and depression in Korean population by cross-sectional study. Only underweight group had a significantly higher risk of depression than normal weight group in both men and women. Our results showed that the underweight group (BMI <18.5) had the greatest risk of depression, followed by the obese group (BMI >30), the normal weight group (BMI 18.5–25), and the overweight group (BMI 25–30), consecutively. This is similar to the trend shown in the study by Noh et al[41] that showed a U-shaped distribution. The authors used data from the 2010 Korean Longitudinal Study of Aging conducted by the Korean Labor Institute, and showed a significant relationship between BMI and depression symptoms in 7920 Korean adults 50 to 102 years old. The groups were classified using the WHO Asia-Pacific criteria. The underweight group (BMI <18.5) had the highest incidence of depression, with the highest Center for Epidemiologic Studies Depression Scale (CES-D) scores, followed by the severely obese group (BMI >30), normal weight group (BMI 18.5–23), and obese group (BMI 25–30), consecutively. The overweight group (BMI 23–25) had the lowest incidence of depression, with the lowest CES-D scores. Both women and men in the underweight group had high incidences of depression.[41]

As our multivariate analyses revealed, the underweight group showed a significant positive association with depression, with an OR of 3.34. Underweight men had a greater risk of depression (OR = 5.71) than underweight women (OR = 2.65). These results remained after adjusting for covariates such as age, education level, household income, residential area, marital status, comorbidities, smoking, alcohol drinking habits, and stress perception. Although it was not significant, the obese group showed a positive relationship with depression (OR = 1.27), while the overweight and above overweight groups had negative relationships with depression (OR = 0.77 and 0.84, respectively).

There have been several studies on the relationship between obesity and depression, but their outcomes have been inconsistent. One Korean study on elderly Korean adults >60 years old showed that obesity indices and depression symptoms were only significant in women and not men. Obese women with a BMI >25 were less likely to be depressed than underweight women with a BMI <23. Overweight women did not show any significant relationships.[42] Another Korean study on Korean adult women >20 years old showed that obese women with a BMI >25 had a higher incidence of depression, with high CES-D scores, followed by overweight and normal weight women, consecutively. They did not assess the underweight group.[43]

What are the reasons for these differences in results among studies investigating the association between BMI and body weight, even when performed with participants from similar cultural backgrounds? First, differences in the ages of the participants may contribute to the conflicting results. Elderly subjects aged ≥60 years are at a higher risk of developing comorbidities than their younger counterparts, and limitations in the physical and cognitive abilities of older adults may also affect their body weight or lead to mental health problems, such as depression.[22] Further, even younger adults between the ages of 20 and 40 years who are socially and economically active have different priorities and values, and urban and rural dwellers are exposed to different stress-inducing environmental factors; these

Table 1

Baseline characteristics of study subjects.

	Total	Men	Women	*P*
Number	4026 (100)	1692 (42.0)	2334 (58.0)	
Age, yr	46.21 ± 13.96	46.49 ± 14.15	46.01 ± 13.82	.29
Height, cm	163.38 ± 8.88	170.88 ± 6.55	157.95 ± 5.89	<.001
Weight, kg	63.31 ± 11.92	71.22 ± 11.15	57.57 ± 8.75	<.001
WC, cm	80.43 ± 9.90	85.02 ± 8.90	77.10 ± 9.24	<.001
BMI, kg/m^2	23.63 ± 3.44	24.35 ± 3.29	23.10 ± 3.46	<.001
PHQ-9 score	2.70 ± 3.60	2.12 ± 3.06	3.13 ± 3.89	<.001
Obesity status				<.001
Underweight: <18.5	185 (4.6)	43 (2.5)	142 (6.1)	
Normal: 18.5 to <25.0	2609 (64.8)	988 (58.4)	1621 (69.5)	
Overweight: 25 to <30	1057 (26.3)	579 (34.2)	478 (20.5)	
Obesity: ≥30	175 (4.3)	82 (4.8)	93 (4.0)	
PHQ-9 score				<.001
<10	3796 (94.3)	1626 (96.1)	2170 (93.0)	
≥10	230 (5.7)	66 (3.9)	164 (7.0)	
Age, yr				.50
19–29	566 (14.1)	231 (13.7)	335 (14.4)	
30–39	821 (20.4)	351 (20.7)	470 (20.1)	
40–49	841 (20.9)	347 (20.5)	494 (21.2)	
50–59	939 (23.3)	382 (22.6)	557 (23.9)	
60–69	859 (21.3)	381 (22.5)	478 (20.5)	
Education (missing 2)				<.001
Elementary (≤6 y)	613 (15.2)	186 (11.0)	427 (18.3)	
Junior high (≤9 y)	439 (10.9)	186 (11.0)	253 (10.8)	
Senior high (10–12 y)	1489 (37.0)	635 (37.5)	854 (36.6)	
College (≥13 y)	1483 (36.9)	685 (40.5)	798 (34.2)	
Household income (missing 11)				.01
Low	451 (11.2)	163 (9.7)	288 (12.4)	
Middle low	1033 (25.7)	417 (24.7)	616 (26.5)	
Middle high	1291 (32.2)	566 (33.5)	725 (31.2)	
High	1240 (30.9)	543 (32.1)	697 (30.0)	
Residential areas				.10
Urban	3390 (84.2)	1406 (83.1)	1984 (85.0)	
Rural	636 (15.8)	286 (16.9)	350 (15.0)	
Marital status (missing 2)				<.001
Married	2966 (73.7)	1250 (73.9)	1716 (73.5)	
Never married	732 (18.2)	360 (21.3)	372 (15.9)	
Other	326 (8.1)	81 (4.8)	245 (10.5)	
Comorbidities				.58
No	2815 (69.9)	1191 (70.4)	1624 (69.6)	
Yes	1211 (30.1)	501 (29.6)	710 (30.4)	
Cancer				.09
No	3868 (96.1)	1636 (96.7)	2232 (95.6)	
Yes	158 (3.9)	56 (3.3)	102 (4.4)	
Smoking (missing 29)				<.001
Non-smoker	2459 (61.5)	374 (22.4)	2085 (89.7)	
Ex-smoker	699 (17.5)	571 (34.1)	128 (5.5)	
Current smoker	839 (21.0)	728 (43.5)	111 (4.8)	
Alcohol (missing 27)				<.001
<1/mo	1746 (43.7)	433 (25.9)	1313 (56.5)	
≥1/mo	2253 (56.3)	1241 (74.1)	1012 (43.5)	
Periodic physical activity (missing 8)				<.001
No	1769 (44.0)	676 (40.0)	1093 (46.9)	
Yes	2249 (56.0)	1013 (60.0)	1236 (53.1)	
Stress perception (missing 29)				<.01
Low	2997 (75.0)	1290 (77.1)	1707 (73.5)	
High	1000 (25.0)	383 (22.9)	617 (26.5)	

Missing values were excluded. Data expression as estimated mean ± standard error or estimated percent (standard error), as appropriate; *P*-value was obtained by independent *t* test or chi-squared test. BMI = body mass index, PHQ-9 = 9-item Patient Health Questionnaire, WC = waist circumference.

aspects may also contribute to the differences in study results. Therefore, one of the merits of this study is that it improves sample representation using the KNHANES data of individuals between 18 and 69 years of age.

A study conducted in China and Japan revealed that obesity had a negative linear association with depression.[16,44] A number of other Asian studies have also presented data that support the "jolly fat person" hypothesis. The hypothesis suggests that the

Table 2

Relationship of various characteristics and body mass index groups (Men = 1692).

	Underweight	Normal	Overweight	Obese	*P*
Number	43 (2.5)	988 (58.4)	579 (34.2)	82 (4.8)	
PHQ-9 score					<.001
<10	35 (81.4)	950 (96.2)	562 (97.1)	79 (96.3)	
≥10	8 (18.6)	38 (3.8)	17 (2.9)	3 (3.7)	
Age, y					<.01
19–29	14 (32.6)	146 (14.8)	56 (9.7)	15 (18.3)	
30–39	6 (14.0)	188 (19.0)	132 (22.8)	25 (30.5)	
40–49	6 (14.0)	204 (20.6)	120 (20.7)	17 (20.7)	
50–59	7 (16.3)	220 (22.3)	142 (24.5)	13 (15.9)	
60–69	10 (23.3)	230 (23.3)	129 (22.3)	12 (14.6)	
Education					.75
Elementary (≤6 y)	8 (18.6)	107 (10.8)	63 (10.9)	8 (9.8)	
Junior high (≤9 y)	6 (14.0)	111 (11.2)	61 (10.5)	8 (9.8)	
Senior high (10–12 y)	18 (41.9)	366 (37.0)	218 (37.7)	33 (40.2)	
College (≥13 y)	11 (25.6)	404 (40.9)	237 (40.9)	33 (40.2)	
Household income (missing 3)					.01
Low	9 (20.9)	100 (10.1)	48 (8.3)	6 (7.3)	
Middle low	13 (30.2)	241 (24.4)	136 (23.5)	27 (32.9)	
Middle high	11 (25.6)	307 (31.1)	220 (38.1)	28 (34.1)	
High	10 (23.3)	338 (34.3)	174 (30.1)	21 (25.6)	
Residential areas					.21
Urban	32 (74.4)	814 (82.4)	493 (85.1)	67 (81.7)	
Rural	11 (25.6)	174 (17.6)	86 (14.9)	15 (18.3)	
Marital status (missing 1)					<.01
Married	23 (53.5)	711 (72.0)	460 (79.4)	56 (68.3)	
Never married	17 (39.5)	225 (22.8)	94 (16.2)	24 (29.3)	
Other	3 (7.0)	51 (5.2)	25 (4.3)	2 (2.4)	
Comorbidities					<.001
No	35 (81.4)	738 (74.7)	364 (62.9)	54 (65.9)	
Yes	8 (18.6)	250 (25.3)	215 (37.1)	(25.3)	
Cancer					.17
No	39 (90.7)	957 (96.9)	561 (96.9)	79 (96.3)	
Yes	4 (9.3)	31 (3.1)	18 (3.1)	3 (3.7)	
Smoking (missing 19)					.77
Non-smoker	9 (20.9)	223 (22.8)	119 (20.8)	23 (28.4)	
Ex-smoker	13 (30.2)	329 (33.7)	203 (35.4)	26 (32.1)	
Current smoker	21 (48.8)	424 (43.4)	251 (43.8)	32 (39.5)	
Alcohol (missing 18)					.03
<1/mo	19 (44.2)	252 (25.8)	138 (24.1)	24 (29.6)	
≥1/mo	24 (55.8)	725 (74.2)	435 (75.9)	57 (70.4)	
Periodic physical activity (missing 3)					.73
No	19 (44.2)	390 (39.6)	230 (39.8)	37 (45.1)	
Yes	24 (55.8)	596 (60.4)	348 (60.2)	45 (54.9)	
Stress perception (missing 19)					.10
Low	27 (62.8)	761 (78.0)	443 (77.3)	59 (72.8)	
High	16 (37.2)	215 (22.0)	130 (22.7)	22 (27.2)	

Missing values were excluded.

P-value was obtained by chi-squared test.

PHQ-9 = 9-item Patient Health Questionnaire.

degree of obesity is inversely proportional to anxiety in middle-aged women and men, and is also inversely proportional to depression, particularly in men.[18,45] However, multiple studies have reported results that do not concur with this hypothesis. Most American studies report that degree of obesity is proportional to depression in women, although it is not significantly related to depression in men.[24,25,46] Moreover, studies performed in the same country do not necessarily show similar results. Some studies report that depression increases as BMI increases,[12–15] whereas other studies assert that depression increases as BMI decreases.[16–21] Still, other studies suggest that there is no correlation between the 2 parameters.[22,23] What are the factors that contribute to such different results? First, the relationship between obesity and depression, and the contribution of neurotransmitters, play a role in these variable results. There are several factors that affect obesity and depression including the degree of obesity, race, sex, socioeconomic status, and gene–environment interactions.[25]

We speculate that depression is higher among underweight individuals because after correcting for factors such as the demographics, financial security, and cultural backgrounds of participants, thinner and fitter individuals are likely to feel happy while corpulent individuals are likely to feel depressed. Because it has been demonstrated that anxiety and depression increase

Table 3

Relationship of various characteristics and body mass index groups (Women = 2334).

	Underweight	Normal	Overweight	Obese	*P*
Number	142 (6.1)	1621 (69.5)	478 (20.5)	93 (4.0)	
PHQ-9 score					<.001
<10	120 (84.5)	1516 (93.5)	450 (94.1)	84 (90.3)	
≥10	22 (15.5)	105 (6.5)	28 (5.9)	9 (9.7)	
Age, yr					<.001
19–29	58 (40.8)	233 (14.4)	33 (6.9)	11 (11.8)	
30–39	42 (29.6)	349 (21.5)	63 (13.2)	16 (17.2)	
40–49	24 (16.9)	364 (22.5)	89 (18.6)	17 (18.3)	
50–59	14 (9.9)	383 (23.6)	136 (28.5)	24 (25.8)	
60–69	4 (2.8)	292 (18.0)	157 (32.8)	25 (26.9)	
Education (missing 2)					<.001
Elementary (≤6 y)	5 (3.5)	242 (14.9)	154 (32.2)	26 (28.0)	
Junior high (≤9 y)	6 (4.2)	164 (10.1)	75 (15.7)	8 (8.6)	
Senior high (10–12 y)	54 (38.0)	603 (37.2)	157 (32.8)	40 (43.0)	
College (≥13 y)	77 (54.2)	610 (37.7)	92 (19.2)	19 (20.4)	
Household income (missing 8)					<.01
Low	19 (13.4)	177 (11.0)	77 (16.2)	15 (16.1)	
Middle low	35 (24.6)	410 (25.4)	145 (30.5)	26 (28.0)	
Middle high	44 (31.0)	502 (31.1)	149 (31.3)	30 (32.3)	
High	44 (31.0)	526 (32.6)	105 (22.1)	22 (23.7)	
Residential areas					<.001
Urban	127 (89.4)	1407 (86.8)	379 (79.3)	71 (76.3)	
Rural	15 (10.6)	214 (13.2)	99 (20.7)	22 (23.7)	
Marital status (missing 1)					<.001
Married	65 (45.8)	1196 (73.9)	385 (80.5)	70 (75.3)	
Never married	64 (45.1)	258 (15.9)	37 (7.7)	13 (13.0)	
Other	13 (9.2)	166 (10.2)	56 (11.7)	10 (10.8)	
Comorbidities					<.001
No	131 (92.3)	1200 (74.0)	242 (50.6)	51 (54.8)	
Yes	11 (7.7)	421 (26.0)	236 (49.4)	42 (45.2)	
Cancer					.74
No	138 (97.2)	1547 (95.4)	457 (95.6)	90 (96.8)	
Yes	4 (2.8)	74 (4.6)	21 (4.4)	3 (3.2)	
Smoking (missing 10)					<.01
Non-smoker	113 (79.6)	1459 (90.4)	431 (90.7)	82 (88.2)	
Ex-smoker	19 (13.4)	77 (4.8)	26 (5.5)	6 (6.5)	
Current smoker	10 (7.0)	78 (4.8)	18 (3.8)	5 (5.4)	
Alcohol (missing 9)					.52
<1/mo	74 (52.1)	906 (56.1)	277 (58.2)	56 (60.2)	
≥1/mo	68 (47.9)	708 (43.9)	199 (41.8)	37 (39.8)	
Periodic physical activity (missing 5)					.08
No	75 (52.8)	732 (45.3)	243 (50.9)	43 (46.2)	
Yes	67 (47.2)	885 (54.7)	234 (49.1)	50 (53.8)	
Stress perception (missing 10)					<.01
Low	87 (61.3)	1180 (73.1)	369 (77.7)	71 (76.3)	
High	55 (38.7)	434 (26.9)	106 (22.3)	22 (23.7)	

P-value was obtained by chi-squared test.

PHQ-9 = 9-item patient health questionnaire. Missing values were excluded.

when individuals attempt to lose weight, obsessing over weight loss may lead to a loss of appetite, and in more severe cases, to depression.[47] On the other hand, we put forth the following reasons to explain why depression may be higher among relatively obese individuals. First, individuals with depression demonstrate either a reduced or an increased appetite. Appetite may increase as depression causes the brain to release an excessive amount of the stress hormone cortisol compared with normal individuals. Elevated cortisol increases appetite, and leads to the accumulation of fat within the viscera, leading to increased visceral fat and obesity.[48] Moreover, insufficient levels of the neurotransmitter serotonin cause depression. Because sugar intake increases the release of serotonin, individuals with depression often experience sugar cravings. Compared with normal weight individuals, obese individuals tend to resort to binge eating during emotionally stressful situations, such as when they are angry, lonely, bored, or depressed, in an attempt to relieve such negative emotions through eating.[49] Furthermore, when obese individuals are on a diet, food deprivation may exacerbate their depression. As such, obesity and depression are in a mutual causal relationship, which may contribute to the differences in findings among studies.[50] Hence, studies should take various socio-demographic and health-related features into account, depending on the age and sex of the subjects.

The second reason for the disparity in the results among studies on obesity and depression is that the means used to assess

Table 4

Relationship of various characteristics and depression groups.

	PHQ-9 score <10	PHQ-9 score ≥10	*P*
Number	3796 (94.3)	230 (5.7)	
WC, cm	80.57 ± 9.85	78.11 ± 10.48	<.001
BMI, kg/m^2	23.67 ± 3.40	22.90 ± 3.97	<.01
Age, y			<.01
19–29	515 (13.6)	51 (22.2)	
30–39	771 (20.3)	50 (21.7)	
40–49	810 (21.3)	31 (13.5)	
50–59	892 (23.5)	47 (20.4)	
60–69	808 (21.3)	51 (22.2)	
Education (missing 2)			.01
Elementary (≤6 y)	563 (14.8)	50 (21.7)	
Junior high (≤9 y)	414 (10.9)	25 (10.9)	
Senior high (10–12 y)	1400 (36.9)	89 (38.7)	
College (≥13 y)	1417 (37.3)	66 (28.7)	
Household income (missing 11)			<.001
Low	387 (10.2)	64 (27.9)	
Middle low	974 (25.7)	59 (25.8)	
Middle high	1236 (32.6)	55 (24.0)	
High	1189 (31.4)	51 (22.3)	
Residential areas			.42
Urban	3192 (84.1)	198 (86.1)	
Rural	604 (15.9)	32 (13.9)	
Marital status (missing 2)			<.001
Married	2834 (74.7)	132 (57.4)	
Never married	671 (17.7)	61 (26.5)	
Other	289 (7.6)	37 (16.1)	
Comorbidities			.57
No	2658 (70.0)	157 (68.3)	
Yes	1138 (30.0)	73 (31.7)	
Cancer			.08
No	3652 (96.2)	216 (93.9)	
Yes	144 (3.8)	14 (6.1)	
Smoking (missing 29)			.02
Non-smoker	2322 (61.6)	137 (59.6)	
Ex-smoker	669 (17.8)	30 (13.0)	
Current smoker	776 (20.6)	63 (27.4)	
Alcohol (missing 27)			.24
<1/mo	1637 (43.4)	109 (47.4)	
≥1/mo	2132 (56.6)	121 (52.6)	
Periodic physical activity (missing 8)			.81
No	1666 (44.0)	103 (44.8)	
Yes	2122 (56.0)	127 (55.2)	
Stress perception (missing 29)			<.001
Low	2946 (78.2)	51 (22.2)	
High	821 (21.8)	179 (77.8)	

P-value was obtained by chi-squared test.

BMI = body mass index, PHQ-9 = 9-item Patient Health Questionnaire. Missing values were excluded, WC = waist circumference.

depression vary across studies. There are multiple scales used to measure depression symptoms, including CES-D, GDS, and PHQ-9.[51] One of the scales, CES-D, includes multiple parameters and is relatively more time-consuming to use. In addition, it asks the participant questions related to the last week, which may lead to different responses when administered in the future. PHQ-9, on the other hand, is shorter and simpler, and is likely to have less variation and higher accuracy in the responses of participants during future administration, because it asks the participant about the last 2 weeks.[51] As seen here, the choice of scale used to assess depression varies across studies, and even when the same scale is used, the cut-off score for depression may vary. For instance, a total score of ≥16 on the CES-D scale is typically used to diagnose depression in a patient. However, the optimal cut-off score is still under debate.[52,53] Most studies described previously used a cut-off score of 10 on the CES-D to diagnose depression. The study by Son and Kim[43] defined the cut-off as 21 points, whereas the study by Kim et al[54] used a cut-off score of 25 points. Variation in cut-off scores for the scales used to assess depression results in variation in the sensitivity and specificity of the scale, ultimately leading to differences in depression diagnoses and conflicting results in terms of the severity of depression.

Our study had a couple of limitations. First, it used a cross-sectional design, which hindered the accurate examination of the causal relationship between obesity and depression risk. Second, this study assessed the severity of depression symptoms at the time of BMI measurement. Hence, we did not consider cases characterized as "incidences of depression" or "diagnosis of depression by a physician," and only used the PHQ-9 score, a scale used to assess depression that reflects the respondent's state of mind for the past 2 weeks. Third, this study may contain a residual confounding effect due to variables not considered in relation to obesity and depression. Nevertheless, this study also had several advantages. First, the representation of samples was enhanced using KNHANES 2014. Few studies about depression and obesity conducted in Asians. This work involved a large-scale, nationwide study of the Korean population. Second, we compared all of the age groups relatively consistently, without placing emphasis on the younger or older generation, using data for individuals aged 18 to 69 years. Third, we classified underweight, normal, overweight, and obese groups according to international WHO BMI criteria, not restricted to

Table 5

Logistic regression analysis for obesity and depression.

		Crude OR	*P*	Adjusted OR*	*P*	Adjusted OR†	*P*
Total	Normal weight	1.00		1.00		1.00	
	Underweight	3.34 (2.18, 5.11)	<.001	2.76 (1.77, 4.30)	.00	2.38 (1.45, 3.88)	<.01
	Overweight	0.77 (0.54, 1.08)	.13	0.75 (0.53, 1.07)	.11	0.73 (0.50, 1.06)	.10
	Obesity	1.27 (0.69, 2.34)	.44	1.17 (0.63, 2.17)	.61	1.21 (0.62, 2.33)	.58
	Above overweight	0.84 (0.61, 1.15)	.27	0.82 (0.59, 1.12)	.21	0.80 (0.57, 1.13)	.20
Men	Normal weight	1.00		1.00		1.00	
	Underweight	5.71 (2.48, 13.15)	<.001	4.18 (1.74, 10.01)	.001	3.27 (1.22, 8.75)	.02
	Overweight	0.76 (0.12, 1.35)	.35	0.77 (0.43, 1.38)	.38	0.60 (0.32, 1.13)	.11
	Obesity	0.95 (0.29, 3.14)	.93	0.83 (0.25, 2.80)	.77	0.62 (0.17, 2.27)	.47
	Above overweight	0.78 (0.45, 1.35)	.38	0.78 (0.45, 1.36)	.38	0.60 (0.33, 1.10)	.10
Women	Normal weight	1.00		1.00		1.00	
	Underweight	2.65 (1.61, 4.35)	<.001	2.19 (1.29, 3.70)	.003	2.00 (1.12, 3.57)	.02
	Overweight	0.90 (0.58, 1.38)	.63	0.85 (0.54, 1.32)	.47	0.90 (0.56, 1.45)	.66
	Obesity	1.55 (0.76, 3.16)	.23	1.46 (0.71, 3.01)	.31	1.75 (0.79, 3.88)	.17
	Above overweight	1.00 (0.68, 1.47)	.99	0.95 (0.63, 1.41)	.79	1.03 (0.67, 1.58)	.91

Results are presented odds ratio (OR) or adjusted OR with 95% confidence interval (95% CI) by using logistic regression analysis.

* Adjusted for age, educational level, household income, habitation, and marital status.

† Adjusted for age, educational level, household income, habitation, marital status, comorbidities, smoking, alcohol drinking, and stress perception.

the Asia-pacific criteria. In addition, considering that the typical BMI cut-off for obesity in Asia is 25, we included both obese (BMI >30) and overweight (BMI between 25.0 and 29.9) groups as "above overweight" group in our analysis. Finally, we used PHQ-9 scores to assess degrees of depression. In the future, we plan to design longitudinal cohort studies considering the bidirectional mutual relationship between obesity and depression.

In conclusion, being underweight can increase the risk of developing depression, and obesity may also be a risk factor.

5. Author contributions

Soo Min Hong contributed to the study concept and design, interpretation, and results, and wrote the manuscript; Yang-Im Hur contributed to the study concept and design, analysis and interpretation of the data, statistical analysis, and manuscript writing. All of the authors reviewed and approved the final manuscript.

References

[1] World Health Organization (2016) Obesity and overweight. http://www.who.int/mediacentre/factsheets/fs311/en/ Accessed April 30, 2017.

[2] Kim NS, Moon OR, Kang JH, et al. Increasing prevalence of obesity related disease for Koreans associated with overweight and obesity. Korean J Prev Med 2001;34:309–15.

[3] Ma J, Xiao L. Obesity and depression in US women: results from the 2005–2006 National Health and Nutritional Examination Survey. Obesity (Silver Spring) 2010;18:347–53.

[4] Chapman DP, Perry GS, Strine TW. The vital link between chronic disease and depressive disorders. Prev Chronic Dis 2005;2:A14.

[5] Park JH, Yoon SJ, Lee HY, et al. Estimating the burden of psychiatric disorder in Korea. J Prev Med Public Health 2006;39:39–45.

[6] Ladwig KH, Marten-Mittag B, Lowel H, et al. Synergistic effects of depressed mood and obesity on long-term cardiovascular risks in 1510 obese men and women: results from the MONICA-KORA Augsburg Cohort Study 1984–1998. Int J Obes (Lond) 2006;30:1408–14.

[7] Werrij MQ, Mulkens S, Hospers HJ, et al. Overweight and obesity: the significance of a depressed mood. Patient Educ Couns 2006;62:126–31.

[8] Fabricatore AN, Wadden TA, Higginbotham AJ, et al. Intentional weight loss and changes in symptoms of depression: a systematic review and meta-analysis. Int J Obes (Lond) 2011;35:1363–76.

[9] de Wit L, Luppino F, van Straten A, et al. Depression and obesity: a meta-analysis of community-based studies. Psychiatry Res 2010;178:230–5.

[10] Atalantis E, Baker M. Obesity effects on depression: systematic review of epidemiological studies. Int J Obes (Lond) 2008;32:881–91.

[11] McCrea RL, Berger YG, King MB. Body mass index and common mental disorders: exploring the shape of the association and its moderation by age, gender and education. Int J Obes (Lond) 2012;36:414–21.

[12] Ohayon MM. Epidemiology of depression and its treatment in the general population. J Psychiatr Res 2007;41:207–13.

[13] Sachs-Ericsson N, Burns AB, Gordon KH, et al. Body mass index and depressive symptoms in older adults: the moderating roles of race, sex, and socioeconomic status. Am J Geriatr Psychiatry 2007;15:815–25.

[14] Zhong W, Cruickshanks KJ, Schubert CR, et al. Obesity and depression symptoms in the Beaver Dam Offspring Study population. Depress Anxiety 2010;27:846–51.

[15] Li ZB, Ho SY, Chan WM, et al. Obesity and depressive symptoms in Chinese elderly. Int J Geriatr Psychiatry 2004;19:68–74.

[16] Chang HH, Yen ST. Association between obesity and depression: evidence from a longitudinal sample of the elderly in Taiwan. Aging Ment Health 2012;16:173–80.

[17] Crisp AH, Queenan M, Sittampaln Y, et al. 'Jolly fat' revisited. J Psychosom Res 1980;24:233–41.

[18] Kuo SY, Lin KM, Chen CY, et al. Depression trajectories and obesity among the elderly in Taiwan. Psychol Med 2011;41:1665–76.

[19] Palinkas LA, Wingard DL, Barrett-Connor E. Depressive symptoms in overweight and obese older adults: a test of the "jolly fat" hypothesis. J Psychosom Res 1996;40:59–66.

[20] Yu NW, Chen CY, Liu CY, et al. Association of body mass index and depressive symptoms in a Chinese community population: results from the Health Promotion Knowledge, Attitudes, and Performance Survey in Taiwan. Chang Gung Med J 2011;34:620–7.

[21] Forman-Hoffman VL, Yankey JW, Hillis SL, et al. Weight and depressive symptoms in older adults: direction of influence? J Gerontol B Psychol Sci Soc Sci 2007;62:S43–51.

[22] Ohayon MM, Hong SC. Prevalence of major depressive disorder in the general population of South Korea. J Psychiatr Res 2006;40:30–6.

[23] Heo M, Pietrobelli A, Fontaine K, et al. Depressive mood and obesity in US adults: comparison and moderation by sex, age, and race. Int J Obes (Lond) 2006;30:513–9.

[24] Carpenter KM, Hasin DS, Allison DB, et al. Relationships between obesity and DSM-IV major depressive disorder, suicide ideation, and suicide attempts: results from a general population study. Am J Public Health 2000;90:251–7.

[25] Stunkard AJ, Faith MS, Allison KC. Depression and obesity. Biol Psychiatry 2003;54:330–7.

[26] Konttinen H, Kiviruusu O, Huurre T, et al. Longitudinal associations between depressive symptoms and body mass index in a 20-year follow-up. Int J Obes (Lond) 2014;38:668–74.

[27] Luppino FS, de Wit LM, Bouvy PF, et al. Overweight, obesity, and depression. A systematic review and meta-analysis of longitudinal studies. Arch Gen Psychiatry 2010;67:220–9.

[28] Jokela M, Berg V, Silventoinen K, et al. Body mass index and depressive symptoms: testing for adverse and protective associations in two twin cohort studies. Twin Res Hum Genet 2016;19:306–11.

[29] Korean Society for the Study of Obesity, Obesity fact sheet 2016. http://www.kosso.or.kr/file/factsheet_1006new6_web.pdf/ Accessed April 30, 2017.

[30] Kweon S, Kim Y, Jang MJ, et al. Data resource profile: the Korea National Health and Nutrition Examination Survey (KNHANES). Int J Epidemiol 2014;43:69–77.

[31] World Health Organization. The Asia-Pacific Perspective: Redefining Obesity and its Treatment. Sydney: Health Communications Australia; 2000.

[32] Barba C, Cavalli-Sforza T, Cutter J, et al. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet 2004;363:157–63.

[33] Han C, Jo SA, Kwak JH, et al. Validation of the Patient Health Questionnaire-9 Korean version in the elderly population: the Ansan Geriatric study. Compr Psychiatry 2008;49:218–23.

[34] Spitzer RL, Williams JB, Kroenke K, et al. Validity and utility of the PRIME-MD patient health questionnaire in assessment of 3000 obstetric-gynecologic patients: the PRIME-MD Patient Health Questionnaire Obstetrics-Gynecology Study. Am J Obstet Gynecol 2000;183:759–69.

[35] Association APDiagnostic and statistical manual of mental disorders. 4th editionAmerican psychiatric association, Washington DC:1994.

[36] Association APDiagnostic and Statistical Manual of Mental Disorders. 3rd editionAmerican Psychiatric Association, Washington DC:1987.

[37] Kroencke K, Spitzer R, Williams J. The PHQ-9: validity of a brief depression severity measure. J Gen Intern Med 2001;16:606–13.

[38] Choi HS, Choi JH, Park KH, et al. Standardization of the Korean version of Patient Health Questionnaire-9 as a screening instrument for major depressive disorder. J Korean Acad Fam Med 2007;28:114–9.

[39] Yoon YS, Oh SW, Park HS. Socioeconomic status in relation to obesity and abdominal obesity in Korean adults: a focus on sex differences. Obesity (Silver Spring) 2006;14:909–19.

[40] Kendler KS, Gardner CO, Prescott CA. Toward a comprehensive developmental model for major depression in men. Am J Psychiatry 2006;163:115–24.

[41] Noh JW, Kwon YD, Park J, et al. Body mass index and depressive symptoms in middle aged and older adults. BMC Public Health 2015;15:310.

[42] Kim E, Song JH, Hwang JY, et al. Obesity and depressive symptoms in elderly Koreans: evidence for the "Jolly Fat" hypothesis from the Ansan Geriatric (AGE) Study. Arch Gerontol Geriatr 2010;51:231–4.

[43] Son YJ, Kim G. The relationship between obesity, self-esteem and depressive symptoms of adult women in Korea. Korean J Obes 2012;21:89–98.

[44] Kuriyama S, Koizumi Y, Matsuda-Ohmori K, et al. Obesity and depressive symptoms in elderly Japanese: the Tsurugaya Project. J Psychosom Res 2006;60:229–35.

[45] Crisp AH, McGuiness B. Jolly fat: relation between obesity and psychoneurosis in general population. Br Med J 1976;1:7–9.

[46] Istvan J, Zavela K, Weidner G. Body weight and psychological distress in NHANES I. Int J Obes Relat Metab Disord 1992;16:999–1003.

[47] Glucksman ML, Hirsch J. The response of obese patients to weight reduction: a clinical evaluation of behavior. Psychosom Med 1968;30:1–1.
[48] Katon W, Ciechanowski P. Impact of major depression on chronic medical illness. J Psychosom Res 2002;53:859–63.
[49] Ganley RM. Emotion and eating in obesity: a review of the literature. Int J Eat Disord 1989;8:343–61.
[50] Markowitz S, Friedman MA, Arent SM. Understanding the relation between obesity and depression: causal mechanisms and implications for treatment. Clin Psychol Sci Prac 2008;15:1–20.
[51] Smarr KL, Keefer AL. Measures of depression and depressive symptoms: Beck Depression Inventory-II (BDI-II), Center for Epidemiologic Studies Depression Scale (CES-D), Geriatric Depression Scale (GDS), Hospital Anxiety and Depression Scale (HADS), and Patient Health Questionnaire-9 (PHQ-9). Arthritis Care Res (Hoboken) 2011;63(Suppl):S454–66.
[52] Haringsma R, Engels G, Beekman A, et al. The criterion validity of the Center for Epidemiological Studies Depression Scale (CES-D) in a sample of self-referred elders with depressive symptomatology. Int J Geriatr Psychiatry 2004;19:558–63.
[53] Turk DC, Okifuji A. Detecting depression in chronic pain patients: adequacy of self-reports. Behav Res Ther 1994;32:9–16.
[54] Kim JY, Chang HM, Cho JJ, et al. Relationship between obesity and depression in the Korean working population. J Korean Med Sci 2010;25:1560–7.