Relationship between obesity and depression in Korean adults
Korea National Health and Nutrition Examination Survey 2014
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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 Korean 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 $\geq 10$ 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 $\geq 30$]: 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.\textsuperscript{1} As the prevalence of obesity increases, obesity-related diseases such as hypertension and dyslipidemia will frequently arise.\textsuperscript{2} Obesity contributes to other comorbidities and depression is one of the most common psychiatric disorders related to obesity.\textsuperscript{3} Obesity and depression contribute to the global burden of economic costs, morbidities, and mortalities.\textsuperscript{4,5} These conditions correlate with many complications such as cardiovascular diseases and diabetes mellitus.\textsuperscript{6,7} Previous studies on the relationship between obesity and depression had contradictory outcomes.\textsuperscript{8–10} Some studies reported that obese people also tend to have depression,\textsuperscript{11–14} but other studies did not support this conclusion in all subjects.\textsuperscript{15–20} Several studies found no relationship between obesity and depression,\textsuperscript{21,22} whereas others reported a positive relationship between obesity and depression in women but not in men.\textsuperscript{23,24} Obesity and depression have a reciprocal relationship.\textsuperscript{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.\textsuperscript{26,27} Interestingly, the same results were obtained in twin cohort studies.\textsuperscript{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.\textsuperscript{129} The aim of this study...
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 Korean 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-SC in 2014) and the Institutional Review Board of Seoul Paik Hospital of Inje University (Institutional Review Board No. PAIK 2017-02-003).

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 symptomatology 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 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 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
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. A number of other Asian studies have also presented data that support the “jolly fat person” hypothesis. The hypothesis suggests that the

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  | 49.49 ± 14.15  | 46.01 ± 13.82  | .29   |
| Height, cm              | 163.38 ± 8.88  | 170.88 ± 6.55  | 157.96 ± 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/m²              | 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 (6.7)      | 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 (22.3)     | 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          | 859 (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 (44.3)    | 676 (40.0)     | 1093 (46.9)    |       |
| Yes                     | 2249 (55.6)    | 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.
The degree of obesity is inversely proportional to anxiety in middle-aged women and men, and is also inversely proportional to depression, particularly in men.\textsuperscript{[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.\textsuperscript{[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,\textsuperscript{[12–15]} whereas other studies assert that depression increases as BMI decreases.\textsuperscript{[16–21]} Still, other studies suggest that there is no correlation between the 2 parameters.\textsuperscript{[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.\textsuperscript{[25]}

\begin{table}[h]
\centering
\caption{Relationship of various characteristics and body mass index groups (Men = 1692).}
\begin{tabular}{lcccc}
\hline
 & Underweight & Normal & Overweight & Obese & \\
\hline
Number & 43 (2.5) & 988 (58.4) & 579 (34.2) & 82 (4.8) & \\
PHQ-9 score & & & & & \\
<10 & 35 (81.4) & 950 (96.2) & 562 (97.1) & 79 (96.3) & <.001 \\
\geq10 & 8 (18.6) & 38 (3.8) & 17 (2.9) & 3 (3.7) & \\
Age, y & & & & & \\
19–29 & 14 (32.6) & 146 (14.8) & 56 (9.7) & 15 (18.3) & .01 \\
30–39 & 6 (14.0) & 188 (19.0) & 132 (22.8) & 25 (30.5) & \\
40–49 & 6 (14.0) & 204 (20.5) & 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 (\leq6 y) & 8 (18.6) & 107 (10.8) & 63 (10.9) & 8 (8.8) & \\
Junior high (\leq9 y) & 6 (14.0) & 111 (11.2) & 61 (10.9) & 8 (8.8) & \\
Senior high (10–12 y) & 18 (41.9) & 366 (37.0) & 218 (37.7) & 33 (40.2) & \\
College (\geq13 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 (30.3) & \\
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 (22.9) & 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) & \\
\geq1/mo & 24 (55.8) & 725 (74.2) & 435 (75.9) & 57 (70.4) & \\
Periodic physical activity (missing 3) & & & & & .73 \\
No & 19 (44.2) & 390 (39.8) & 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) & \\
\hline
\end{tabular}
\end{table}

Missing values were excluded. \(P\)-value was obtained by chi-squared test. PHQ-9 = 9-item Patient Health Questionnaire.
when individuals attempt to lose weight, obsessing over weight loss may lead to a loss of appetite, and in more severe cases, to depression. 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. 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. 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. 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 3

|                     | 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 (37.2) | 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 (70.6)  | 1459 (90.4)| 431 (90.7) | 82 (85.2)|       |
| 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)   | 865 (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.
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 comparing 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 4

| Relationship of various characteristics and depression groups. |
|---------------------------------------------------------------|
| PHQ-9 score < 10 | PHQ-9 score ≥ 10 | P |
|---------------------------------------------------------------|
| Number | 3796 (94.3) | 230 (5.7) | 1.00 |
| WC, cm² | 80.57 ± 9.85 | 78.11 ± 10.48 | <.001 |
| BMI, kg/m² | 23.67 ± 3.40 | 22.90 ± 3.97 | <.01 |
| Age, y | 19–29 | 515 (13.6) | 51 (22.2) | 1.00 |
| 30–39 | 771 (20.3) | 50 (21.7) | .81 |
| 40–49 | 810 (21.3) | 31 (13.5) | .24 |
| 50–59 | 892 (23.5) | 47 (20.4) | .02 |
| 60–69 | 906 (23.9) | 51 (22.2) | .01 |
| Education (missing 2) | Elementary (< 6 y) | 563 (14.8) | 50 (21.7) | .63 |
| Junior high (< 9 y) | 414 (10.9) | 25 (10.9) | .24 |
| Senior high (10–12 y) | 1400 (36.9) | 89 (38.7) | .02 |
| College (≥ 13 y) | 1417 (37.3) | 66 (28.7) | .01 |
| Household income (missing 11) | Low | 387 (10.2) | 64 (27.9) | .001 |
| Middle low | 974 (25.7) | 59 (25.6) | .63 |
| Middle high | 1236 (32.6) | 55 (24.0) | .24 |
| High | 1189 (31.4) | 51 (22.3) | .42 |
| Residential areas | Urban | 3192 (84.1) | 198 (86.1) | 1.00 |
| Rural | 604 (15.9) | 32 (13.9) | .24 |
| Marital status (missing 2) | Married | 2834 (74.7) | 132 (57.4) | .001 |
| Never married | 671 (17.7) | 61 (26.5) | .001 |
| Other | 289 (7.6) | 37 (16.1) | .001 |
| Cancer | No | 2658 (70.0) | 157 (68.3) | .01 |
| Yes | 1138 (30.0) | 73 (31.7) | .001 |
| Smoking (missing 29) | Non-smoker | 2322 (61.6) | 137 (59.0) | .08 |
| Ex-smoker | 669 (17.8) | 30 (13.1) | .24 |
| Current smoker | 776 (20.6) | 73 (30.7) | .01 |
| Alcohol (missing 27) | <1/mo | 1637 (43.4) | 109 (47.4) | .08 |
| ≥1/mo | 2132 (56.6) | 121 (52.6) | .001 |
| Periodic physical activity (missing 8) | No | 1666 (44.0) | 103 (44.8) | .81 |
| Yes | 2122 (56.0) | 127 (55.2) | .81 |
| Stress perception (missing 29) | Low | 2946 (78.2) | 51 (22.2) | .01 |
| High | 821 (21.8) | 179 (77.8) | .01 |

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.

Table 5

| Logistic regression analysis for obesity and depression. |
|----------------------------------------------------------|
| OR | P | Adjusted OR | P | Adjusted OR | P |
|----------------------------------------------------------|
| Total | Normal weight | 1.00 | 1.00 | 1.00 | 1.00 |
| Underweight | 3.34 (2.18, 5.11) | <.001 | 2.76 (1.77, 4.30) | .01 | 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 | 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, 3.15) | .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, 1.36) | .36 | 0.78 (0.45, 1.36) | .36 | 0.60 (0.32, 1.13) | .10 |
| Women | Normal weight | 1.00 | 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 23, 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.

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