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Obesity and Depression Symptoms in the Beaver Dam Offspring Study Population

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Abstract

Background—Depression and obesity are both important public health problems. However, it is not clear whether obesity contributes to depression. Our study aims to evaluate the association between obesity and possible depression.

Methods—During the Beaver Dam Offspring Study (BOSS) examination, participants' body weight and height were measured with a Detecto 758C digital scale with height bar, and depression symptoms were measured with the Center for Epidemiological Studies-Depression Scale (CES-D). Other relevant information (such as demographic factors, lifestyle factors, comorbidities and use of anti-depressants) was also collected during the examination. There were 2641 participants included in the analyses.

Results—Obesity was associated with possible depression measured by CES-D scale (OR =1.6, 95% CI: 1.3–2.0) after controlling for age and gender. The association remained similar after further adjustments. Obesity was significantly associated with all four domains measured by CES-D scale after controlling for age and sex, with the largest effect on "Somatic complaints" domain (beta 0.15, 95% CI: 0.0836–0.223). The association with "Interpersonal difficulties" was not significant after further adjustments.

Conclusions—Obesity was associated with a higher risk of possible depression, and had different influences on specific domains of depression symptoms measured by CES-D scale. These findings suggest the need for longitudinal studies on the effects of obesity on specific depression symptoms.

Keywords

obesity; depression; epidemiology

Introduction

Depression symptoms are a common source of distress and dysfunction and have a great impact on the quality of life. Major depressive disorder affects approximately 14.8 million American adults, or about 6.7 % of the U.S. population age 18 and older in a given year (1). It is estimated that by the year 2020, unipolar major depression will be the second leading cause of global disease burden (2). Obesity is another important public health problem. Since the mid-

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seventies, the prevalence obesity has increased sharply: data from two National Health and Nutrition Examination Survey (NHANES) surveys showed that among adults aged 20–74 years, the prevalence of obesity increased from 15.0% (in the 1976–1980 survey) to 32.9% (in the 2003–2004 survey) (3).

Obesity is a major risk factor for cardiovascular disease but its relation to psychological diseases remains unclear. Data from 41,654 respondents in the National Epidemiologic Survey on Alcohol and Related Conditions showed that obesity defined by self-reported height and weight was associated with increased risk for any mood disorder, major depressive disorder, and dysthymic disorder, in both men and women (odds ratios ranged from 1.35 to 1.88) (4). Other studies reported the positive association between obesity and depression (5–8). However, a recent systematic review stated that the association between obesity and depression was not consistent across studies (9); the evidence from these studies was considered weak due to quality issues, such as use of self-reported BMI, invalid measurement of depression, lack of description of the sampling process, low response rate, loss of follow-up and residual confounding. The aim of our study was to evaluate the association between obesity and depression symptoms in a large cohort using standardized protocols to measure and define obesity and depression.

Materials and Methods

Study Population

The Beaver Dam Offspring Study (BOSS) is a cohort study of adult children of participants in the Epidemiology of Hearing Loss Study (EHLS), which was designed to investigate sensory changes across generations and to provide important information on how genetic and changing environmental risk factors affect health. The description of the EHLS study can be found in previous publications (10). In 2005, the adult children of the original EHLS population were invited to participate in the BOSS examination. Of the 4965 offspring identified, 3285 (66.2%) participated, 731 (14.7%) refused, 23 (0.5%) had died, and 926 (18.7%) failed to complete an examination or questionnaire. Participants were slightly older than non-participants (mean age 48 vs. 46 years at the time of recruitment), and more likely to be women (54.6% vs. 44.4%). More than 99% of the participants were reported as non-Hispanic white. This study was approved by the University of Wisconsin-Madison Health Sciences Institutional Review Board, and all participants provided written informed consent.

Measurements

The Center for Epidemiological Studies-Depression Scale (CES-D) was used to measure depression symptoms in our population (11). The scale has been used for screening for depression in research and clinical settings (12–13). It is composed of 20-item questions, which measure depression symptoms in 4 domains (factors): Depression Affect, Somatic Complaints/ Activity Inhibition, Positive Affect, and Interpersonal Difficulties (Table 1). During the appointment, participants were instructed to complete the CES-D form by indicating how often they experienced each symptom in the past week. The response is a four-point scale ranging from 0 to 3 indicating the frequency: “rarely or none of the time, or <1 day”, “some or little of the time, or 1–2 days”, “occasionally or a moderate amount of the time or 3–4 days” and “most of the time or 5–7 days”, except for questions 4, 8, 12 and 16, for which the scale is reversed. Higher total scores indicate worse depressive symptoms. For the 4 factors (domains), higher factor scores indicate worse depression symptoms other than the domain “Positive affect”. A total score of >15 for the 20 questions is the usual cutoff for possible mild to major depression.

Participants were examined and interviewed by staff trained and certified in the study protocol. Body weight and height were measured with a Detecto 758C digital scale (Cardinal Scale

Manufacturing Co., Webb City, MO) with height bar. The body mass index (BMI) was calculated as the ratio of body weight (kg) and square of height (m). Overweight and obese is defined as BMI $\geq$ 25 kg/m^2, $\geq$ 30 kg/m^2, respectively. Blood pressure was measured with a Dinamap Procare 100 (GE Medical Systems, Milwaukee, WI) after the participant rested at least 5 minutes. The measurement was taken three times at one minute intervals and the average of the last two measurements was used in the analyses. Blood samples were collected from participants, and hemoglobin A1C was assessed at the Collaborative Studies Clinical Laboratory, Fairview-University Medical Center, Minneapolis, MN.

We selected potential confounders based on those reported in previous studies (9). Social Economic Status (SES) and demographic factors, including education levels (<12 yrs, 12 yrs, 13–15 yrs, and 16+ yrs), family income and marital status (married, single, and others) were included as well as comorbidites and lifestyle factors. Hypertension was defined as a diagnosis of hypertension and current anti-hypertensive medications or measured blood pressure $\geq$ 140 mmHg (systolic) or $\geq$ 90 mmHg (diastolic). Cardiovascular disease (CVD) was defined as self-reported doctor diagnosed myocardial infarction, stroke or angina. Diabetes was defined as a self-report of doctor diagnosed diabetes or measured A1C>6.1%. Sleep apnea was defined as a self-report of doctor diagnosed sleep apnea. Hearing was measured by audiometry and hearing loss was defined as pure tone average of 500, 1000, 2000 and 4000 Hz >25dB in either ear (14). Age-related Macular Degeneration (AMD) was assessed by digital retinal images and a standardized grading system (15). We included these two sensory disorders because hearing loss and AMD are associated with poorer quality of life and increased prevalence of symptoms of depression (16–19). Lifestyle factors included smoking status (never/former/current smokers), history of heavy alcohol use (ever drank 4 or more alcoholic beverages daily), and exercise (regular weekly exercise sufficient to work up a sweat). Participants were asked to bring all of their current medications to the examination to identify participants who currently used anti-depressive medications.

Statistical analysis

The association between obesity and possible depression (CES-D score > 15) was assessed with logistic regression; taking anti-depressants was analyzed as an alternative outcome in a supplementary analysis. Since some confounders (such as physical activity) could also act as mediators, they were included in the models sequentially. Covariates that had significant p-values or changed the effect of obesity modestly were included in the final model. Subgroup analysis was performed among participants without CVD or diabetes as a sensitivity analysis. These analyses were performed with SAS 9.1 (SAS Institute, Cary, N.C.).

The multiple indicators, multiple causes (MIMIC) model was used to assess the associations of obesity with specific domains of the CES-D scale, controlling for the important confounders. Before fitting the MIMIC model, the confirmatory factor analysis (CFA) was performed to check if the CES-D 4-domain structure was applicable in our population. The MIMIC model was evaluated as good fit by checking the fit indicators (20–21): 1) a comparative fit index (CFI) value greater than 0.9; 2) a Tucker-Lewis (TLI) index value greater than 0.9; 3) a root mean square error of approximation (RMSEA) value close to .06 or less; 4) a weighted root mean square residual (WRMR) values close to 1.0 or lower. The statistical significance of the factor loadings, and that the residual variances did not take negative values for any of the items were also taken into account when evaluating the model fit. These analyses were conducted with Mplus Version 4.21 (22).

Results

A total of 2641 participants out of the total BOSS population with complete CES-D and BMI data were included in the analyses. The age range was 21–84 yrs (mean: 49.2 yrs, sd: 9.9 yrs);

and 45.1% were male. The BMI range was 17.4 – 61.6 kg/m^2 (mean: 30.1 kg/m^2, sd: 6.6 kg/m^2). These people were similar to the BOSS population in terms of mean age (49.2 yrs vs. 48.7 yrs), male percentage (45.1% vs. 45.4%), mean BMI (30.1 kg/m^2 vs. 30.2 kg/m^2), percentage of taking anti-depressants (16.1 % vs. 15.9 %) and other aspects such as SES factors and comorbid conditions.

The range of the CES-D total score was 0–52 (mean: 8.4, sd: 7.4). According to the cutoff, 14.1% participants were considered to have possible mild to major depression. The percent of overweight and obese participants were 34% and 44%. Generally speaking, comparing to those normal weight people, they were older, more often men, had worse SES, and were more likely to be smokers and report a history of heavy drinking and have more comorbid conditions (Table 2).

Obesity was significantly associated with the possible depression in sequentially adjusted models (Table 3). After adjusting for important confounders, obese participants had an OR of 1.5 (95% CI: 1.1–1.9, P=0.002) to have possible depression comparing to those non-obese people (model 5). Further adjusting for use of anti-depressants did change the result (data not shown). In the sensitivity analysis with participants free of CVD and diabetes, the results were similar (OR: 1.4, 95% CI: 1.1–1.8, P= 0.01). When taking anti-depressants was used as an alternative outcome, obesity was associated with a higher OR of taking anti-depressants (OR: 1.7, 95%CI: 1.3–2.1, P<.0001). In addition, models using BMI as a continuous variable showed similar results, and each 5 unit increase in BMI was associated an OR of 1.1 (95% CI: 1.0–1.20, P =.003) for possible depression after adjusting for important confounders.

Our CFA results showed that Radloff's original 4-domain structure was applicable in our population. The model fit indicators were: RMSEA = 0.055, CFI = 0.93, TLI = 0.98, WRMR = 2.1. The factors loading were high (standardized factor loadings ranged from 0.508–0.956), and all were statistically significant. In the MIMIC models, obesity had significant effects on all 4 domains, with the strongest effect on somatic domain after adjusting for age and sex: obese participants had an average 0.15 (95% CI: 0.09–0.22) units higher score in the domain of "Somatic complaints" (Table 4). When taking the SES factors into account, the effect on the "Interpersonal difficulties" was no longer significant; the effects were similar when further adjusting for other confounders.

Discussion

Our data support that there is a positive association between obesity and depression symptoms. Although the effect size was small (OR: 1.4–1.6 in Table 3), the association was consistent in different analyses. It was robust in sequential models with different confounders, and was consistent in the subgroup analysis restricted to participants free of CVD and diabetes. A similar association was present in analyses with use of anti-depressants as the outcome. The magnitude of this association was consistent with some previous studies, which suggested that the ORs ranged from 1.4 to 1.9 for different psychiatric disorders (4,8). One study suggested that there might be a U-shape association between BMI and depression (23): being underweight or overweight were both associated with depression comparing to normal weight. In our population, only 9 (0.32%) participants were underweight (BMI<18.5 kg/m^2), so we were unable to examine the possible U-shape association.

The 4-factor structure of CES-D scale was originally developed in the Caucasian population (11). After that, although varied CES-D factor structures were found in different populations, such as different ethnic/cultural groups, diseased groups (24–25), the scale has been shown to be suitable for many different groups (26). We found that the original 4-factor structure of the CES-D scale was applicable in a relatively heavier population: the prevalence of overweight

(including obesity) and obesity in our study population were 78% and 44% respectively, while they were 66.3% and 32.2% among U.S. adults age 20 years and over in 2003–2004 according to the NHANES data (CDC website: http://www.cdc.gov/nchs/products/pubs/pubd/hestats/overweight/overwght_adult_03.htm).

Although our study population was relatively heavier than the national population, they did not have higher CES-D scores, or a higher prevalence of possible depression. The mean CES-D score (8.4) and the prevalence of possible depression (14.1%) were similar to those reported in the original study of the CES-D scale (11), in which the mean score ranged from 7.53–8.58, and the prevalence of possible depression ranged from 15–19%. Other factors may have protected them from having worse depression symptoms. In our study, obesity is not the only factor associated with depression, other factors, such as education, income, and life styles had important effects on depression symptoms. Thus, factors like better educational levels (97.5% were high school graduates, and 68.5% had at least some college education) and good regular exercising habit (61% participants had regular exercise weekly) may have helped offset the adverse effect of obesity on depression symptoms.

By breaking down the depression symptoms measured by CES-D scale into the 4 domains, we can better understand how obesity may affect different aspects of depression. Adjusting for age and sex, obesity had significant influences on all four domains of self-reported depression symptoms, with the largest effect on the “Somatic complaints”. This indicates that the obese participants had more complaints on psychosomatic problems, which may due to the obesity associated diseases and malfunction. After further adjusting for SES factors and other factors, the effect sizes of obesity were decreased a little bit but were still significant for all domains except for the “interpersonal difficulties” domain. This suggests that obese people may feel worse in the aspects of “Depression affect”, “Somatic complaints” and “Positive affect”, but being obese does not limit individuals from enjoying good personal relationships when other conditions (such as SES factors) were taking into consideration.

The limitations of our study include that we cannot determine the direction of the association due to its cross-sectional design. Second, we may have missed some confounders in our analyses. For example, dementia may confound the association between obesity and depression, especially among elderly populations (27). In our examination, the Mini-Mental State Examination (MMSE) was administered to participants older than 50 years; we only found 3 possible cases of impaired cognition. Therefore, dementia is not likely to be a confounder in our case. Finally, selection bias may be of concern. Of the BOSS population, 81% had completed the CES-D and included in our analyses, and they were similar to the BOSS population in terms of age, male percentage, mean BMI and other demographic factors. Thus we consider that our sample population was representative of the total population and the likelihood of introducing selection bias is low.

It is also important to realize that over-adjustment may exist in the multi-variable adjustment models since some risk factors may be part of the causal pathway. For example, less exercise may be a cause for weight gain as well as a result from weight gain. When adjusting for exercise, the effect size of BMI may be incorrectly diluted. Thus, we performed the analyses by sequentially adding confounders to the models.

Strengths of our study include: 1) a relatively large sample size and a relatively heavier population, which enable us to better evaluate the association of obesity and depression; 2) a valid measurement of depression symptoms as the CES-D scale was tested and proved to be applicable in our population; 3) the breakdown of the depression symptoms into different domains for analyses; 4) a comprehensive adjustment of potential confounders, including

sensory impairments, which have been rarely investigated in previous studies; 5) consistent results from different analyses.

Conclusion

Our study found a consistent association between obesity and depression symptoms in a slightly heavier, midlife population. Obesity had significant effects on the domains of "Depressed affect", "Somatic complaints" and "Positive affects" but not "Interpersonal difficulties" measured by the CES-D scale after including SES factors in the model. These results suggest that obesity may contribute to depression symptoms and may have different effects on various aspects of depression symptoms. Longitudinal studies are needed to determine the effect of obesity on specific depression symptoms.

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Table 1

CES-D questionnaire items and the abbreviations

20 questions	Abbreviation
1. I was bothered by things that don't usually bother me.	Bother
2. I did not feel like eating, my appetite was poor.	Eat
3. I felt that I could not shake off the blues even with the help of my family or friends.	Blue
4. I felt that I was just good as other people.	Good
5. I had trouble keeping my mind on what I was doing.	Focus
6. I felt depressed.	Down
7. I felt everything I did was an effort.	Effort
8. I felt hopeful about the future.	Hope
9. I thought my life had been a failure.	Fail
10. I felt fearful.	Fear
11. My sleep was restless.	Sleep
12. I was happy.	Happy
13. I talked less than usual.	Quiet
14. I felt lonely.	Alone
15. People were unfriendly.	Aloof
16. I enjoyed life.	Enjoy
17. I had crying spells.	Cry
18. I felt sad.	Sad
19. I felt that people dislike me.	Shun
20. I could not get "going".	Drag

Four factors are: Depression affect (sad, cry, down, blue, alone, fear, fail); somatic complaints (effort, drag, focus, sleep, bother, eat, quiet); positive affect (enjoy, good, happy hope); interpersonal difficulties (shun, aloof).

Table 2

The study population according to BMI categories*

	Normal BMI (n=581) Mean (sd) or %	Overweight (n=887) Mean (sd) or %	Obese (n=1173) Mean (sd) or %	P
Age (years)	45.7 (9.1)	48.6 (9.9)	50.6 (9.6)	<.0001
Male	24.8	52	50.5	<.0001
BMI (kg/m^2) categories	22.7 (1.6)	27.4 (1.4)	35.8 (5.4)	NA
CES-D score	7.8 (7.2)	7.7 (6.9)	9.1 (7.7)	<.0001
Education levels				
<12 years	2.3	2.5	2.7	
12 years	24.8	28.5	31.5	
13–15 years	29.3	30.9	37.9	
16+ years	31.4	38.1	28.0	<.0001
Family income ($1,000)				
<40	19.5	20.7	24.4	
<60	21.5	21.5	23.7	
<75	17.9	18.7	20	
<100	17	14.6	16.2	
100+	24	24.4	15.7	<.0001
Marital status				
Married	73.3	74.3	72.2	
Single	17.2	14.5	14.8	
Others	9.5	11.2	13.0	0.1
Smoking status				
Current smoker	21.2	18.4	32.0	
Past smoker	23.1	27.0	15.1	0.0003
Heavy drinking habit (%)	14.5	16.5	20.9	0.001
Regular exercise habit (%)	68.5	64.1	55.1	<.0001
CVD prevalence	1.4	2.4	4.7	0.0003
Diabetes prevalence	0.9	3.4	13.4	<.0001
Hypertension prevalence	15.0	29.3	51.7	<.0001
Diagnosed sleep apnea %	1.2	1.6	8.4	<.0001
Hearing impairment (%)	8.6	13.8	15.7	0.0002
Any macular degeneration %	2.4	3.9	3.6	0.3
Anti-depressant medication	12.7	13.8	19.4	0.0001

*Overweight and obese is defined as BMI ≥ 25 kg/m^2, and BMI ≥ 30 kg/m^2, respectively.

Table 3

ORs for the association between obesity (BMI ≥ 30 kg/m^2) and possible depression (dependent variable) in multi-variable adjusted models

	OR	95% CI	P - value
Model 1	1.6	1.3–2.0	<.0001
Model 2	1.5	1.2–1.9	0.001
Model 3	1.4	1.1–1.8	0.005
Model 4	1.4	1.1–1.8	0.01
Model 5	1.5	1.1–1.9	0.002

Model 1: age and gender adjusted;

Model 2: further adjusted for demographics: marital status, family income and education levels;

Model 3: further adjusted for chronic diseases: CVD, diabetes, hypertension and sleep apnea, hearing and AMD;

Model 4: further adjusted for life style factors: smoking and drinking habits, regular exercises;

Model 5: Age sex, education level, family income, marital status, CVD, sleep apnea, hearing loss and AMD, regular exercises adjusted.

Table 4

Effects of obesity on the 4-domains of depression symptoms measured by CES-D scale: regression coefficients from the MIMIC models

	Depression affect			Somatic complaints			Positive affect			Interpersonal difficulties		
	Estimate	95% CI		Estimate	95% CI		Estimate	95% CI		Estimate	95% CI	
Model 1	0.11	0.038	0.187	0.15	0.086	0.223	−0.10	−0.15	−0.041	0.11	0.023	0.186
Model 2	0.09	0.015	0.167	0.12	0.051	0.193	−0.07	−0.125	−0.017	0.07	−0.015	0.153
Model 3	0.08	0.002	0.158	0.10	0.029	0.172	−0.06	−0.117	−0.007	0.07	−0.020	0.152

Model 1: age sex adjusted;

Model 2: Age sex, education level, family income, marital status adjusted;

Model 3: Age sex, education level, family income, marital status, CVD, sleep apnea, hearing loss and AMD, regular exercises adjusted

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