

PAPER

Relationship of Obesity to Depression: a Family-based Study

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OBJECTIVE: To examine the relationship between obesity and depression in a sample of extremely obese individuals and their siblings and parents.

SUBJECTS: A total of 1730 European Americans (558 men, 1172 women, aged 49.29 ± 15.42 y, body mass index (BMI) of 35.57 ± 11.53 kg/m²) and 373 African Americans (103 men, 270 women, aged 44.85 ± 15.08 years, BMI of 36.83 ± 11.31 kg/m²) in a sample of 482 nuclear families segregating extreme obesity and normal weight.

MEASUREMENTS: Individual BMI, history of depression treatment and covariates (age, sex, race, education, marital status, socioeconomic status, chronic medical conditions and exercise program).

RESULTS: Greater odds for depression were found for the obese, European American, women, the unmarried, the more educated, those with chronic physical disorder(s) and the offspring of depressed parents. A trend test found that the odds ratios for depression increased with BMI and number of chronic medical conditions ($P < 0.0001$). Multivariate logistic regression analyses indicated that BMI, race, marital status, chronic medical conditions and family history were the predictors of depression for both the genders. Hierarchical analyses revealed that BMI significantly increased the risk above that predicated by the combined effects of all other variables.

CONCLUSIONS: Extreme obesity was associated with the increased risk for depression across gender and racial groups, even after controlling for chronic physical disease, familial depression and demographic risk factors. More detailed research is needed to determine the underlying mechanisms.

International Journal of Obesity (2004) **28**, 790–795. doi:10.1038/sj.ijo.0802626

Published online 16 March 2004

Keywords: depression; family study; body mass index; odds ratio; obesity

Introduction

The prevalence of obesity has been rapidly increasing in both children and adults during the past 2 decades.^{1–4} Although it is documented that obesity contributes to a variety of physical illness, such as hypertension, coronary heart disease and diabetes mellitus,^{5,6} much less is known about the possible links of obesity to mental disorders. It is commonly believed that obese people experience more psychological distress that may lead to depression. However, existing information on the relationship between obesity and depression is inconsistent. Some studies reported that obese people were at elevated risk for depression.^{7–11} Others found that heavier people were less depressed,^{12–15} especially middle-aged men. There were several reports indicating no effect of obesity on the risk of

depression.^{16–18} Some surveys revealed that the association might be sex-specific.^{19–21} The discrepancies may be due in part to the differences in the levels of obesity, differences between clinical and epidemiological samples, inconsistent control of covariates such as sex, socioeconomic status and race, and differences among various subgroups in levels of obesity. Furthermore, although reports suggest that depression is a strongly familial condition,²² studies involving obese individuals generally have not examined the role of family history of depression. More independent studies are needed to clarify the role of obesity in the risk for depression. This report examines the relationship between obesity and depression in a national sample of 482 nuclear families segregating extreme obesity and normal weight.

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Received 25 June 2003; revised 18 December 2003; accepted 2 February 2004; published online 16 March 2004

Methods

Subjects

Subjects consisted of individuals from families ascertained nationwide over a 10-y period beginning in 1992 to

participate in ongoing genetic studies of obesity at the University of Pennsylvania. The recruitment process has been described previously.^{23,24} Briefly, to be included in the study, probands must have a self-reported body mass index (BMI) greater than or equal to 40 kg/m², have one or more siblings with a current BMI greater than or equal to 30 kg/m², one or more siblings with a maximum lifetime BMI less than 27 kg/m², and at least one parent with a maximum lifetime BMI less than 27 kg/m² as well. Recruited probands and their first-degree relatives were measured for weight, height and other anthropometric measurements and interviewed for histories of treatment for physical and mental disorders by trained investigators. As most of the recruited families were European and African American, other ethnic-origin families were excluded from the present study. A total of 57 individuals with missing information on BMI or history of depression treatment were also excluded. This led to the present study sample of 2103 individuals (482 probands, 320 fathers, 439 mothers, 304 brothers and 558 sisters) from 482 nuclear families (445 European American and 37 African American). As we included parental depression as a covariate in the analysis, we focused on the analyses in the obese probands and their siblings (482 probands and 962 siblings).

BMI

Trained research personnel measured height and weight when they interviewed the subjects. BMI was computed by dividing weight in kilograms by the square of height in meters (kg/m²). As sample size ($n = 11$) was very small for the underweight category (BMI < 18.5 kg/m²) and the purpose of the study was to examine the association between depression and obesity, we divided subjects into four groups according to BMI (< 27, 27–< 30, 30–< 40 and ≥ 40 kg/m²) and defined obese as BMI ≥ 30 kg/m². We also used continuous BMI values in multivariate analyses.

Questionnaire

The questionnaire was structured and designed to collect information about the subject's sociodemographic characteristics (race, sex, age, marital status, residence, occupation, education, exercise program), and history of physical medical conditions (autoimmune endocrine diseases, heart trouble, hypertension, renal disease, diabetes, stroke, hyperlipidemia, neurological disease, cancer) and mental health conditions (depression, eating disorders, nervous anxiety, nervous breakdown, nervous fears and suicide attempt).

The age was categorized as < 30, 30–< 45, ≥ 45 y. Educational attainment was dichotomized as < 12 years or ≥ 12 years. Marital status also was dichotomized as married vs other (divorced, separated, widowed, never married). Socioeconomic status was grouped as high (white collar, professional and business owner) and low (blue collar, unemployed, welfare). The occurrence of chronic physical disorders was based on the available medical records. Mental

health questions were assessed based on a checklist. Subjects were questioned as to whether a condition had ever occurred and whether the treatment was received for the condition. A subject was considered to be depressed, if they answered a history of depression and had undergone treatment for depression. For obese probands and their siblings, family history of depression depended on status of parental treatment for depression.

Validity of assessment of depression by questionnaire

In all, 40 subjects (25 with reported treated depression and 15 without reported depression by questionnaire assessment) were selected for a validation study. A psychiatrist (LES) from the Department of Psychiatry at the University of Pennsylvania independently diagnosed subjects utilizing a Structured Clinical Interview derived from the mood disorders section of the fourth version of the Diagnostic and Statistical Manual of Mental Disorders (SCID). The interview was conducted on telephone. The psychiatrist was blind to questionnaire information regarding previous diagnosis or treatment for depression. According to SCID diagnosis, the sensitivity and specificity of questionnaire assessment were 92% (23/25) and 87% (13/15), respectively. These data support the validity of questionnaire assessment (Table 1).

Statistical analyses

We used the statistical package SAS (version 8.02) for all statistical analyses. Separate bivariate logistic regression models were used to estimate the crude odds ratios of depression by all the risk factors investigated. A full multivariate logistic regression model was used to calculate the adjusted odds ratios of depression by including all the risk factors. For the risk factors with three or more categories, Cochran–Armitage trend test was used to detect the trend. We performed hierarchical logistic regression analysis in the subgroups to assess the effect of BMI on a model including all other significant predictors. A likelihood ratio χ^2 ($-2(\ln L1 - \ln L2)$) test was employed to assess the statistical significance.

Table 1 Validation of depression assessment by questionnaire

Depression by Questionnaire ^a	Depression by SCID ^b		
	Yes	No	Total
Yes	23	2	25
No	2	13	15
Total	25	15	40

Kappa = 0.80, 95% CI: 0.60–0.98^c

^aQuestionnaire, based on face-to-face interview for history of depression treatment. ^bSCID, Structured Clinical Interview based on Diagnostic and Statistical Manual of mental disorders (DSM-IV). ^cKappa, Cohen K Statistic; CI, confidence interval.

Results

Demographic characteristics of the sample

In all, 82% of the families (397/482) and subjects (1730/2103) were European American. The proportion of females was 68% in European-American sample (1172/1730), 72% in African-American sample (270/373) and 69% in the combined sample (1442/2103). For obese probands and their siblings, the mean BMI was not statistically different between the two race groups (38.31 ± 12.04 kg/m² for European American and 38.37 ± 11.53 kg/m² for African American, $P=0.9381$), whereas the mean age differed for siblings (39.63 ± 8.78 years for European American and 37.69 ± 9.90 y for African American, $P=0.0035$). In all, 43% of obese probands (210/482) and 16% of siblings (153/962) reported depression and depression treatment. Among 363 obese probands and siblings who reported depression treatment, 90% were female subjects (328/363) and 91% were European American (332/363).

Bivariate and full multivariate logistic regression analyses

Table 2 presents the crude and adjusted odds ratios of depression by putative risk factors in obese probands and their full siblings. For bivariate analyses, greater odds for depression were found for the obese (OR = 1.69 for BMI ≥ 30 , OR = 3.42 for BMI ≥ 40 , $P < 0.0001$), European American (OR = 3.24, $P < 0.0001$), women (OR = 4.25, $P < 0.0001$), the unmarried (OR = 1.40, $P = 0.0064$), those with one (OR = 2.05) or more chronic physical disorders (OR = 4.03, $P < 0.0001$) and those having parental depression (OR = 3.06, $P < 0.0001$). Decreased odds for depression were seen for the less educated (OR = 0.67, $P = 0.0014$) and those with low socioeconomic status (OR = 0.74, $P = 0.0215$). A trend test found a strong association of depression with BMI ($P < 0.0001$) and chronic physical disorders ($P < 0.0001$). For multivariate analyses, while the adjusted odds ratios were lower than the corresponding crude odds ratios with an

Table 2 Odds ratios (OR) of depression by risk factors in obese probands and their siblings

Risk factors	Depression		OR _c (95% CI) ^a	OR _a (95% CI) ^b
	Yes	No		
BMI (kg/m²)[*]				
15–<27	43	242	1.00	1.00
27–<30	17	107	0.89 (0.49, 1.64)	0.89 (0.46, 1.67)
30–<40	79	263	1.69 (1.12, 2.55)	1.42 (0.90, 2.26)
≥ 40	224	369	3.42 (2.37, 4.92)	1.89 (1.21, 2.97)
Age (y)				
14–<30	38	146	1.00	1.00
30–<45	217	567	1.47 (0.99, 2.17)	1.27 (0.83, 2.00)
≥ 45	108	268	1.55 (1.00, 2.36)	1.12 (0.69, 1.82)
Race				
African American	31	228	1.00	1.00
European American	332	753	3.24 (2.18, 4.82)	3.41 (2.26, 5.30)
Sex				
Male	35	306	1.00	1.00
Female	328	675	4.25 (2.92, 6.17)	3.04 (2.06, 4.61)
Socioeconomic status				
High	127	279	1.00	1.00
Low	236	700	0.74 (0.57, 0.96)	1.23 (0.74, 2.04)
Marital status				
Married	168	535	1.00	1.00
Other	195	444	1.40 (1.10, 1.78)	1.68 (1.27, 2.21)
Education				
≥ 12 y	162	344	1.00	1.00
<12 y	201	635	0.67 (0.53, 0.86)	0.57 (0.35, 0.92)
Exercise program				
Yes	169	414	1.00	1.00
No	194	565	0.84 (0.66, 1.07)	0.88 (0.67, 1.16)
Chronic physical disorders[*]				
None	121	583	1.00	1.00
1	94	221	2.05 (1.50, 2.80)	1.91 (1.36, 2.68)
≥ 2	148	177	4.03 (3.00, 5.40)	3.08 (2.21, 4.31)
Parental depression				
No	333	951	1.00	1.00
Yes	30	28	3.06 (1.80, 5.20)	1.82 (1.02, 3.27)

^{*} $P < 0.0001$, based on Cochran–Armitage trend test in univariate analysis; ^aOR_c: crude odd ratio; CI, confidence interval; ^bOR_a: adjusted odds ratio based on multivariate logistic regression analysis.

exception of educational attainment, almost all associations observed by bivariate analyses remained statistically significant except for socioeconomic status.

We also tested for a possible interaction between the family history of depression and obesity in the individual as a way to evaluate possible gene–environment or gene-gene interactions. Neither the full model nor a model with only BMI and family history produced a statistically significant result (results not shown).

Hierarchical logistic regression analyses

Table 3 reports the effect of BMI on the model including all other significant predictors (95% CI for adjusted odds ratio did not include 1 in Table 2) based on hierarchical logistic regression analyses within different subgroups of obese probands and their siblings. Depression was positively associated with BMI with an overall OR of 1.81 ($P < 0.0001$) for a 20-unit increment in BMI. To control the effects of race and gender, we reran the analyses within the different subgroups. Similar findings were found across the subgroups. The corresponding odds ratios for a 20-unit increment in BMI were 1.58 for all females ($P = 0.0001$), 2.65 for all males

($P = 0.0057$), 1.64 for European Americans ($P < 0.0001$) and 2.19 African Americans ($P = 0.0394$).

Relationship between depression and BMI among siblings without chronic physical disorders and parental depression

Table 4 reports on the relationship between the depression and BMI in siblings without a history of chronic physical disease and parental depression adjusting for the effects of marital status, educational attainment, race and sex if applicable. The results showed that there was a positive association of depression with BMI across the gender and racial groups, although some observed associations were not statistically significant because of the decreased sample size.

Discussion

Since both obesity and depression are increasingly prevalent and associated with hypertension, coronary heart disease, diabetes mellitus, as well as increased risk for mortality,^{1,2,4,25–31} a conceivable link between these two disorders has been postulated and may be a relevant consideration in

Table 3 Hierarchical logistic models showing relation of BMI to depression in obese probands and their siblings

Siblings	N	Variables in the model	Model 1 OR (95% CI)	Model 2 OR (95% CI) ^a	χ^2 (P*)
All	1344	BMI (kg/m ²)		1.81 (1.49, 2.19)	19.9010 (< 0.0001)
		Race (European vs African American)	3.42 (2.26, 5.19)	3.50 (2.03, 5.33)	
		Sex (female vs male)	3.80 (2.58, 5.59)	3.24 (2.18, 4.80)	
		Marital status (other vs married)	1.77 (1.36, 2.31)	1.63 (1.25, 2.14)	
		Education (<12 vs ≥ 12 y)	0.67 (0.51, 0.87)	0.65 (0.50, 0.85)	
		Chronic physical disorder (yes vs no)	2.74 (2.10, 3.59)	2.44 (1.86, 3.20)	
		Parental depression (yes vs no)	2.19 (1.24, 3.86)	1.81 (1.03, 3.20)	
All females	1003	BMI (kg/m ²)		1.58 (1.22, 2.19)	14.4186 (0.0001)
		Race (European vs African American)	3.30 (2.14, 5.10)	3.37 (2.18, 5.22)	
		Marital status (other vs married)	1.65 (1.24, 2.19)	1.53 (1.15, 2.05)	
		Education (<12 vs ≥ 12 y)	0.68 (0.52, 0.91)	0.66 (0.50, 0.87)	
		Chronic physical disorder (yes vs no)	2.74 (2.06, 3.65)	2.47 (1.84, 3.31)	
		Parental depression (yes vs no)	2.13 (1.19, 3.80)	1.81 (1.04, 3.23)	
		BMI (kg/m ²)		2.65 (1.49, 5.60)	
Race (European vs African American)	4.92 (1.10, 21.99)	5.07 (1.13, 22.69)			
Marital status (other vs married)	2.93 (1.36, 6.28)	2.67 (1.22, 5.82)			
Education (<12 vs ≥ 12 y)	0.54 (0.26, 1.13)	0.51 (0.24, 1.09)			
Chronic physical disorder (yes vs no)	2.92 (1.38, 6.17)	2.25 (1.03, 4.88)			
Parental depression (yes vs no)	3.94 (0.38, 40.38)	2.42 (0.23, 26.03)			
BMI (kg/m ²)		1.64 (1.22, 2.19)	16.4302 (< 0.0001)		
Sex (female vs male)	3.74 (2.51, 5.58)	3.22 (2.14, 4.84)			
Marital status (other vs married)	1.86 (1.40, 2.46)	1.72 (1.30, 2.29)			
Education (<12 vs ≥ 12 y)	0.67 (0.50, 0.88)	0.64 (0.48, 0.85)			
Chronic physical disorder (yes vs no)	2.52 (1.90, 3.34)	2.24 (1.67, 3.00)			
Parental depression (yes vs no)	2.31 (1.30, 4.13)	1.96 (1.10, 3.50)			
BMI (kg/m ²)		2.19 (1.00, 4.66)		4.2424 (0.0394)	
Sex (female vs male)	4.47 (1.01, 19.75)	3.55 (0.79, 16.02)			
Marital status (other vs married)	1.13 (0.50, 2.57)	0.99 (0.43, 2.30)			
Education (<12 vs ≥ 12 y)	0.74 (0.32, 1.72)	0.79 (0.34, 1.85)			
Chronic physical disorder (yes vs no)	5.79 (2.36, 14.20)	5.03 (2.02, 12.51)			

*Statistical significance of BMI was assessed by likelihood ratio test ($\chi^2 = -2(\ln L1 - \ln L2, df = 1)$); $\ln L1$, log likelihood in model 1; $\ln L2$, likelihood in model 2; P, based on likelihood ratio test; OR, odds ratio; CI, confidence interval. ^aOdds ratios are presented for a 20-unit change in BMI.

Table 4 Adjusted odd ratios of depression for BMI by race and sex among obese probands and their siblings without chronic physical disorders and parental depression

Race	Female			Male			Both		
	N	OR (%95 CI) ^a	P*	N	OR (%95 CI) ^a	P*	N	OR (%95 CI) ^a	P*
European American	355	1.49 (1.00, 2.19)	0.0800	174	3.87 (1.00, 13.7)	0.0499	529	1.49 (1.00, 2.19)	0.0334
African American	107	4.66 (1.00, 19.5)	0.0619	45	2.21 (0.03, 66.6)	0.3906	152	6.73 (1.81, 27.4)	0.0060
Combined	462	1.49 (1.00, 2.19)	0.0272	219	5.60 (1.81, 13.4)	0.0049	681	1.81 (1.22, 2.65)	0.0048

^aOdds ratios are presented for a 20-unit change in BMI adjusted for marital status, educational attainment, sex and race if applicable; CI, confidence interval. *P, based on likelihood ratio test.

public health. To date, reports of cross-sectional, longitudinal and intervention studies using community or clinic-based samples have been inconsistent. Our current study provides a support for an association between the obesity and depression.

In both bivariate and multivariate analyses, we found that obesity was positively associated with depression. The observed associations between these two disorders were comparable in magnitude with those reported in several community-based studies.^{7,8,20} In the present study, the effects of some putative correlates of depression, such as sex, race, marital status, education attainment, chronic physical problems and family history, were also demonstrated.

To examine whether the obesity–depression relationship differed across gender and racial groups,^{19–21} we performed hierarchical logistic regression analyses within subsets of the sample. We examined the association by adjusting other factors with a significant effect on depression, mainly marital status, education, chronic physical diseases and familial depression. Our results (Tables 3 and 4) indicated that the relationship between obesity and depression differed little for men and women or European–American and African–American samples, although the association in some subgroups did not reach statistical significance. We also examined the effects of gender and race on the association between depression and obesity by incorporating BMI by sex, BMI by race and BMI by sex by race interaction terms in the multivariate analyses. None was statistically significant.

That family history of depression should be a risk factor for depression in obese individuals is well established, and our results are consistent with that relationship. Depression is a familial trait and predicted depression in our sample. However, there was no interaction between the family history and individual's BMI, suggesting that genetic factors related to the depression appear not to interact with obesity in their influence on depression. Moreover, a substantial portion of the obesity–depression association is independent of any familial predisposition to depression.

Since a history of chronic physical problems was one of the strongest correlates of depression across most subgroups, we excluded siblings with a history of chronic physical disorder and parental depression within the subgroups. A similar

association pattern (positive association, see Table 4) held across all the subgroups, although statistical significance was not reached in some subsets due to small sample size. Chronic physical illness, as suggested in many studies, may be a mediator between obesity and depression. However, our data did not find diminished associations among the siblings without a history of chronic illness. The consistency of this pattern suggests that chronic illness is not the only pathway linking obesity to depression.

A major difference between the current and previous studies is in the level of obesity. The subjects were recruited from the families ascertained through extremely obese probands (BMI ≥ 40 kg/m²) with a mean BMI of approximately 50 kg/m². As recently suggested by Onyike *et al* (2003), the association between obesity and depression may be limited primarily to the individuals with extreme obesity.³² Severity of obesity may in part account for the failure to find an association between obesity and depression in men in some studies, since the prevalence of severe obesity is much lower in men than in women.

Although some studies reported patterns of association between obesity and depression that differed across genders or racial groups, our results indicated positive covariation between extreme obesity and depression across the two genders and racial groups. The larger proportion of extremely obese individuals, many with medical problems, may in part account for the consistent positive associations in our samples.

Our results documented a moderate, but comparable to other studies, magnitude of association between elevated levels of relative body weight (BMI) and depression. The somewhat reduced effect in our sample could be due to unidentified depression in obese individuals. We selected a self-report of depression treatment rather than self-reported depression alone to ensure the validity of the diagnoses. Based on our validation study, any misclassification should lead to underestimates of depression and lower odds ratios. For this reason, any bias should be conservative with respect to an obesity–depression association.

In summary, our results show that obesity increased the risk for depression across races and genders, even after controlling for chronic physical disease, familial depression and demographic risk factors. More detailed research is

needed to fully characterize the relationship between obesity and depression. The psychosocial, biological and genetic factors that underlie this association are unknown. Additional studies incorporating genetically informative designs as well as demographic, societal, environmental, behavioral and cognitive factors will be needed.

Acknowledgements

We thank the participating families for their generous cooperation. This research was supported in part by NIH Grants R01DK44073, R01DK48095 and R01DK56210 to RAP.

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