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Obesity and Migraine: The Effect of Age, Gender and Adipose Tissue Distribution

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Abstract

Objective—To evaluate the prevalence of migraine/severe headaches in those with and without general obesity and abdominal obesity (Abd-O) and the effect of gender and age on this relationship.

Background—General, or total body obesity (TBO), as estimated by body mass index, is a risk factor for migraine chronification. However, there are conflicting data as to whether TBO is associated with migraine prevalence. Abd-O has been shown to be a better predictor of various disease states than TBO, but has not been evaluated in general population studies in association with migraine.

Methods—Data from a general population survey, the National Health and Nutrition Examination Survey, were used to obtain demographics, self-report of migraine/severe headaches and measured body mass indices, including height, weight, and waist circumference. All analyses were stratified by age and gender and multivariate analyses were determined through use of logistic regression models.

Results—A total of 21,783 participants were included in the analysis. Between 20–55 years of age, the prevalence of migraine was increased in both men and women with TBO as compared with those without, ($P = .001$). Migraine was also more prevalent in those with Abd-O as compared with those without (men: 20.1% vs 15.9%, $P < .001$; women: 36.9% vs 28.8.2%, $P < .001$). After 55 years of age, the prevalence of migraine in men was no longer associated with either TBO or Abd-O. Similarly, after 55 years of age, the prevalence of migraine in women was no longer associated with TBO. However, in women older than 55 years, the prevalence of migraine was *decreased* in those with Abd-O as compared with those without Abd-O (14.4% vs 17.4%, $P < .05$). After adjusting for demographics, cardiovascular risk factors and Abd-O, results were similar for the association between migraine prevalence and TBO in both younger and older men and women. After adjusting for demographics, cardiovascular risk factors and TBO, migraine prevalence was no longer associated with Abd-O in younger men, but remained associated with an increased odds ratio of having migraine in younger women, as well as a decreased odds ratio in older women.

Conclusion—The relationship between migraine and obesity varies by age, gender, and adipose tissue distribution (eg, TBO vs Abd-O). In men and women ≥ 55 years old, migraine prevalence is

increased in those with TBO, independent of Abd-O. In addition, in men and women 55 years old, migraine prevalence is increased in those with Abd-O; and in women this association is independent of TBO. In men older than 55 years, migraine is not associated with either TBO or Abd-O. However, in women older than 55 years, migraine prevalence is decreased in those with Abd-O and is independent of TBO.

Keywords

migraine; abdominal obesity; general obesity; body mass index; waist circumference

Migraine is a common and often disabling disorder that occurs more commonly in adult women than men of all ages. Migraine or probable migraine has been estimated to occur in 34.5% of adult women and 20.1% of adult men in the general population.¹ The relationship between migraine or other headache disorders and markers of cardiovascular disease has been a focus of research interest in recent years.² In particular, general obesity or total body obesity (TBO), as estimated by the body mass index (BMI), has been shown to be related to headache disorders in several clinical and epidemiologic studies.³⁻⁹ However, there is considerable uncertainty about the nature of the obesity/headache relationship and whether it is specific to migraine, or chronic daily headache, or headache in general.

In a general population study in 2003, individuals with TBO and episodic headache were shown to be at an increased risk of incident chronic daily headache over a 1-year period relative to those without TBO (odds ratio [OR] = 5.3 [1.4-21.8]).³ Yet data relating obesity and episodic migraine have been conflicting. Two clinic-based studies suggested that migraine occurs with a higher relative frequency in those with TBO than those without TBO.^{4,5} However, 2 general population-based studies of adults did not find a relationship between migraine and TBO.^{6,7} A third study found an association between TBO and headache but not self-reported migraine.⁸ Finally, a recent general population study found that TBO was associated with the prevalence of migraine or severe headaches.⁹

Several factors may contribute to these conflicting reports. First, all but one⁹ of the prior studies evaluating migraine prevalence and obesity estimated BMI based on self-reported height and weight. Multiple studies in various disorders have shown that BMI is commonly underestimated when self-reported as compared with when it is measured, including in migraineurs.¹⁰⁻¹³ This measurement error might obscure the true relationship between migraine and obesity if it is differential.

Second, the degree to which anthropometric measurements (such as the BMI and waist circumference [WC]) correlate with adipose tissue mass vs lean body mass varies by both age and gender.^{8,12-15} Specifically, aging has been shown to be associated with a progressive increase in the ratio between fat and lean body mass – even in those who manage to maintain a constant BMI as they become older. Thus, the degree to which BMI is proxy measurement for total body fat is age-dependent.¹³⁻¹⁵ In addition, adipose tissue distribution patterns are different in women and men, with younger women having more adipose tissue depots in a gluteo-femoral distribution than abdominally, while men of all ages and older women have more abdominal adipose tissue depots than young women.¹⁶⁻¹⁸

Third, multiple studies in various disorders, including cardiovascular disease and diabetes, have shown that abdominal obesity (Abd-O) may be a better predictor than general/TBO, as estimated by BMI, for disease risk and all-cause mortality.¹⁸⁻²⁰ Furthermore, although Abd-O is generally present in those with TBO, the presence of Abd-O does not necessitate the presence of TBO. For example, in 2003-2004, it was estimated that 31% of men and 33% of women in the United States were obese by BMI; however, 42% of men and 61% of women

in the United States were estimated to have Abd-O.¹⁸ Notably, one clinic-based study has suggested that Abd-O is a risk factor for chronic daily headache in women.²¹

In the present study, we further explore the relationship between migraine and obesity, examining separately the effects of TBO and Abd-O. We hypothesize that migraine prevalence is associated with TBO and Abd-O in an age and gender-dependent manner, and that the association with Abd-O is independent of TBO.

METHODS

The National Health and Nutrition Examination Survey (NHANES) is a cross-sectional survey of the general United States population conducted by the National Center for Health Statistics (NCHS).²² Each year approximately 5000 participants are interviewed in their homes with health measurements completed in mobile examination units. The data collected from these surveys are used to set national standards for health-related measures and are used in developing public health policies. More detailed information about NHANES, sample selection and data collection methodology can be found at <http://www.cdc.gov/nchs/nhanes.htm>. All participants gave informed consent to participate and all procedures were approved under NCHS's Institutional Review Board.

The analysis herein is based on participants in the 1999-2000, 2001-2002, and 2003-2004 surveys, which included a "miscellaneous pain" component and are used in these analyses.

Demographic and Clinical Variables

Demographic and clinical variables, including age, gender, race, highest educational attainment, yearly household income, marital status, smoking, and alcohol consumption, were evaluated using a standardized questionnaire. Education level was reported as less than high school, completed high school or more than high school. Income was recoded as \$0, in \$10,000 increments from \$4999 to \$74,999, or as >\$75,000. Current smokers were defined as those who were currently smoking and smoked ≥100 cigarettes during their lifetime. Former smokers were defined as those who had smoked ≥100 cigarettes during their lifetime but had stopped; those who had smoked <100 cigarettes during their lifetime were classified as nonsmokers. Alcohol consumption (g/day) was determined from a 24-hour dietary recall.

Self-report of a medical history of diabetes was evaluated. Those who responded affirmatively to the question "Have ever been told by a doctor or health professional you have diabetes or sugar diabetes?" were considered to have diagnosed diabetes. Those who answered that they had not been told so or that they had borderline diabetes were not considered to have diagnosed diabetes. Up to 4 blood pressure measurements were obtained from participants. The average of all measurements available for each participant was used for those with more than one measurement, and the one that was available used for participants who only had one measurement. Serum total cholesterol was measured enzymatically in serum or plasma, using standard laboratory techniques.

Migraine Assessment

The NHANES pain questionnaire was administered to all participants over 20 years of age ($n = 21,783$). The assessment of migraine was determined through a single question: "During the past 3 months, did you have severe headaches or migraines?" Subjects were considered to have prevalent migraines or severe headaches if they answered "yes" to this question. Herein, the group of participants answering "yes" to this question will be collectively referred to as migraine participants.

Anthropometric Measurements

All body measurements were taken using standard anthropometric protocols. Weight was recorded in kilograms using a calibrated digital scale. Height in meters was obtained from a fixed stadiometer. WC was measured in centimeters (cm) using an anthropometric tape on skin at the level of the ilium. BMI was calculated using the standard formula weight/height². TBO was defined by the World Health Organization standards, with obesity defined as a BMI ≥ 30 for both men and women. Abd-O was defined by the World Health Organization standards, using a WC ≥ 88 cm (34.6 inches) for women and ≥ 102 cm (40.2 inches) for men.²³⁻²⁶

Statistical Analysis

A combined file for all 3 data sets (1999-2000, 2001-2002, and 2003-2004) was constructed and used for these analyses. Proportional weighting was used because of the complex sampling design used by NHANES. All means are presented with the standard deviation. Independent *t*-tests and chi-square tests were used to determine significance for crude comparisons as appropriate. Significance was determined at $\alpha = 0.05$.

We calculated sex and age-specific OR and 95% confidence intervals using logistic regression to estimate the odds of migraine in obese individuals compared with nonobese individuals after adjusting for demographic and clinical variables (above). We modeled TBO and Abd-O as categorical variables using the standard cut points (above) and also modeled BMI and WC as continuous variables. As we anticipated that the relationship between the continuous measures and migraine might be nonlinear, we added higher-order terms to the models as necessary.

We hypothesized that the relationship between obesity and migraine might be different in younger and older individuals given that adipose tissue distribution changes with age, particularly in women, and particularly after the age of menopause.^{16-18,27} We explored this hypothesis by including an age × obesity interaction term in the models using the a priori cut point of 55 years. We used 55 years as our cut point as this is the upper limit of the reported average age of menopause in the United States (ranging from 51 to 55).²⁷⁻²⁹ As there was a significant interaction between age and BMI obesity for men ($P = .01$) and women ($P = .01$) and between age and WC obesity for women ($P < .001$), the remainder of the analyses are stratified by both gender and age (< 55 years, ≥ 55 years).

Stepwise backwards elimination was used to trim the model and therefore, total cholesterol and systolic blood pressure were eliminated as they were nonsignificant and did not affect the other variables. All analyses were completed in spss version 16.

RESULTS

Demographics

The analytic sample consisted of 10,623 men and 11,160 nonpregnant women. The overall prevalence of migraine was 14.9% in men and 27.6% in women. The majority of the sample was Caucasian and married, with most participants having completed at least a high school education (Table 1).

Older (>55 years of age) compared with younger (20-55 years of age) men were significantly more likely to be white, have completed at least a high school education, and be married, and were less likely to have had migraine. Additionally, older men had a higher mean BMI, higher mean WC, and lower median income than younger men.

Similar results were seen for older (>55 years of age) as compared with younger (20-55 years old) women. Older women were more likely to be white and have completed at least high school, and were less likely to have had migraine. Older women also had a higher mean BMI, higher mean WC, and lower median incomes. In contrast to men, older women were equally likely to be married as younger women, but were more likely to have been widowed (Table 1).

TBO and Abd-O Prevalence

TBO (defined as BMI ≥ 30) was present in 27.7% of younger men, 29.8% of older men, 32.3% of younger women and 35.0% of older women. Abd-O (defined as WC >88 cm [34.6 inches] in women and 102 cm [40.2 inches] in men) was more prevalent than TBO, evident in 35.0% of younger men, 53.5% of older men, 53.2% of younger women, and 72.8% of older women (Table 1).

The great majority (96.5%) of those with TBO were also abdominally obese; only 3.5% of those with TBO did not have Abd-O. However, 20.8% of those with Abd-O did not have TBO. Specifically, the proportion of individuals with Abd-O who did not meet criteria for TBO was: 9.9% of younger men, 21.4% of younger women, 24.5% of older men, and 37.9% of older women.

Prevalence of Migraine in TBO and Abd-O

Crude Analysis—The crude prevalence of migraine was increased in younger men and women as compared with older men and women (Table 1). Average BMI and WC were generally higher in younger (≤ 55 years) women and men with migraine compared with women and men without migraine. In contrast, average BMI and WC were generally similar or decreased in older women and men with migraine compared with women and men without migraine (data not shown, available upon request).

The crude prevalence of migraine was consistently increased in younger men and women classified as obese, either by BMI (Fig. 1A,B) or by WC (Fig. 1C,D). Specifically, in those ≤ 55 years, the crude migraine prevalence was increased in those men and women with TBO, as compared with those men and women without TBO (men: 20.2% vs 16.1%, $P = .001$; women: 39.1% vs 30.2%, $P = .001$; Fig. 2). Similarly, in those ≤ 55 years, the crude migraine prevalence was increased in those men and women with Abd-O, as compared with those men and women without Abd-O, $P = .001$ (men: 20.1% vs 15.9%, $P = .001$; women: 36.9% vs 28.8%, $P = .001$; Fig. 2).

Additionally, although crude migraine prevalence in younger men was not increased in those with Abd-O but without TBO, as compared with those men without either Abd-O or TBO (18.5% vs 15.8%, not significant), crude migraine prevalence was increased in younger women with Abd-O but without TBO, as compared with those women without either TBO or Abd-O (women: 33.6% vs 28.8%, $P = .001$; Fig. 2).

The crude prevalence of migraine was not associated with TBO (BMI) in older men or women (Fig. 1A,B) and it was not associated with Abd-O (WC) in older men (Fig. 1C). However, the crude prevalence of migraine was *decreased* in older women with Abd-O as compared with those without Abd-O (14.4% vs 17.4%, $P = .03$), particularly from ages 60-69 years (Figs. 1D and 2). Additionally, older women with Abd-O but without TBO also had a *decreased* migraine prevalence, as compared with those older women without either Abd-O or TBO (12.9% vs 17.7%, $P = .003$; Fig. 2).

Multivariate Analysis—After adjusting for age, income, educational level, race, smoking, alcohol use, diabetes, and Abd-O, the odds of migraine were increased in younger individuals with TBO compared with those without TBO for both men (OR = 1.38 [1.1-1.7]) and women (OR = 1.20 [1.04-1.39]) (Table 2). TBO was not associated with migraine for older men or women (Table 2).

In men >55 years of age, after adjusting for all covariates except Abd-O, the association of migraine prevalence with TBO was still not significant (OR = 0.82 [0.58-1.16]); similarly in women >55 year of age, when adjusting for all covariates except Abd-O, migraine prevalence remained unassociated with TBO (OR = 0.85 [0.67-1.08]).

After adjusting for age, income, educational level, race, smoking, alcohol use, diabetes, and TBO, the odds of migraine were increased in younger women with Abd-O compared with women without Abd-O (OR = 1.26 [1.1-1.45]) but not for younger men with Abd-O compared with younger men without Abd-O (OR = 1.03 [0.84-1.27]) (Table 2). However, when adjusting for all covariates except TBO in younger men, Abd-O was significantly associated with an increase in migraine prevalence in younger men (OR = 1.3 [1.13-1.49]). Abd-O was not associated with migraine prevalence in older men (Table 2). Abd-O was associated with a *decrease* in migraine prevalence in older women (OR = 0.73 [0.56-0.97]) (Table 2).

When BMI and WC were modeled as continuous variables, inclusion of higher-order terms (BMI² and WC²) demonstrated a significant nonlinear association between both measures of obesity and migraine for all age and gender strata. After adjusting for all covariates as above, and including all 4 terms in the model (eg, BMI, BMI², WC, WC²), all obesity terms lost significance.

DISCUSSION

We conducted an in-depth analysis of data from the NHANES, conducted by the NCHS, to further investigate the prevalence of migraine in general obesity and Abd-O. Our findings suggest that the prevalence of migraine in obese subjects varies based on the distribution pattern of adipose tissue, as well as gender and age. Specifically, our primary findings are as follows:

In adults 55 years old:

- Migraine prevalence is increased in those with TBO (as estimated by BMI using measured height and weight), independently of Abd-O (WC), in both women and men
- Migraine prevalence is increased in those with Abd-O (WC), and is independent of TBO (BMI) in women

In adults >55 years old:

- Migraine prevalence is not associated with TBO or Abd-O in men
- Migraine prevalence is not associated with TBO (BMI) in women
- Migraine prevalence is *decreased* in women with Abd-O (WC), independent of TBO (BMI)

Our findings support the previous clinical and epidemiological studies suggesting that there is an association between migraine prevalence and obesity.^{4,5,9} First, as in the prior analysis by Ford et al (which was based on the NHANES database from 1999 to 2002 and evaluated TBO, but did not evaluate Abd-O), we found an association between migraine prevalence

and TBO.⁹ The utilization of measured BMIs in the NHANES database may account for our study and Ford et al's finding a significant association between migraine prevalence and TBO as compared with those studies that did not.^{10,11}

Additionally, for the first time in a general population-based study, we evaluated the prevalence of migraine in those with Abd-O, and compared and contrasted it with the prevalence of migraine found in association with TBO. We found that migraine prevalence varies based on the distribution of adipose tissue (as either TBO or Abd-O) as well as by age and gender. While migraine prevalence was increased in younger men and women with Abd-O, migraine was *less* prevalent in older women with Abd-O. To some extent, the differences in metabolic function of adipose tissue from different depots and the response of adipocytes to sex hormones with age may explain our findings.^{13-15,29} Men begin depositing adipose tissue centrally, in the abdominal region, during puberty, which continues throughout the adult male life.¹⁷ In contrast, during puberty women preferentially deposit more adipose tissue in the gluteofemoral region; however, postmenopausally it changes to an abdominal pattern similar to men.^{14,17,27}

Differences in adipocyte function and expression of proteins have been shown to exist based on fat depot locations, as either gluteo-femoral or abdominal.¹⁷ Additionally, differences in adipocyte function and protein expression have also been noted between visceral adipose tissue (VAT) and subcutaneous adipose tissue (SAT) in the abdominal region. Along with a lower prevalence of migraine, men have more VAT and less SAT than women.³⁰ However, postmenopausally women have an increase in VAT.

Adipocytes secrete and produce many substances, including hormones, cytokines (such as interleukin-6), and adipocytokines (such as adiponectin); the quantities secreted by adipocytes vary based on depot location.^{17,30} Thus, it is possible that these gender and age-related differences in adipose tissue distribution and the ratio of VAT to SAT in the abdominal region modulate the secretion and production of cytokines and adipocytokines in such a way as to contribute to the gender and age differences in migraine.^{17,27,31-33} However, as previously noted, the pattern of adipose tissue in older women resembles the pattern found in men. Thus, it would be expected for the migraine prevalence in older women to also resemble that seen in men. Yet we found a protective role for Abd-O in regards to migraine prevalence in older women. The explanation for this phenomenon is not clear. It may be related to undefined differences in the function of different adipose tissue depots or in the ratio of VAT to SAT that occurs with aging; alternatively, selective mortality or a survivorship bias could play a role. Future research is needed to more fully evaluate this relationship.

In our study it is not possible to definitively say whether TBO or Abd-O is more significant in regards to migraine prevalence. However, given our data showing (1) that over 96% of those with TBO had Abd-O; (2) that younger men and women with Abd-O had a higher migraine prevalence than those without; (3) that migraine prevalence in women with Abd-O even without TBO was associated with migraine, it suggests that not just general obesity but also Abd-O (either alone or with TBO) could be modifiable risk factors for episodic migraineurs.

Finally, it is interesting to speculate that obesity may at least in part contribute to why those with a lower level of education are at greater risk for migraine, as Abd-O is also more prevalent in those with a lower level of education.³⁴

Caution is required in assessing these results. Migraine was diagnosed based on participant self-report of migraine and severe headaches. It is possible that some participants who were classified as migraineurs would not fulfill International Classification of Headache

Disorders, 2nd edition criteria for migraine or probable migraine and that some participants with mild or moderate migraine were excluded as they were unaware that they had migraine. However, the prevalence of migraine in the current study (14.9% men; 27.6% women) is comparable to, although slightly lower, than what a previous general population study reported for all migraine, whether definitive or probable migraine (20% men; 34.5% women).¹

Additionally, we cannot be certain that some obese individuals included in our study did not have idiopathic intracranial hypertension. However, the contribution to our study from this disorder would be of small magnitude, given that the prevalence of idiopathic intracranial hypertension is approximately 0.005-0.021% in the general population.^{35,36}

CONCLUSIONS

Our findings suggest that the prevalence of migraine in obesity varies based on adipose tissue distribution, gender and age. In our study, migraine prevalence was increased with TBO, independently of Abd-O, in adult men and women less than 55 years of age. In addition, in men and women less than 55 years, migraine prevalence was increased in those with Abd-O, and this association was independent of TBO in women. Although after 55 years of age, migraine prevalence was not associated with obesity in men, migraine prevalence was *decreased* in women older than 55 years who had Abd-O. These differences may be a result of the sexual dimorphism of adipose tissue distribution and function. Further research in regards to the role of adipose tissue distribution in migraineurs, with attention to gender differences throughout the life cycle, may help elucidate migraine disease mechanisms.

Appendix

APPENDIX I:

- **Abdominal obesity (Abd-O):** Also referred to as central obesity and relates to excessive adipose tissue in the abdominal region. Abd-O is composed of both visceral and subcutaneous adipose tissue.
- **Body mass index (BMI):** A calculation based on a person's height and weight. Although weight measures more than just adipose tissue, BMI is used to estimate general total body obesity. Note: Very fit people with high muscle mass, such as athletes and military personnel, may be classified as overweight based solely on BMI. In addition, aging is accompanied with a progressive increase in the ratio between fat and lean body mass, even in individuals who maintain a constant BMI as they become older.
- **General obesity/total body obesity (TBO):** Refers to excessive adipose tissue throughout the body, including both the abdominal and gluteo-femoral regions. Total body weight includes muscle, bone, and internal organs, in addition to adipose tissue. When total body weight is expressed in relation to body height, it may be used as an estimation of TBO.
- **Subcutaneous adipose tissue (SAT):** Adipose tissue depots located between the epidermis and muscle.
- **Visceral adipose tissue (VAT):** Adipose tissue located inside the peritoneal cavity, which includes mesenteric, epididymal, and perirenal adipose depots.
- **Waist circumference (WC):** A measurement taken at the level of the ileum used to estimate abdominal obesity.

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Fig 1. Age and gender-stratified prevalence of migraine by total body obesity and by abdominal obesity (total body obesity was estimated based on body mass index [BMI]. Abdominal obesity was estimated based on waist circumference). * $P < .001$; † $P < .01$; ‡ $P < .05$.

Fig 2.

Prevalence of migraine in those with and without TBO and Abd-O by gender and age. TBO = total body obesity measured by BMI; Abd-O = abdominal obesity measured by waist circumference. * $P < .05$; ** $P < .01$; *** $P < .001$. # indicates group with small n (men ≤ 55 years, $n = 181$; men > 55 years, $n = 10$; women ≤ 55 years, $n = 32$; women > 55 years, $n = 0$).

Table 1

Demographic and Clinical Characteristics

	Male		Female	
	55 years (n = 7899) n (%)	>55 years (n = 2724) n (%)	55 years (n = 7732) n (%)	>55 years (n = 3428) n (%)
Mean age (years) (SD)	37.5 (10.1)	67.8 (8.5) *	38.1 (10.1)	69.1 (8.9) *
Race				
White	5488 (69.5)	2229 (81.8) *	5289 (68.4)	2734 (79.8) *
African American	859 (10.9)	222 (8.2)	995 (12.9)	313 (9.1)
Hispanic	1217 (15.4)	202 (7.4)	1120 (14.5)	274 (8.0)
Other	335 (4.2)	71 (2.6)	327 (4.2)	105 (3.1)
Education				
<High school	1425 (18.1)	782 (28.8) *	1317 (17.1)	999 (29.2) *
High school	2156 (27.3)	612 (22.5)	1906 (24.7)	1039 (30.4)
>High school	4307 (54.6)	1322 (48.7)	4501 (58.3)	1381 (40.4)
Marital status				
Married	4259 (56.4)	2054 (77.5) *	4189 (55.9)	1630 (49.5) *
Divorced/separated	734 (9.7)	237 (8.9)	1147 (15.3)	457 (13.9)
Widowed	30 (0.4)	217 (8.2)	135 (1.8)	1042 (31.6)
Living with partner	607 (8.0)	53 (2.0)	510 (6.8)	39 (1.2)
Never married	1915 (25.4)	91 (3.4)	1507 (20.1)	126 (3.8)
Smoking status				
Never	3660 (46.4)	856 (31.5) *	4384 (56.7)	1954 (57.1) *
Former	1674 (21.2)	1440 (53.0)	1273 (16.5)	1081 (31.6)
Current	2559 (32.4)	423 (15.6)	2070 (26.8)	387 (11.3)
Alcohol use (g/day)				
0	4606 (61.4)	1856 (71.0) *	5513 (75.1)	2718 (83.1) *
24	1028 (13.7)	369 (14.1)	1070 (14.6)	394 (12.0)
>24	1863 (24.8)	388 (14.9)	754 (10.3)	158 (4.8)
Reported diabetes	316 (4.0)	444 (16.3) *	304 (3.9)	502 (14.7) *
Reported migraine	1362 (17.2)	225 (8.3) *	2553 (33.0)	524 (15.3) *
Median income	\$45,000	\$35,000 *	\$45,000	\$25,000 *
Mean systolic blood pressure (SD)	120.6 (13.0)	134.5 (19.4) *	115.2 (15.9)	141.0 (23.1) *
Mean total cholesterol (SD)	201.6 (45.2)	204.3 (43.5) **	196.1 (37.4)	220.6 (39.5) *
Mean BMI (SD)	27.8 (5.6)	28.2 (5.1) *	28.0 (7.2)	28.6 (6.3) *
Mean WC (cm) (SD)	98.0 (14.9)	104.1 (13.1) *	91.6 (16.0)	96.9 (14.3) *
Total body obesity (BMI ≥ 30)	2142 (27.7)	780 (29.8) **	2443 (32.3)	1139 (35.0) **
Abdominal obesity (WC ≥ 102 cm men/ 88 cm women)	2671 (35.0)	1381 (53.5) *	3960 (53.2)	2329 (72.8) *

* *P* .001 for 55 years vs >55 years

^{**} P .05 for 55 years vs >55 years.

BMI = body mass index; SD = standard deviation; WC = waist circumference.

Table 2

Odds Ratios (OR) of Migraine in Those With Total or Abdominal Obesity Relative to Those Without Obesity, Stratified by Sex and Age

	Men			
	55 years (n = 3303)		>55 years (n = 2140)	
	OR	95% CI^{\$}	OR	95% CI^{\$}
Total body obesity (BMI ≥ 30)	1.38	(1.11, 1.70)	0.72	(0.47, 1.11)
Total body obesity [†] (BMI ≥ 30)	1.38	(1.20, 1.59)	0.77	(0.54, 1.10)
Abdominal obesity (WC ≥ 102 cm)	1.03	(0.84, 1.27)	1.13	(0.77, 1.66)
Abdominal obesity [‡] (WC ≥ 102 cm)	1.30	(1.13, 1.48)	0.97	(0.70, 1.34)
Age (per 1 year)	1.00	(1.00, 1.01)	0.94	(0.92, 0.96)
Income (per \$10,000)	0.89	(0.86, 0.91)	0.89	(0.82, 0.96)
Education				
>High school	Reference		Reference	
High school	1.30	(1.11, 1.51)	1.56	(1.02, 2.40)
<High school	1.82	(1.51, 2.20)	2.16	(1.43, 3.27)
Race				
Caucasian	Reference		Reference	
African American	0.72	(0.57, 0.90)	0.98	(0.56, 1.69)
Hispanic	0.65	(0.53, 0.80)	1.01	(0.58, 1.75)
Other	0.76	(0.54, 1.08)	1.82	(0.75, 4.41)
Smoke				
Never	Reference		Reference	
Former	1.30	(1.09, 1.55)	0.71	(0.49, 1.02)
Current	1.47	(1.26, 1.72)	0.98	(0.63, 1.53)
Alcohol use				
None	Reference		Reference	
24 g/day	0.91	(0.75, 1.11)	0.96	(0.59, 1.56)
>24 g/day	0.57	(0.48, 0.68)	0.64	(0.37, 1.11)
Diabetes	1.08	(0.79, 1.48)	1.45	(0.98, 2.14)
	Women			
	55 years (n = 3169)		>55 years (n = 2125)	
	OR	95% CI	OR	95% CI
Total body obesity (BMI ≥ 30)	1.20	(1.04, 1.39)	0.96	(0.74, 1.26)
Total body obesity [†] (BMI ≥ 30)	1.39	(1.24, 1.55)	0.86	(0.68, 1.10)
Abdominal obesity (WC ≥ 88 cm)	1.26	(1.10, 1.45)	0.73	(0.56, 0.97)
Abdominal obesity [‡] (WC ≥ 88 cm)	1.39	(1.25, 1.56)	0.74	(0.58, 0.94)
Age (per 1 year)	1.00	(0.99, 1.00)	0.95	(0.94, 0.97)
Income (per \$10,000)	0.91	(0.89, 0.94)	1.01	(0.96, 1.07)
Education				

	Men			
	55 years (n = 3303)		>55 years (n = 2140)	
	OR	95% CI [§]	OR	95% CI [§]
>High school	Reference		Reference	
High school	1.05	(0.93, 1.20)	1.28	(0.97, 1.70)
<High school	1.12	(0.95, 1.31)	1.83	(1.35, 2.47)
Race				
Caucasian	Reference		Reference	
African American	0.87	(0.73, 1.03)	1.12	(0.76, 1.66)
Hispanic	1.00	(0.85, 1.18)	1.41	(0.96, 2.07)
Other	0.92	(0.70, 1.22)	1.10	(0.61, 1.99)
Smoke				
Never	Reference		Reference	
Former	0.88	(0.76, 1.03)	1.20	(0.93, 1.53)
Current	1.14	(1.00, 1.30)	1.17	(0.84, 1.64)
Alcohol use (24 hours)				
None	Reference		Reference	
24 g	0.62	(0.53, 0.73)	0.66	(0.46, 0.96)
>24 g	0.96	(0.80, 1.15)	0.32	(0.15, 0.65)
Diabetes	1.44	(1.09, 1.89)	0.84	(0.60, 1.18)

ORs are adjusted for all other variables in the table except where indicated for obesity measures.

[†] Adjusted for all measures except abdominal obesity.

[‡] Adjusted for all covariates except total body obesity.

[§] A 95% confidence interval that does not include 1.0 indicates a significant OR. Significant ORs greater than 1.0 indicate increased odds, whereas those less than 1.0 indicate decreased odds.

BMI = body mass index; WC = waist circumference.