Body Mass Index and Adult Weight Gain Among Reproductive Age Women with Migraine

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Abstract

Objective—To evaluate the cross-sectional relationship between migraine and pre-gravid obesity; and to assess the risk of adult weight gain among women with history of a pediatric diagnosis of migraine.

Background—Obesity, comorbid with pain disorders including migraine, shares common pathophysiological characteristics including systemic inflammation, and derangements in adipose-tissue derived cytokines. Despite biochemical and epidemiological commonalities, obesity-migraine associations have been inconsistently observed.

Methods—A cohort of 3,733 women was interviewed during early pregnancy. We ascertained participants' self-reported history of physician-diagnosed migraine and collected self-reported information about pre-gravid weight, adult height and net weight change from age 18 to the 3-monthsperiodpriorto pregnancy. Using pre-gravid body mass index, we categorized participants as follows: lean (<18.5 kg/m^2); normal (18.5–24.9 kg/m^2); overweight (25–29.9 kg/m^2), obese (30–34.9 kg/m^2), severely obese (35–39.9 kg/m^2), and morbidly obese (≥ 40 kg/m^2). Logistic regression procedures were used to estimate odds ratios (ORs) and 95% confidence intervals (CIs).

Results—After adjusting for confounders, relative to normal weight women, obese women had a 1.48-fold increased odds of migraine(OR=1.48; 95%CI 1.12–1.96). Severely obese (OR=2.07; 95%CI 1.27–3.39) and morbidly obese (OR=2.75; 95%CI 1.60–4.70) had the highest odds of migraines. Women with a history of diagnosed pediatric migraine had a 1.67-fold higher odds of gaining ≥10.0 kg above their weight at age 18, as compared with non-migraineurs (OR=1.67; 95%CI 1.13–2.47).

Conclusion—These data support earlier observations of migraine-obesity association among women, and extend the literature to include evidence of adult weight gain among women with a history of pediatric migraine.

Keywords

Migraine; Obesity; Adult Weight Gain; Pediatric Migraine; Body Mass Index

INTRODUCTION

Migraine, a recurrent neurovascular headache disorder, is characterized by episodes of severe throbbing, pulsatile headache associated with nausea, vomiting, photophobia, phonophobia, and aversion to physical activity.[1, 2] Findings from the American Migraine Prevalence and Prevention study indicate that the prevalence of migraine rises from 4% before puberty to a peak of 25% in women during their childbearing years, with a decrease after menopause.[3] Additionally, an estimated total 35 million US adults (18.2% of women and 6.5% of men) are thought to suffer from migraine.[4, 5] Apart from impairing quality of life, migraine is associated with great economic costs attributable to increased medical care and loss of productivity time – totaling $20 billion in 2004.[5]

Several investigators have noted that obesity is comorbid with pain disorders including chronic daily headache.[6] Others have noted that migraine and obesity share common pathophysiological characteristics including endothelial dysfunction,[7] systemic inflammation,[8] derangements in adipocytokines,[7, 9, 10] and hematological mediators that favor a pro-thrombotic phenotype,[8] and dyslipidemia.[11] Moreover, both migraine and obesity are important risk factors of chronic cardiovascular and pregnancy-related metabolic disorders including angina, myocardial infarction,[11–14] ischemic stroke,[15] and preeclampsia.[16, 17] However, despite the biochemical and epidemiological commonalities of migraine and obesity, results from prior studies have been inconsistent, with some demonstrating a positive association between the two conditions,[5, 18, 19] whereas others have not.[20–23] Notably, positive associations of obesity and migraine have been more consistently observed when classified as reproductive aged women[5, 18, 19] whereas negative associations have been consistently found in *all* studies evaluating peri and post-menopausal women.[18, 22, 23] Given the inconsistent literature and that few prior studies have sought to evaluate the extent to which, if at all, adult weight gain is elevated among subjects diagnosed with migraine as children, we conducted the present study. Using data from a large prospective cohort, we first sought to evaluate the cross-sectional relationship between migraine and pregravid obesity among reproductive aged women. We also sought to assess the risk of adult weight gain among women with history of a pediatric diagnosis of migraine (i.e., a diagnosis prior to age 18 years). We hypothesized that pediatric migraineurs, as compared with non-migraineurs counterparts, were more likely to gain weight as adults.

METHODS

Study Design and Setting

We analyzed data from the Omega Study, a prospective cohort study designed to examine risk factors of adverse pregnancy outcomes including preeclampsia. Participants were recruited from women attending prenatal care clinics affiliated with Swedish Medical Center and Tacoma General Hospital in Seattle and Tacoma, Washington, USA. Recruitment began in December 1996.[24] The study protocol was approved by the Institutional Review Boards of Swedish Medical Center and Tacoma General Hospital. All participants provided informed consent.

Eligible women were those who began prenatal care before 20 weeks gestation, spoke and read English, were ≥18 years of age, and planned to carry the pregnancy to term and deliver at either of the two hospitals. During early pregnancy, participants were asked to complete a structured interviewer administered questionnaire regarding socio-demographic characteristics, lifestyle habits, and medical and reproductive histories. Pregnancy outcome information was abstracted from hospital and clinic medical records.

Analytical Population

The analytical study population was derived from participants enrolled in the Omega Study between 1996 and 2008. During this period, 5,063 eligible women were approached and 4,000 (79%) agreed to participate. Women with incomplete information concerning prior history of migraine (n=267) were excluded from this analysis. Hence a cohort of 3,733 women remained for analysis.

Data Collection

From structured questionnaire and medical records, we obtained information of covariates including subject's age, educational attainment, self-reported height, and pre-pregnancy weight, reproductive and medical histories. We also collected information on smoking status. Pre-pregnancy body mass index (BMI) was calculated as pre-pregnancy weight in kilograms divided by height in meters squared. Subjects' history of migraine diagnosis was determined by response to the questions "Has a doctor ever told you that you have migraine headache?" and "If so, how old were you when your doctor gave you this diagnosis?" The pediatric age range for this study was defined *a priori* to include children up to the age of 18 years. Subjects who reported having a physician diagnosis of migraine were classified as having pediatric diagnosed migraine.

Interviewers asked each woman to report her height without shoes, her recalled weight at age 18, and her weight during the 3-month period before her study pregnancy (pregravid weight). We used this pregravid body mass index (BMI) to estimate adiposity. Obesity was categorized using the following cut points: <18.5 (lean), 18.5–24.9 (normal), 25.0–29.9 (overweight), and ≥30.0 kg/m^2 (obese). For some additional exploratory analyses, we further categorized participants pregravid BMI in the following expanded categories: <18.5 (lean), 18.5–24.9 (normal), 25.0–29.9 (overweight), 30.0–34.9 (obese), 35.0 to 39.9 (severely obese) and ≥40.0 kg/m^2 (morbidly obese). We categorized height according to approximate quartiles: ≤1.60, 1.61–1.65, 1.66–1.69, and ≥1.70 meters. We calculated the net change in weight from age 18 to just before the study pregnancy and categorized it as follows: loss of 2.5 kg or more, net change of fewer than 2.5 kg, 2.6–4.9 kg gain, 5.0–9.9 kg gain, and ≥10.0 kg gain. These categorizations were chosen *a priori* and were similar to those used in studies of weight change in relation to chronic diseases in older women.[25]

Statistical Analyses

We compared the frequency distribution of socio-demographic, lifestyle, behavioral and medical history characteristics of participants according to their pregravid body mass index. We used unadjusted and multivariable-adjusted logistic regression models to calculate odds ratios (ORs) and 95% confidence intervals (CIs) of the association between pre-gravid body mass index categories and migraine diagnosis. We also estimated unadjusted and multivariable adjusted ORs and 95%CIsto evaluate associations of adult weight gain with migraine diagnosis among those participants who were diagnosed with the disorder prior to their 18th birthday. We assessed confounding by entering covariates into the logistic regression model one at a time, and adjusted ORs were compared to unadjusted ORs. Final logistic regression models included covariates that altered unadjusted ORs by 10%, as well as age, race/ethnicity, educational attainment, marital status, prior history of chronic

hypertension or diabetes, smoking status, and participation in leisure time physical activity. Additional adjustments for parity did not materially alter reported ORs. All reported p-values are 2-tailed with statistical significance set at 0.05.

RESULTS

The socio-demographic, medical, and behavior characteristics of the study cohort are presented in Table 1. The frequency of current smokers, unmarried status, and positive family history of hypertension and diabetes increased across categories of pre-gravid BMI. Heavier women were less likely to have completed high school and to be nulliparous when compared with other women. Overall, 18% percent of women in the present cohort reported having a positive history of physician-diagnosed migraine. The age-specific prevalence of migraine for the entire cohort and according to participants' pre-gravid obesity status (BMI < 30 vs. ≥30 kg/m^2) is summarized in Figure 1. As shown in Table 2, obese women (BMI ≥30.0 kg/m^2), as compared with women in the referent group (BMI 18.5–24.5 kg/m^2), had a 1.63-fold increased odds of migraine (OR=1.63; 95%CI 1.25–2.12). After adjusting for age, race/ethnicity, educational attainment, marital status, chronic hypertension or diabetes, smoking and exercise status, the odds ratio for migraine was attenuated to 1.48, though the association remained statistically significant(OR=1.48; 95%CI 1.12–1.96). Results from analyses that further explored the odds of migraine according to extended categories of body mass index are summarized in Figure 2. The odds of migraine were 2-fold higher (OR=2.07; 95%CI 1.27–3.39) and 2.75-fold higher (OR=2.75; 95%CI 1.60–4.70) among severely obese (35–39.9 kg/m^2), and morbidly obese (≥40 kg/m^2) women.

We next evaluated the odds of adult weight gain among women with a history of diagnosed pediatric migraine compared with women having no history of migraine. Pediatric migraineurs were younger, more likely to be non-Hispanic white, to be single, and to have a personal history of hypertension as compared with non-migraineurs. The two study groups were similar with regards to annual household income, educational attainment, and history of exercise as a teenager (Supplementary Table 1). Pediatric migraineurs and non-migraineurs had similar mean weights at age 18 years, and similar adult height as those women without a history of migraine (Supplementary Table 2). However, on average, pediatric migraineurs had higher pre-gravid body mass index (25.0±7.1 vs. 23.4±4.7 kg/m^2, p-value=0.001) and higher adult weight gain values (11.1±14.3 vs. 7.6±10.4 kg, p-value=0.001) as compared with non-migraineurs. As shown in Table 3, after adjusting for age, race/ethnicity, history of chronic hypertension, smoking status, adult height and BMI at age 18, adult weight gain was significantly associated with pediatric migraine. Pediatric migraineurs had a 1.67-fold higher odds of gaining at least 10.0 kg in adulthood than non-migraineurs (OR=1.67; 95%CI 1.13–2.47). Associations of pediatric migraine with other anthropometric measures are summarized in Table 3.

DISCUSSION

In our cohort of reproductive aged women, BMI was associated with migraine diagnosis in a linear fashion. After adjusting for confounders we found that obese women (BMI ≥30.0 kg/m^2), when compared with normal weight women (BMI 18.5–24.5 kg/m^2), were more likely to have had a diagnosis of migraine (OR=1.48; 95%CI 1.12–1.96). Further analyses revealed a linear trend in the prevalence and odds of migraine according to the severity of obesity. Extremely obese women (BMI ≥40.0 kg/m^2) had a 2.75-fold higher odds of migraine (95%CI 1.60–4.70) when compared with the reference group. We also found that women diagnosed with migraine as children, were more likely than women without a diagnosis, to gain a substantial amount of weight as adults. Women with a diagnosis of migraine as a

child had a 1.67-fold increased odds of gaining ≥10.0 kg since the age of 18 (OR=1.67; 95%CI 1.13–2.47), as compared with non-migraineurs.

Our finding of a cross-sectional association of migraine with obesity is in agreement with previous studies which evaluated the migraine-obesity relationship in predominantly reproductive age populations,[5, 18] though not all,[20, 21] prior studies on this topic. Ford et al[5] reported a positive association between measured BMI and self-reported migraine or severe headache. The authors noted that obese (BMI ≥30 kg/m^2) participants in the 1999–2002 National Health and Nutrition Examination Survey (NHANES), had a significantly higher risk of having headache including migraine (OR=1.37; 95%CI 1.09–1.72) as compared with participants who had normal BMI values (18.5–24.5 kg/m^2).[5] Peterlin et al[18] in their analysis of 21,783 adult participants NHANES, reported that the relationship between migraine or severe headaches and obesity may vary by age, gender, and adipose tissue distribution. The authors reported that the prevalence of self-reported migraine/severe headache was increased in younger (≤55 years) men and women with obesity (categorized as measure BMI ≥30 kg/m^2), independent of abdominal obesity (waist circumference ≥88 cm for women and ≥102 cm for men). After adjusting for confounders including as age, race and abdominal obesity, the ORs of migraine or severe headache for overall obesity were 1.38 (95%CI 1.1–1.7) for men and 1.20 (95%CI 1.04–1.39) for women <55 years of age. Abdominal obesity was independently associated with increased odds of migraine and severe headache among women (OR=1.26, 95%CI 1.10–1.45), but not men (OR=1.03, 95%CI 0.84–1.27). The authors observed no clear evidence of a positive association between migraine or severe headache with either overall obesity or abdominal obesity among older (>55 years) men and women.

In our present study, we observed particularly higher odds of a life-time prevalence of self-reported physician diagnosed migraine among severely obese and morbidly obese reproductive age women. This observation is also in general agreement with results from a small clinic based study of extremely obese women. There is a very high frequency of migraine noted among the morbidly obese. Horev et al,[26] in their clinic-based study of 27 morbidly obese women attending preoperative clinic for laparoscopic gastric banding, noted that 48% reported suffering from severe migraine.

Our findings, and those of others,[5, 18] are inconsistent with some published reports.[20, 22] Mattssonet al[22] found no association between chronic migraine and obesity in their study of 684 peri and post menopausal Swedish women aged 40–74 years (OR=1.1; 95%CI 0.6–1.8). Similarly, Bigal et al,[20] in their telephone interview study of 30,215 adults, aged 18–89 years of age, found no evidence suggestive of a positive association between prevalent migraine and obesity based on self-reported BMI. The authors did, however, observe significant associations of body mass index with episodic migraine of high frequency. Compared with the normal weight group (18.5–24.9 kg/m^2), obese (30–34.9 kg/m^2) subjects have a 1.9-foldincreased odds (OR = 1.9; 95%CI 1.9–4.4) and morbidly obese (≥ 35 kg/m^2) subjects have a 5.7-foldincreased odds (OR=5.7; 95%CI 3.6–8.8) of having 10–14 headaches days per month. Attack severity was also associated with BMI; 65% of the morbidly obese (OR=1.9, 95%CI 1.2–2.4) report severe migraine attacks compared to 54% of the normal weight group.

Inconsistent findings across studies may be attributable to methodological differences in obesity and migraine classification and in participant selection. Residual confounding, and sample size may also have contributed to observed inconsistencies across studies. For example, some have argued that the obesity-migraine association may be more consistently observed among migraineurs with concurrent sleep apnea,[27] whereas others note that age and gender significantly contributes to a change in disease risk.[28]

To the best of our knowledge, investigators have not previously evaluated risk of adult weight gain in patients diagnosed with migraine during childhood or early adolescence. However, available evidence from an observational follow-up study of 913 children across seven pediatric headache centers in the US, suggest cross-sectional associations of weight change with the prevalence and severity of headache and migraine.[29] For children whom were obese or overweight at the initial visit, BMI change was positively correlated with change in headache frequency at 3 and 6 month follow-up (r=0.32, p=0.01). Our observations potentially extend the literature by indicating increased odds of adult weight gain among migraineurs diagnosed with the condition prior to age 18 years.

The biological mechanisms underlying observed migraine-obesity and migraine-adult weight gain associations are yet to be fully elucidated. However, investigators have proposed several plausible and compelling hypotheses by which obesity (or severe headache) might lead to the development, worsening and chronification of headache disorders including migraine[28, 30, 31]. Plasma concentrations of calcitonin gene-related peptide (CGRP), an important neurobiological mediator,[32] are increased in obese versus non-obese women;[33] and this has been implicated as one mechanism that accounts for associations of migraine, migrainous symptoms, and appetite with weight gain and obesity.[20, 31] An alternative, or perhaps complementary, hypothesis is that the effects of obesity are mediated by a low-grade chronic inflammatory state. Adipose tissue secretes numerous cytokines, and adipocytokines known to influence immune and vascular endothelial functions as well as glucose metabolism in ways that favor chronic inflammation (including neurovascular inflammation), platelet aggregation, endothelial dysfunction and insulin resistance--conditions common to migraine and obesity.[28, 34] Investigators[35, 36] also speculate that common underlying pathophysiological neuro-endocrine alterations involving the hypothalamus, serotonin and melatonin synthesis and secretion may, in part, explain observations of increased odds of obesity and weight gain in patients with migraine and other primary headache disorders.

The observation that the prevalence of migraine or severe headaches varies with the distribution of adipose tissue, age and gender,[18] with increased prevalence among younger men and women with central adiposity, and decreased prevalence in older women with central adiposity have led some investigators to postulate that differences in sex hormones, age, menopausal status, and the site of adipose tissue storage (e.g., peripheral vs. central fat depots) may exert different neuro-endocrinological effects across the life-course and thus may account for inconsistent findings of obesity with migraine, headaches and their clinical course across study populations. Yet other investigators[31] hypothesize that migraine may increase adiposity, via eating behaviors. This biologically plausible hypothesis is, in part, supported by our observation of increased odds of weight gain among women who were diagnosed with migraine as children.

While the strengths of this study include the large sample size, and relatively high participation rates, several limitations of our study merit discussion and consideration. First, participants' migraine status was based on self-reports made during interviews and on medical records review. Similar questions to the ones we used in the current study to ascertain subject's migraine status have been widely used in epidemiological studies such the Women's Health Study[37] and the National Health and Nutrition Examination Surveys (NHANES);[18] and investigators have documented good agreement between migraine classification based on self-reports with information derived from medical records review.[37, 38] Nevertheless, we cannot exclude the possibility of that migraine status was under-reported in our study. This concern is particularly important given that underreporting is likely related to participants' social class, educational status and other socio-demographic characteristics. Studies that systematically use screening and confirmatory diagnostic

evaluations will likely attenuate concerns about misclassification of migraine diagnoses in epidemiological studies. We were also unable to differentiate migraineurs on the basis of features such as the frequency and severity of attacks and efficacy and type of therapies used to manage symptoms. Moreover, we did not have information concerning the age of migraine onset. Hence, our use of age of migraine diagnosis can only be viewed as a proxy for migraine onset. Second, errors in reporting of anthropometric characteristics are likely to have occurred.[39] Weights reported by participants in other studies, however, have been shown to be valid.[40] Troy et al[40] reported that women's self-reported recalled weight at 18 years was highly correlated (r=0.87) with weight at ages 17–21 abstracted from nursing school records. Third, although we adjusted for several potential confounders, we cannot exclude the possibility of residual confounding due to misclassification of adjusted variables or confounding by other unmeasured variables (e.g., the severity and frequency of migraine and medications used to control symptoms). Lastly, the generalizability of our study may also be limited as our cohort was primarily comprised of Non-Hispanic White and well-educated women. The concordance of our results with those from other studies that have included racially, ethnically and geographically diverse populations, however, serve to attenuate these concerns.

In summary, we found the positive association between pre-gravid body mass index and prevalent migraine. Our data support some earlier observations that the odds of migraine are increased in reproductive-aged women who are obese; and extend the literature to include evidence of adult weight gain among women with a history of pediatric migraine. If confirmed, our findings add to the call for further studies designed to comprehensively evaluate the effects of migraine (and its treatment) on appetite, energy expenditure, and dietary and sleep behaviors. Information from such studies may motivate the development and promotion of public health campaigns that target young adults with migraine, chronic headache and other pain disorders who may be more attuned to making healthful behavioral changes that can positively impact their reproductive outcomes and long-term health.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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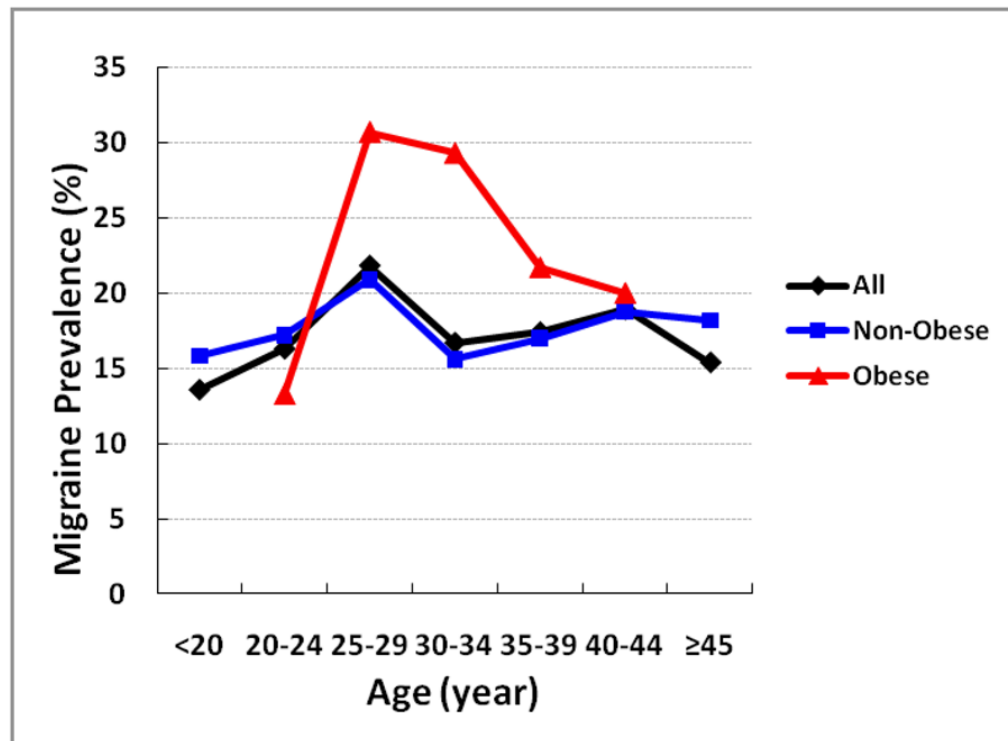
Figure 1.
Age-specific prevalence of migraine for the entire cohort (black) and according to
participants' obesity status (BMI < 30 vs. ≥30 kg/m^2)
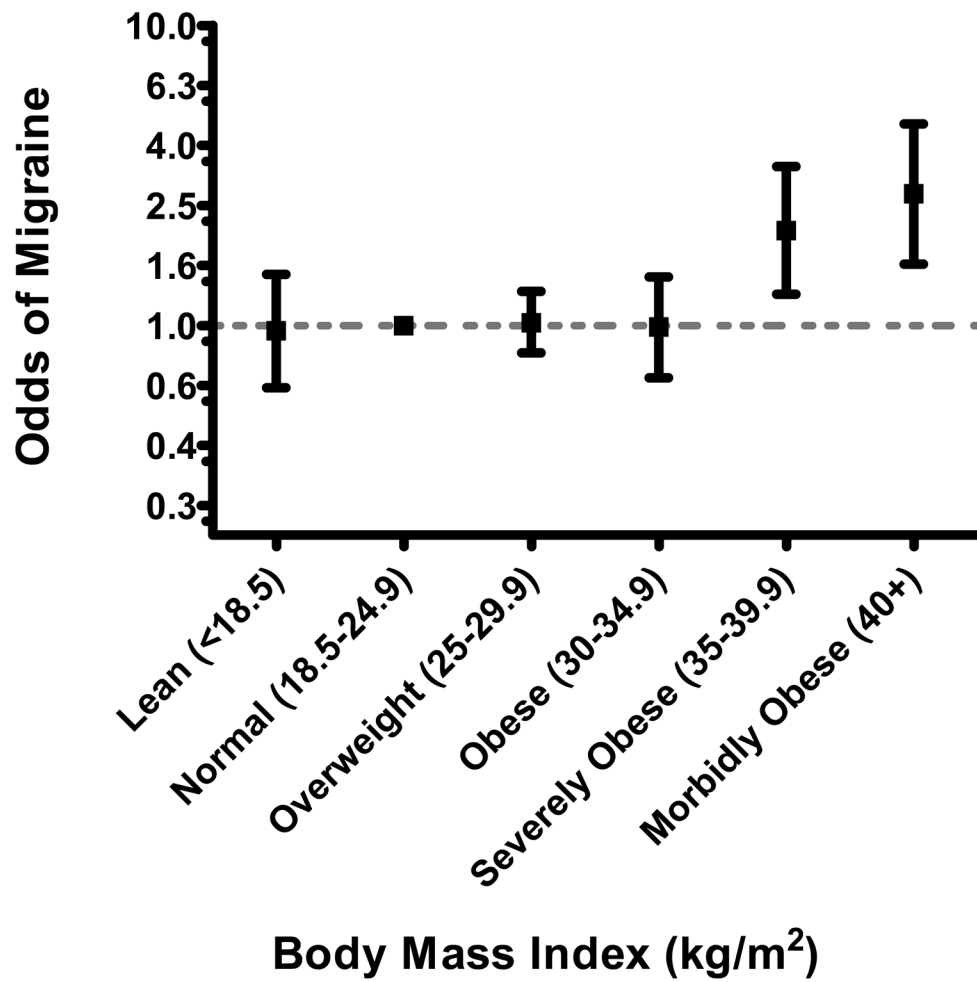
Figure 2.
Adjusted odds ratio (OR) and 95% confidence intervals (CI) of migraine according to participants' body mass index OR and 95% CI adjusted for participants' age, race/ethnicity, educational attainment, marital status, history of chronic hypertension or diabetes mellitus, smoking and exercise status

Table 1

Socio-demographic and other characteristics of the study cohort, Seattle and Tacoma, Washington, USA 1996–2008

| Characteristics	Cohort (N=3733)	Pregravid Body Mass Index (kg/m²)				P-value Trend test
	%	Lean (<18.5) (N=160)	Normal (18.5–24.9) (N=2623)	Overweight (25.0–29.9) (N=612)	Obese (≥30.0) (N=338)	
Age (years)*	32.6 ± 4.5	32.0 ± 4.8	32.7 ± 4.3	33.0 ± 4.8	32.1 ± 5.4	0.80
<30	22.7	25.6	22.0	22.2	28.1	0.02*
30–34	43.6	45.7	44.9	39.7	39.3	
35–39	27.1	23.1	27.1	29.4	24.6	
≥40	6.6	5.6	6.0	8.7	8.0	
Race/ethnicity						
Non-Hispanic White	86.4	84.4	87.8	84.6	80.2	<0.001
Other	13.6	15.6	12.2	15.4	19.8	
Annual Household Income ($)						
<30,000	3.4	5.0	2.6	4.3	7.7	<0.001
30,000–69,999	19.8	13.8	18.1	21.9	32.0	
≥ 70,000	73.5	75.0	76.3	71.2	54.7	
Missing	3.3	6.3	3.0	2.8	5.6	
Parity						
0	62.4	57.5	64.7	59.2	53.0	<0.001
1–2	36.3	41.9	34.5	39.0	42.3	
≥ 3	1.3	0.6	0.8	1.8	4.7	
Education ≤ high school	4.1	1.9	3.2	4.6	10.4	<0.001
Unmarried	9.0	8.1	8.2	9.6	14.5	0.001
History of Diabetes Mellitus	1.3	0.6	1.0	1.0	4.7	<0.001
History of Chronic Hypertension	4.8	1.9	2.3	8.7	18.6	<0.001
Family History of Diabetes Mellitus	14.8	8.8	13.2	17.5	25.2	<0.001
Family History of Hypertension	50.0	46.3	48.5	51.1	62.1	<0.001
Currently Employed	81.5	76.3	81.6	83.5	79.6	0.62
Current Smoker	27.8	21.9	26.4	34.0	30.8	0.001

Characteristics	Cohort (N=3733)	Pregravid Body Mass Index (kg/m^2)				
		Lean (<18.5) (N=160)	Normal (18.5–24.9) (N=2623)	Overweight (25.0–29.9) (N=612)	Obese (≥30.0) (N=338)	P-value Trend test
	%					
Consume Multivitamin	97.3	95.6	97.5	97.2	97.0	0.54
No Current Exercise	7.9	7.5	6.4	8.8	17.5	<0.001
Pre-pregnancy Body Mass Index (kg/m^2)*	23.6 ± 5.0	17.9 ± 0.8	21.6 ± 1.7	27.0 ± 1.4	35.8 ± 5.7	<0.001

*
Mean ± standard deviation (SD)

Table 2

Unadjusted and adjusted odds ratios (OR) and 95% confidence intervals (CI) of migraine according to categories of participants' body mass index Seattle and Tacoma, Washington, USA 1996–2008

| | Pregravid Body Mass Index (kg/m^2) | | | | |
	Lean (<18.5) (N=160)	Normal (18.5–24.9) (N=2,623)	Overweight (25.0–29.9) (N=612)	Obese (≥30.0) (N=338)	P-value Trend test
Physician Diagnosed Migraine					
No, n (%)	134 (83.8)	2174 (82.9)	502 (82.0)	253 (74.8)	
Yes, n (%)	26 (16.3)	449 (17.1)	110 (18.0)	85 (25.2)	
Unadjusted OR (95%CI)	0.94 (0.61–1.45)	1.00 (Reference)	1.06 (0.84–1.35)	1.63 (1.25–2.12)	0.004
* Adjusted OR (95%CI)	0.96(0.62–1.48)	1.00 (Reference)	1.02(0.81–1.29)	1.48(1.12–1.96)	0.04

*
Adjusted for age, race/ethnicity, educational attainment, marital status, history of chronic hypertension or diabetes mellitus, smoking and exercise status

Table 3

Unadjusted and adjusted odds ratios (OR) and 95% confidence intervals (CI) of adult weight gain according to participants' pediatric migraine Seattle and Tacoma, Washington, USA 1996–2008

Anthropometric Characteristics	Pediatric Migraine (N=220)	No Migraine (N=3063)	Unadjusted OR(95%CI)	Adjusted OR(95%CI)
Adult Height (m)				
≤1.60	31 (14.1)	386 (12.6)	1.01 (0.66–1.54)	1.23 (0.79–1.92)
1.61–1.65	46 (20.9)	702 (22.9)	0.82 (0.57–1.19)	0.87 (0.59–1.26)
1.66–1.69	54 (24.6)	856 (28.0)	0.79 (0.56–1.13)	0.81 (0.57–1.16)
≥1.70	89 (42.4)	1119 (36.5)	1.00 (Reference)	1.00 (Reference)[3]
Body Mass Index at Age 18 (kg/m²)				
Lean (<18.5)	40 (18.2)	542 (17.7)	1.11 (0.78–1.60)	1.19 (0.83–1.72)
Normal (18.5–24.9)	151 (68.6)	2281 (74.5)	1.00 (Reference)	1.00 (Reference)[1]
Overweight (25.0–29.9)	21 (9.6)	150 (4.9)	2.11 (1.30–3.44)	1.69 (1.02–2.80)
Obese (≥30.0)	6 (2.7)	45 (1.5)	2.01 (0.85–4.80)	1.62 (0.66–3.95)
Unknown	2 (0.9)	45 (1.5)		
Pregravid Body Mass Index (kg/m²)				
Lean (<18.5)	8 (3.6)	134 (4.4)	0.90 (0.43–1.86)	0.89 (0.43–1.87)
Normal (18.5–24.9)	145 (65.9)	2174 (71.0)	1.00 (Reference)	1.00 (Reference)[2]
Overweight (25.0–29.9)	34 (15.5)	502 (16.4)	1.02 (0.69–1.49)	1.00 (0.68–1.48)
Obese (≥30.0)	33 (15.0)	253 (8.2)	1.96 (1.31–2.92)	1.72 (1.13–2.63)
Adult Weight Gain (kg)				
≤ −2.5	12 (5.4)	244 (8.0)	0.82 (0.43–1.59)	0.68 (0.33–1.39)
−2.5 to 2.5	42 (19.1)	703 (22.9)	1.00 (Reference)	1.00 (Reference)[4]
2.6 to 4.9	25 (11.4)	478 (15.6)	0.88 (0.53–1.46)	0.91 (0.54–1.52)
5.0 to 9.9	51 (23.2)	676 (22.1)	1.26 (0.83–1.93)	1.30 (0.85–2.00)
≥ 10.0	88 (40.0)	917 (29.9)	1.61 (1.10–2.35)	1.67 (1.13–2.47)
missing	2 (0.9)	45 (1.5)		

[1] Adjusted for age, race/ethnicity, history of chronic hypertension and smoking status

[2] Adjusted for age, race/ethnicity, marital status, history of chronic hypertension, and smoking status

[3] Adjusted for age, race/ethnicity, history of chronic hypertension, smoking status, and body mass index at age 18

[4] Adjusted for age, race/ethnicity, history of chronic hypertension, smoking status, adult height and body mass index at age 18