Published in final edited form as:

Cephalalgia. 2009 February ; 29(2): 269–278. doi:10.1111/j.1468-2982.2008.01716.x.

Body Mass Index, Migraine, Migraine Frequency, and Migraine Features in Women

Anke C. Winter, MD, Klaus Berger, MD, MPH, Msc, Julie E. Buring, ScD, and Tobias Kurth, MD, ScD

Institute of Epidemiology and Social Medicine (A.C.W., K.B.), University of Muenster, Muenster, Germany; the Divisions of Preventive Medicine (T.K., J.E.B.) and Aging (T.K., J.E.B.), Department of Medicine, Brigham and Women's Hospital, Harvard Medical School; Department of Epidemiology (T.K., J.E.B.), Harvard School of Public Health; Department of Ambulatory Care and Prevention (J.E.B.), Harvard Medical School; all in Boston, MA

Abstract

We evaluated the association of body mass index (BMI) with migraine and migraine specifics in a cross-sectional study of 63,467 women. 12,613 (19.9%) women reported any history of migraine, of whom 9,195 had active migraine. Compared with women without migraine and a BMI <23kg/m², women with a BMI ≥35kg/m² had adjusted odds ratios (ORs) (95% CIs) of 1.03 (0.95-1.12) for any history of migraine. Findings were similar for active migraineurs. Women with a BMI of ≥35kg/m² had increased risk for low and high migraine frequency, with the highest estimate for women who reported daily migraine. Compared with women with the lowest associated risk (migraine frequency <6 times/year; BMI between 27.0-29.9kg/m²), women with a BMI ≥35 kg/m² had OR of daily migraine of 3.11 (1.12-8.67). Among the women with active migraine, a BMI ≥35kg/m² was associated with increased risk of phonophobia and photophobia and decreased risk of a unilateral pain characteristic and aura. Our data confirm previous findings that the association between BMI with migraine is limited to migraine frequency and specific migraine features.

Keywords

Migraine; overweight; obesity; women; epidemiology

The prevalence of obesity is constantly increasing in the U.S. and worldwide (1-3). The World Health Organization defines overweight as body mass index (BMI) between 25.0 and 29.9 kg/m² and obesity as BMI ≥30 kg/m² (2). Approximately 66% of adult Americans are at least overweight and over 30% are obese and these figures are rising (1). The consequences of overweight and obesity include increased risk of diabetes, dyslipidemia, hypertension, cardiovascular disease, and cancer. Furthermore, obesity has been associated with chronic pain conditions.

Address for correspondence: Tobias Kurth, MD, ScD, Brigham and Women's Hospital, Division of Preventive Medicine, 900 Commonwealth Ave East, Boston, MA 02215, phone: 617-732-8355, fax: 617-731-3843, e-mail: tkurth@rics.bwh.harvard.edu.

Statistical Analysis: Dr. Winter (University of Muenster, Germany) and Dr. Kurth (Brigham and Women's Hospital, Boston MA), performed the statistical analyses. Dr. Kurth had full data access and takes full responsibility for the integrity of the data and the accuracy of the data analysis.

Conflict of interest: The authors report no conflict of interest with regard to the specific matter of the manuscript. A full disclosure for each of the authors has been made available to the editors.

An association between obesity and migraine has been the focus of attention of recent studies (4-11) that is supported by plausible biological mechanisms (12). In particular, an association between obesity and high migraine frequency, migraine features such as photophobia and phonophobia, and migraine severity has been suggested (4,8). However, the association between BMI and migraine features is still conflicting (9) (13) and the shape of the association between BMI and migraine frequency remains unclear. A recent study suggested that this association is J-shaped (11).

A link between obesity and migraine would be of importance because of the increasing prevalence of obesity (1-3,14) may led to an increase in the prevalence, frequency, and severity of migraine and may be a potential target for prevention. Furthermore, such a link may increase the risk of co-morbidities that have recently been associated with migraine such as ischemic stroke (15-17) and other ischemic vascular events (18,19). We thus aimed to evaluate the association between BMI and migraine, migraine frequency, and migraine-related features in more than 65,000 female health professionals in the United States.

Methods

Study population

This is a cross-sectional study among participants in the Women's Health Study (WHS), which was a randomised trial designed to evaluate the risks and benefits of low-dose aspirin and vitamin E in the primary prevention of cardiovascular disease and cancer among 39,876 initially apparently healthy women age 45 or older at study entry (1992-1995). The design and methods of the WHS have been described in detail previously (20-23), all participants provided written informed consent, and the Institutional Review Board of Brigham and Women's Hospital, Boston, Massachusetts approved the procedures of the WHS. In brief, invitation letters were mailed to 1,757,247 female health professionals, including registered nurses, licensed vocational nurses, physicians, veterinarians, pharmacists, dietitians, dentists, dental hygienists, speech/hearing/language professionals, physical therapists, and radiology technologists from 52 different states (and the District of Columbia and Commonwealth of Puerto Rico). Of those, 453,787 returned the baseline questionnaire and 194,659 indicated their willingness to participate in the trial. The 65,169 women who were eligible entered the run-in-phase of the trial, in which compliance with placebos intake was evaluated over 12 weeks. A total of 39,876 female health professionals were finally randomized into the WHS (20). For the purpose of this analysis, we included information on the 65,169 women who entered the run-in phase of the trial. A total of 1,464 women with missing information on BMI and 238 with missing information on migraine were excluded, leaving 63,467 participants for this analysis.

Assessment of migraine

Participants were asked on the baseline questionnaire: "Have you ever had a migraine headache?" and "In the past year, have you had a migraine headache?" From this information, we categorised women into "no history of migraine" and "any history of migraine." Furthermore, we distinguished between "active migraine," which includes women with self-reported migraine in the year prior to completing the baseline questionnaire, and "prior migraine," which includes women who reported ever having had a migraine but none in the year prior to completing the questionnaire. Those participants who reported active migraine were further asked details about their migraine attacks, including attack duration of 4 to 72 hours; unilateral location of pain; pulsating quality; inhibition of daily activities; aggravation by routine physical activity; nausea or vomiting; sensitivity to light; and sensitivity to sound. Furthermore, participants with active migraine were asked whether they had an aura or any indication a migraine is coming and the frequency of their migraine (daily, weekly, monthly,

every other month, <6 times per year). In previous studies of the WHS (18,24,25), we have shown good agreement with modified 1988 International Headache Society (IHS) criteria for migraine in the WHS (26). Specifically, we showed that among WHS participants who reported active migraine, 83.5% fulfilled all but one IHS criteria (code 1.7, migrainous disorder), and 46.6% fulfilled all IHS criteria for migraine (code 1.1 migraine without aura) (18).

Body mass index

Participants were asked to report their height and weight on the baseline questionnaire. Based on this information, BMI, defined as weight in kilograms divided by height in meters squared (kg/m^2), was calculated. We categorised BMI values into 6 categories: <23.0, 23.0 to 24.9, 25.0 to 26.9, 27.0 to 29.9, 30.0 to 34.9, and $\geq 35.0 \text{ kg/m}^2$. Further, dividing the leanest group in additional categories did not indicate different associations. Self-reported and directly measured weight were highly correlated ($r=0.96$) in another comparable cohort of female health professionals (27).

Statistical methods

We compared baseline characteristics of participants with respect to BMI categories using analysis of variance for continuous variables and Mantel-Haenszel test for categorical variables. We used age- and multivariable-adjusted multinomial logistic regression models to evaluate the association between BMI categories and migraine status using women with a BMI of <23 kg/m^2 and who had no history of migraine as the reference group. We further used multinomial logistic regression models to evaluate the association between BMI categories and migraine frequencies among women who reported active migraine using women with a BMI of <23 kg/m^2 and with a migraine frequency of <6 times per year as the reference group. To further evaluate the shape of the BMI-migraine frequency association, we also used the group with the lowest associated risk (migraine frequency <6 times/year and BMI between 27.0-29.9 kg/m^2) as reference group. To evaluate the association between BMI and migraine-related features in the subgroup of participants who indicated active migraine, we used multivariable-adjusted unconditional logistic regression models. We evaluated the following migraine features: aura, sensitivity to sound, sensitivity to light, nausea/vomiting, pulsating pain, inhibition of daily activities, aggravation by routine physical activity, and unilateral pain. We calculated prevalence odds ratios (ORs) and 95% confidence intervals (CIs) for the association between BMI categories and the various migraine outcomes.

The multivariable models were adjusted for age (continuous), smoking (never, past, current <15 cigarettes/day, ≥ 15 cigarettes/day), exercise (never/rarely, <1 per week, 1-3 times per week, 4 or more times per week), alcohol consumption (never, <1 per week, weekly, and daily), history of hypertension, postmenopausal status, postmenopausal hormone use (never, past, current), and history of elevated cholesterol ($\geq 240 \text{ mg/dl}$ or use of cholesterol-lowering medication).

We incorporated a missing value indicator if the number of women with missing information on covariates was >300 or imputed a value otherwise. For all analyses, we used SAS (version 9.1, Cary, NC); all p values were two-tailed and we considered a $p < 0.05$ as statistically significant.

Results

Of the 63,467 participants, a total of 12,613 (19.9%) reported any history of migraine of whom 9,195 reported active migraine (migraine during the year prior to the baseline questionnaire). The mean BMI was 26.3 for women without a history of migraine and 26.6 for women with any history of migraine. Table 1 summarises the comparison of the participants' baseline

characteristics with respect to the BMI categories. Compared with women with a BMI of $<23 \text{ kg/m}^2$, women with a BMI of $\geq 35 \text{ kg/m}^2$ were younger, were more likely to have a history of migraine, to have a history of hypertension or diabetes, to currently smoke fewer cigarettes, to have a history of elevated cholesterol, to drink less alcohol, and were less likely to use postmenopausal hormones and to exercise.

In Table 2, we summarise the association between BMI and migraine status. After adjustment for age and compared with women without a history of migraine and with a BMI of $<23.0 \text{ kg/m}^2$, increasing BMI was associated with increased risk of any history of migraine. Women with a BMI between 30.0 and 34.9 had an OR of any migraine history of 1.11 (95% CI=1.04-1.19) that further increased to an OR of 1.21 (95% CI=1.12-1.32) for women with a BMI ≥ 35.0 . The effect estimates were very similar when we made a distinction between active migraine and prior migraine. The association between BMI and migraine, however, entirely diminished after controlling for smoking, exercise, alcohol consumption, history of hypertension, postmenopausal status, postmenopausal hormone intake, and history of elevated cholesterol levels. Compared with women without migraine and a BMI $<23 \text{ kg/m}^2$, women with migraine and a BMI of $\geq 35.0 \text{ kg/m}^2$ had a multivariable-adjusted OR of 1.03 (95% CI=0.95-1.12). Similarly, there was no association between BMI and active migraine or prior migraine (history of migraine but no indication of migraine in the one year prior to the baseline questionnaire).

With regard to the association between BMI and migraine frequency, we found a J-shaped pattern. Among the women with active migraine and compared with women with a BMI $<23 \text{ kg/m}^2$ and a migraine frequency of <6 times per year, the multivariable-adjusted ORs (95% CI) for women with BMI $\geq 35 \text{ kg/m}^2$ were 0.58 (0.42-0.80) for a migraine frequency of every other month, 0.60 (0.48-0.76) for a monthly migraine frequency, 0.59 (0.39-0.87) for a weekly migraine frequency, and 1.46 (0.63-3.37) for a daily migraine frequency (Table 3). Using the BMI category with the lowest associated risk as the reference group (BMI between 27.0 and 29.9), emerged the J-shaped association between BMI and a daily migraine frequency (Figure), with the highest risk estimates for the high-frequency group (OR=3.11; 95% CI=1.12-8.67).

In Table 4, we summarise the association between BMI and migraine-related features among the women who reported active migraine at baseline. An increasing BMI was associated with an increased risk of sensitivity to sound as well as sensitivity to light that remained when adjusting for potential confounders. Among the women with active migraine and compared with women with a BMI of $<23 \text{ kg/m}^2$, women with a BMI $\geq 35 \text{ kg/m}^2$ had a multivariable-adjusted OR for sensitivity to sound of 1.42 (95% CI=1.19-1.70) and an OR of sensitivity to light of 1.39 (95% CI=1.14-1.68) with both significant trends across BMI categories. In addition, there was a suggestion of a trend that increasing BMI is associated with pulsating pain character (p trend = 0.05) and nausea/vomiting (p trend = 0.07) but the risk estimates in the highest BMI category were only slightly increased. On the other hand, an increase in BMI was associated with a decreased risk of reporting a migraine aura (adjusted OR=0.82; 95% CI, 0.68-0.98; p trend = 0.11) and having unilateral pain (OR =0.81; 95% CI, 0.68-0.97; p trend = 0.001).

Discussion

In this large cohort of apparently healthy women, the age-adjusted small increased risk of migraine associated with high BMI values diminished after controlling for potential confounders. We found a J-shaped association between BMI and migraine frequency, indicating that women with a BMI of $<23 \text{ kg/m}^2$ and a BMI of $\geq 35 \text{ kg/m}^2$ were at increased risk for having a daily migraine, with highest estimates for the high BMI group. Among the women with active migraine, we found that increasing BMI is significantly associated with

sensitivity to sound and light. In contrast, increasing BMI was associated with a decreased reporting of migraine aura and a unilateral pain characteristic.

Consistent with our data, several studies did not find an association between BMI and migraine (7,9,19,28). For example, in a cross-sectional study of 30,215 participants, the adjusted OR for migraine was 0.9 (95% CI=0.6-1.2) for participants with BMI of ≥ 35.0 kg/m² compared with participants with a BMI between 18.5 and 24.9 kg/m² (7). In three other studies, no difference was found in mean BMI values of migraineurs and participants without migraine (9,19,28). In contrast, one small study suggested that patients referred for obesity surgery had a higher prevalence of migraine compared with subjects with a BMI of <25.0 kg/m² (5).

Our finding of a J-shaped association between BMI and a high frequency of migraine is consistent with a recent study of 18,989 migraine patients (11). The relative risk for having a migraine frequency of 10-14 days per month was 1.44 (95% CI=0.98-1.96) for migraineurs with a BMI <18.5 kg/m² and 1.74 (95% CI=1.41-1.93) for migraineurs with a BMI of ≥ 35 kg/m² when compared with patients with migraine and a BMI between 18.5 and 24.9 kg/m². Other studies showed increased relative risk estimates for increasing BMI levels. In a cross-sectional study of 30,215 participants, obesity was associated with the number of reported headache days per month. Among migraineurs with an attack frequency of 10 to 14 days per month, the ORs were 2.9 (95% CI=1.9-4.4) for being obese (BMI 30.0 to 34.9 kg/m²) and 5.7 (95% CI=3.6-8.8) for being morbidly obese (BMI ≥ 35.0 kg/m²) (7). In contrast, a recent study from Sweden that included 684 women who participated in a mammogram screening program did not find an association between BMI and migraine frequency, severity, and duration (9).

Two studies indicated an association between obesity and chronic daily headache (CDH), which is defined as headaches occurring 15 or more days per months. In the first study of 1,134 cases of patients with CDH and 798 controls, overweight and obesity were associated with CDH after adjusting for potential confounders (4). Cases and controls were further followed for 11 months, during which time 23 incident cases of CDH occurred. After adjustment, obesity was associated with a 5-fold increased risk of developing CDH (OR=5.28; 95% CI=1.3-21.1) compared with participants with a BMI of <25 kg/m². The second study was a large population-based cross-sectional study, in which BMI was associated with CDH (8). Compared with participants with a BMI between 18.5 and 24.9 kg/m², the OR of CDH was 2.0 (95% CI=1.4-2.4) for participants with a BMI of at least 35 kg/m². Furthermore, the association between BMI and CDH was stronger for patients with transformed migraine compared with patients with chronic tension-type headache. Our data did not allow us to classify migraineurs in having CDH and no data on incident CDH were available.

As potential mechanisms for the observed association between BMI and increase in migraine frequency or CDH of other studies, inflammatory mediators, such as calcitonin gene-related peptide and interleukins have been proposed that subsequently may influence migraine frequency and potentially cause a central sensitisation (12). However, the J-shaped association between BMI and migraine frequency as found in our data and in another large cohort study (11) may suggest more complex mechanisms.

The only other study that evaluated the association between BMI and migraine features is the previously mentioned cross-sectional population-based study (7). Among the subgroup of patients with migraine (n=3,791), a BMI of ≥ 35 kg/m² was associated with more severe headaches, worsened by physical activity, high disability, photophobia, and phonophobia. In addition, women with a BMI of <18.5 had increased risk of unilateral pain, although this finding was not significant (OR=1.31, 95% CI=0.8-1.2). Further in this study, there was no association between BMI and migraine aura status. Our data confirm the association between high BMI levels and photo- as well as phonophobia and the inverse association between BMI and

unilateral pain characteristic. In contrast, we found a modest inverse association with migraine aura status and we did not find associations between BMI and migraine-related inhibition of daily activities or migraine aggravation by physical activity. The nature of subgroup analyses as well as lack of clear biological mechanisms to explain the association between BMI and migraine-specific features, however, should caution the interpretation of these findings.

The present study has several strengths, including the large number of participants and number of women with migraine as well as standardised ascertainment. In addition, we collected information about many migraine features, including migraine aura and migraine frequency. Furthermore, information about a large number of potential confounders was available, allowing us to adjust the association between BMI and migraine. In addition, the homogenous nature of WHS participants further reduced potential confounding.

Several limitations should be considered when interpreting our results. First, information on migraine, migraine frequency, and migraine features was self-reported, and misclassification is possible. However, in previous studies using data from this cohort, good agreement between migraine classification and modified 1988 International Headache Society criteria for migraine (26) were found (18,24,25). In addition, our prevalence of migraine with aura is very close to that found in other population-based studies (29,30), in particular to the 37% figure reported in the American Migraine Study II (29), although this study included participants who were 12 years of age or older. Further, we cannot exclude the possibility that migraine status was underreported. However, we have no reason to believe that underreporting would depend on specific BMI categories and is thus an unlikely explanation of our findings. Second, information on body weight and height was also self-reported. However, studies evaluating the validity of self-reported BMI found excellent correlations (31-33). Third, despite our ability to control for a large number of potential confounders, we cannot exclude the possibility of residual and unmeasurable confounding since our study is observational. Further, our data were cross-sectional not allowing us to determine the time sequence of the association between BMI and migraine. Lastly, the study population is limited to female health professionals aged 45 and older, and the vast majority of them were white. Thus, the present results may not necessarily be extrapolated to other middle aged female populations and different associations between BMI and migraine as well as migraine-specific features in younger women and men cannot be excluded.

In summary, the overwhelming evidence from epidemiologic data does not support a causal relationship between BMI and occurrence of migraine. In contrast, we confirm previous findings of an association between BMI and migraine frequency and specific migraine features that warrant future investigations.

Acknowledgements

We are indebted to the participants in the Women's Health Study for their outstanding commitment and cooperation, and to the entire Women's Health Study staff for their expert and unfailing assistance.

Funding: The Women's Health Study is supported by grants and from the National Heart, Lung, and Blood Institute (HL-43851 and HL-080467), and the National Cancer Institute (CA-47988).

References

1. National Center for Chronic Disease Prevention and Health Promotion. Overweight and obesity: U.S. obesity trends 1985-2006. [April 24, 2008]. Available at: <http://www.cdc.gov/nccdphp/dnpa/obesity/trend/maps/index.htm>
2. World Health Organization. Global strategy on diet, physical activity, and health: obesity and overweight. [April 24, 2008]. Available at: <http://www.who.int/dietphysicalactivity/publications/facts/obesity/en/>

3. Manson JE, Skerrett PJ, Greenland P, VanItallie TB. The escalating pandemics of obesity and sedentary lifestyle. A call to action for clinicians. *Archives of Internal Medicine* 2004;164:249–258. [PubMed: 14769621]
4. Scher AI, Stewart WF, Ricci JA, Lipton RB. Factors associated with the onset and remission of chronic daily headache in a population-based study. *Pain* 2003;106:81–89. [PubMed: 14581114]
5. Peres MF, Lerario DD, Garrido AB, Zukerman E. Primary headaches in obese patients. *Arquivos de Neuro-Psiquiatria* 2005;63:931–933. [PubMed: 16400407]
6. Horev A, Wirguin I, Lantsberg L, Ifergane G. A high incidence of migraine with aura among morbidly obese women. *Headache* 2005;45:936–938. [PubMed: 15985113]
7. Bigal ME, Liberman JN, Lipton RB. Obesity and migraine: a population study. *Neurology* 2006;66:545–550. [PubMed: 16354886]
8. Bigal ME, Lipton RB. Obesity is a risk factor for transformed migraine but not chronic tension-type headache. *Neurology* 2006;67:252–257. [PubMed: 16864817]
9. Mattsson P. Migraine headache and obesity in women aged 40–74 years: a population-based study. *Cephalalgia* 2007;27:877–880. [PubMed: 17635528]
10. Tietjen GE, Peterlin BL, Brandes JL, Hafeez F, Hutchinson S, Martin VT, et al. Depression and anxiety: effect on the migraine-obesity relationship. *Headache* 2007;47:866–875. [PubMed: 17578537]
11. Bigal ME, Tsang A, Loder E, Serrano D, Reed ML, Lipton RB. Body mass index and episodic headaches: a population-based study. *Archives of Internal Medicine* 2007;167:1964–1970. [PubMed: 17923596]
12. Bigal ME, Lipton RB, Holland PR, Goadsby PJ. Obesity, migraine, and chronic migraine: possible mechanisms of interaction. *Neurology* 2007;68:1851–1861. [PubMed: 17515549]
13. Bigal ME, Gironde M, Tepper SJ, Feleppa M, Rapoport AM, Sheftell FD, et al. Headache prevention outcome and body mass index. *Cephalalgia* 2006;26:445–450. [PubMed: 16556246]
14. Hedley AA, Ogden CL, Johnson CL, Carroll MD, Curtin LR, Flegal KM. Prevalence of overweight and obesity among US children, adolescents, and adults, 1999–2002. *JAMA* 2004;291:2847–2850. [PubMed: 15199035]
15. Kurth T, Slomke MA, Kase CS, Cook NR, Lee IM, Gaziano JM, et al. Migraine, headache, and the risk of stroke in women: a prospective study. *Neurology* 2005;64:1020–1026. [PubMed: 15781820]
16. Stang PE, Carson AP, Rose KM, Mo J, Ephross SA, Shahar E, et al. Headache, cerebrovascular symptoms, and stroke: the Atherosclerosis Risk in Communities Study. *Neurology* 2005;64:1573–1577. [PubMed: 15883318]
17. MacClellan LR, Giles WH, Cole J, Wozniak MA, Stern B, Mtichell B, et al. Probable migraine with visual aura and risk of ischemic stroke: The Stroke Prevention in Young Women Study. *Stroke* 2007;38:2438–2445. [PubMed: 17690308]
18. Kurth T, Gaziano JM, Cook NR, Logroscino G, Diener HC, Buring JE. Migraine and risk of cardiovascular disease in women. *JAMA* 2006;296:283–291. [PubMed: 16849661]
19. Kurth T, Gaziano JM, Cook N, Bubes V, Logroscino G, Diener HC, et al. Migraine and risk of cardiovascular disease in men. *Archives of Internal Medicine* 2007;167:795–801. [PubMed: 17452542]
20. Rexrode KM, Lee IM, Cook NR, Hennekens CH, Buring JE. Baseline characteristics of participants in the Women's Health Study. *J Womens Health Gend Based Med* 2000;9:19–27. [PubMed: 10718501]
21. Ridker PM, Cook NR, Lee IM, Gordon D, Gaziano JM, Manson JE, et al. A randomized trial of low-dose aspirin in the primary prevention of cardiovascular disease in women. *New England Journal of Medicine* 2005;352:1293–1304. [PubMed: 15753114]
22. Lee IM, Cook NR, Gaziano JM, Gordon D, Ridker PM, Manson JE, et al. Vitamin E in the primary prevention of cardiovascular disease and cancer: the Women's Health Study: a randomized controlled trial. *JAMA* 2005;294:56–65. [PubMed: 15998891]
23. Cook NR, Lee IM, Gaziano JM, Gordon D, Ridker PM, Manson JE, et al. Low-dose aspirin in the primary prevention of cancer: the Women's Health Study: a randomized controlled trial. *JAMA* 2005;294:47–55. [PubMed: 15998890]

24. Bensenor IM, Cook NR, Lee IM, Chown MJ, Hennekens CH, Buring JE. Low-dose aspirin for migraine prophylaxis in women. *Cephalalgia* 2001;21:175–183. [PubMed: 11442551]
25. Cook NR, Bensenor IM, Lotufo PA, Lee IM, Skerrett PJ, Chown MJ, et al. Migraine and coronary heart disease in women and men. *Headache* 2002;42:715–727. [PubMed: 12390634]
26. Headache Classification Committee of the International Headache Society. Classification and diagnostic criteria for headache disorders cranial neuralgias and facial pain. *Cephalalgia* 1988;8:1–96.
27. Willett W, Stampfer MJ, Bain C, Lipnick R, Speizer FE, Rosner B, et al. Cigarette smoking, relative weight, and menopause. *Am J Epidemiol* 1983;117:651–658. [PubMed: 6859020]
28. Scher AI, Terwindt GM, Picavet HS, Verschuren WM, Ferrari MD, Launer LJ. Cardiovascular risk factors and migraine: the GEM population-based study. *Neurology* 2005;64:614–620. [PubMed: 15728281]
29. Lipton RB, Stewart WF, Diamond S, Diamond ML, Reed M. Prevalence and burden of migraine in the United States: data from the American Migraine Study II. *Headache* 2001;41:646–657. [PubMed: 11554952]
30. Launer LJ, Terwindt GM, Ferrari MD. The prevalence and characteristics of migraine in a population-based cohort: the GEM study. *Neurology* 1999;53:537–542. [PubMed: 10449117]
31. Himes JH, Hannan P, Wall M, Neumark-Sztainer D. Factors associated with errors in self-reports of stature, weight, and body mass index in Minnesota adolescents. *Ann Epidemiol* 2005;15:272–278. [PubMed: 15780774]
32. Frazer KA, Ballinger DG, Cox DR, Hinds DA, Stuve LL, Gibbs RA, et al. A second generation human haplotype map of over 3.1 million SNPs. *Nature* 2007;449:851–861. [PubMed: 17943122]
33. Pavlakis SG, Phillips PC, DiMauro S, De Vivo DC, Rowland LP. Mitochondrial myopathy, encephalopathy, lactic acidosis, and strokelike episodes: a distinctive clinical syndrome. *Annals of Neurology* 1984;16:481–488. [PubMed: 6093682]

Figure.

Association between body mass index and daily migraine frequency. Odds ratios are calculated from a multinomial logistic regression model with women with a migraine frequency of <6 times per year and a body mass index between 27 and 29.9 kg/m² as reference group and adjusted for age, smoking, exercise, alcohol consumption, history of hypertension, postmenopausal status, postmenopausal hormone use, history of elevated cholesterol, and other migraine frequencies.

Table 1
Baseline characteristics according to body mass index categories in the Women's Health Study (N=63,467)

Characteristic	Body Mass Index (kg/m ²)					P-Value
No. of participants	<23.0 18,301	23.0 to 24.9 12,475	25.0 to 26.9 9,744	27.0 to 29.9 10,105	30.0 to 34.9 8,338	>=35.0 4,504
Mean age, years (Std)	53.5 (7.2)	54.1 (7.2)	54.4 (7.3)	54.1 (7.0)	53.6 (6.7)	52.5 (6.2)
Height, m (Std)	1.6 (0.1)	1.6 (0.1)	1.6 (0.1)	1.6 (0.1)	1.6 (0.1)	1.6 (0.1)
Weight, kg (Std)	57.5 (5.8)	64.4 (4.9)	70.3 (5.5)	76.6 (6.4)	86.1 (7.7)	105.9 (14.0)
No history of migraine, %	81.2	80.1	80.0	80.0	79.5	77.6
Any history of migraine, %	18.8	19.9	20.0	20.0	20.5	22.4
Active migraine, %	13.8	14.4	15.2	14.3	14.5	16.4
Active migraine with aura, %	5.5	5.6	6.0	5.8	5.6	5.7
Active migraine without aura, %	8.3	8.8	9.2	8.5	8.8	10.7
Prior migraine, %	5.0	5.5	4.9	5.7	6.0	6.0
History of hypertension†, %	14.2	20.1	24.2	31.5	40.8	53.6
History of diabetes, %	0.8	1.2	2.0	3.8	6.6	10.8
Smoking status, %						
Never	49.1	48.7	48.9	50.1	51.3	51.1
Past	33.5	36.1	36.3	35.6	34.9	36.7
Current <15 cigarettes	6.4	5.6	5.3	4.9	4.5	4.3
Current ≥15 cigarettes	11.0	9.6	9.5	9.3	9.3	7.9
History of elevated cholesterol ≥240 mg/dL	22.9	28.6	31.5	34.9	35.2	34.7
Alcohol intake, %						
Rarely/Never	38.2	41.3	45.2	50.2	56.8	66.7
1-3 drinks/month	12.6	13.0	13.0	13.8	13.8	12.4
1-6 drinks/week	35.5	34.0	32.1	28.4	24.4	18.0
≥1 drinks per day	13.8	11.7	9.7	7.6	5.1	2.9
Postmenopausal	53.3	56.0	56.9	56.0	53.8	48.8
Postmenopausal hormone use, %						
Never	46.0	44.9	46.0	47.9	50.5	57.6
Past	9.0	10.6	11.0	12.0	13.1	13.7
Current	45.0	44.6	43.0	40.1	36.4	28.7
Exercise, %						
Never	32.8	34.9	37.6	43.2	49.2	58.3
<Weekly	17.8	20.1	20.7	21.5	21.8	21.5
Weekly	34.5	33.6	32.7	28.4	24.1	16.7
Daily	14.9	11.3	9.1	6.9	4.9	3.4

Table 2
Associations between body mass index categories and migraine status in the Women's Health Study (N=63,467).

Body mass index, kg/m ² No.	No history of migraine			Any history of migraine			Active migraine			Prior migraine*		
	No.	50,854	%	No.	12,613	%	No.	%	OR (95% CI)	No.	%	OR (95% CI)
Age-adjusted												
<23.0	14,860	29.2		3,441	27.3		2,520	27.4	1.00	921	27.0	1.00
23.0 to 24.9	9,990	19.6		2,485	19.7		1,801	19.6	1.09	684	20.0	1.10
25.0 to 26.9	7,792	15.3		1,952	15.5		1,479	16.1	(1.03-1.16)	473	13.8	(0.99-1.21)
27.0 to 29.9	8,083	15.9		2,022	16.0		1,449	15.8	1.11	573	16.8	0.97
30.0 to 34.9	6,633	13.0		1,705	13.5		1,206	13.1	(1.04-1.18)	499	14.6	(0.86-1.08)
>= 35.0	3,496	6.9		1,008	8.0		740	8.1	(1.03-1.17)	268	7.8	(1.02-1.27)
Multiple-adjusted†									(1.01-1.17)			(1.09-1.36)
<23.0	14,860	29.2		3,441	27.3		2,520	27.4	1.00	921	27.0	1.00
23.0 to 24.9	9,990	19.6		2,485	19.7		1,801	19.6	1.05	684	20.0	1.06
25.0 to 26.9	7,792	15.3		1,952	15.5		1,479	16.1	(0.99-1.12)	473	13.8	(0.95-1.17)
27.0 to 29.9	8,083	15.9		2,022	16.0		1,449	15.8	1.05	573	16.8	0.91
30.0 to 34.9	6,633	13.0		1,705	13.5		1,206	13.1	(0.98-1.12)	499	14.6	(0.82-1.03)
>= 35.0	3,496	6.9		1,008	8.0		740	8.1	1.00	268	7.8	1.03
									(0.94-1.06)			(0.92-1.15)
									0.98			1.06
									(0.91-1.05)			(0.94-1.19)
									1.03			1.04
									(0.95-1.12)			(0.90-1.21)

OR denote odds ratio and CI confidence interval. Odds ratios are calculated by using a multinomial logistic regression model with women without history of migraine who had BMI of <23 kg/m² as reference group.

* Women who indicated a history of migraine but no migraine in the year preceding the baseline questionnaire.

† Adjusted for age, smoking, exercise, alcohol consumption, history of hypertension, postmenopausal status, postmenopausal hormone use, and history of elevated cholesterol.

Adjusted* association between body mass index and frequency of migraine among women with active migraine in the Women's Health Study (N=9,195).

[illegible]

OR denote odds ratio and CI confidence interval. Odds ratios are calculated by using a multinomial logistic regression model with women with a migraine frequency of <6 times/yr and a BMI of <23 kg/m² as reference group.

* Adjusted for age, smoking, exercise, alcohol consumption, history of hypertension, postmenopausal status, postmenopausal hormone use, and history of elevated cholesterol.

Adjusted* association between body mass index and migraine features among women with active migraine in the Women's Health Study (N=9,195)

Table 4

Associated migraine features	<23.0	Body Mass Index (kg/m ²)			>=35.0 OR (95% CI)	P trend [†]
		23.0 to 24.9 OR (95% CI)	25.0 to 26.9 OR (95% CI)	27.0 to 29.9 OR (95% CI)		
Aura	1.00					
Sensitivity to sound	1.00	0.96 (0.84-1.08)	0.99 (0.86-1.13)	1.03 (0.90-1.17)	0.98 (0.85-1.13)	0.11
Sensitivity to light	1.00	1.14 (1.01-1.29)	1.12 (0.98-1.28)	1.08 (0.95-1.24)	1.29 (1.12-1.49)	<.001
Nausea/vomiting	1.00	1.08 (0.95-1.23)	1.11 (0.97-1.28)	1.20 (1.04-1.38)	1.29 (1.10-1.50)	<.001
Pulsating pain	1.00	1.00 (0.88-1.13)	0.95 (0.83-1.08)	1.03 (0.90-1.18)	1.11 (0.96-1.38)	0.07
Inhibition daily activities	1.00	1.06 (0.94-1.20)	1.09 (0.96-1.24)	1.00 (0.88-1.14)	1.23 (1.07-1.43)	0.05
Aggravation by routine physical activity	1.00	1.03 (0.92-1.17)	0.91 (0.80-1.04)	1.00 (0.88-1.14)	1.07 (0.93-1.24)	0.13
Unilateral pain location	1.00	1.12 (0.99-1.27)	0.91 (0.79-1.04)	1.03 (0.90-1.19)	1.20 (1.04-1.40)	0.13
		1.09 (0.96-1.23)	0.82 (0.72-0.93)	0.93 (0.81-1.06)	0.85 (0.73-0.98)	0.001

OR denote odds ratio and CI confidence interval. Odds ratios are calculated by using an unconditional logistic regression model with women with a BMI of <23 kg/m² as reference group.

* Adjusted for age, smoking, exercise, alcohol consumption, history of hypertension, postmenopausal status, postmenopausal hormone use, and history of elevated cholesterol.

[†]P for linear trend.