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Migraine and the risk of incident hypertension among women

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Abstract

Background—Few studies have examined whether migraine is associated with an increased risk of incident hypertension.

Methods—We performed a prospective cohort study among 29,040 women without hypertension at baseline. Women were classified as having active migraine with aura (MA), active migraine without aura (MO), past history of migraine, or no history of migraine. Incident hypertension was defined as new physician diagnosis or newly self-reported systolic or diastolic blood pressure 140 mmHg or 90 mmHg respectively. Cox proportional hazards models were used to evaluate the association between migraine and incident hypertension.

Results—During a mean follow-up of 12.2 years, 15,176 incident hypertension cases occurred. Compared to those with no history of migraine, women who experience MA had a 9% increase in their risk of developing hypertension (95% CI: 1.02, 1.18); women who experience MO had a 21% increase in their risk of developing hypertension (95% CI: 1.14, 1.28); and women with a past history of migraine had a 15% increase in their risk of developing hypertension (95% CI: 1.07, 1.23).

Conclusions—Women with migraine have a higher relative risk of developing hypertension compared to women without migraine.

Keywords

migraine; hypertension; epidemiology; women

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Background

A possible link between migraine and disorders of the vascular system has been explored for decades.^{1,2} For example, migraine, particularly migraine with aura, has been consistently associated with increased stroke risk.^{3,4} Additionally, emerging evidence suggests that migraineurs are at increased risk of developing other cardiovascular disorders including myocardial infarction.^{5,6}

The association between migraine and prevalent hypertension has been studied in several case-control and cross-sectional studies with inconsistent results.⁷ Some studies suggest a positive association between migraine and prevalent hypertension^{8–12}, while others found no association or an inverse association.^{13–17} One prospective population-based study evaluated whether migraine was associated with an increased risk of developing hypertension. After 5 years of follow-up, migraine was associated with an approximately 1.4 fold increased risk of developing hypertension.¹⁸ Other prospective studies evaluated whether hypertension is associated with prevalent migraine with inconsistent results.^{14,19,20} Better understanding whether migraineurs are at increased risk for developing hypertension is important as it may inform clinical management as well as elucidate possible strategies to prevent hypertension and the potential influence of this association in the development of coronary disease in patients with migraine.⁵ In addition, no prospective studies have assessed the role of migraine characteristics, for example aura status or migraine frequency, on the risk of developing hypertension.

We therefore aim to evaluate the association between migraine, including migraine subtypes and migraine frequency, and risk of developing hypertension in a large prospective cohort of middle-aged and older female health professionals.

Methods

The Women's Health Study (WHS) was a large, randomized, placebo-controlled trial designed to test the effects of aspirin and vitamin E on the primary prevention of cardiovascular disease (CVD) and cancer. The design, methods, and main results of the trial have been published previously.^{21,22} Briefly, at baseline (1992–1995), 39,876 US female health professionals aged 45 years or older without a history of cardiovascular disease, cancer, or other major illnesses were randomized to receive low-dose aspirin (versus placebo) or vitamin E (versus placebo) in a 2-by-2 factorial design. Since the end of the trial in March 2004, women continue to be followed on an observational basis. Twice during the first year and yearly thereafter, women were sent follow-up questionnaires asking about demographic, lifestyle, and health information, including information on new diagnosis of hypertension, hypertension medication use, and systolic and diastolic blood pressure.

The WHS was approved by the Institutional Review Board at Brigham and Women's Hospital; all subjects provided written informed consent.

Migraine assessment

The baseline questionnaire asked participants, “Have you ever had migraine headaches?” Women answering affirmatively were further asked “In the past year, have you had migraine headaches?” Women who experienced migraine headaches within the past year were asked about the characteristics of their attacks, including aura or any indication that a migraine was coming, and about the approximate frequency of their migraine headache attacks. Based on their responses, we classified the participants into four groups: no migraine, past history of migraine (women who did not experience migraine headaches in the year before baseline but who have previously experienced migraine headaches), active migraine with aura (MA) (women who experienced migraine within the year before baseline and who reported the presence of aura or any indication that a migraine was coming), and active migraine without aura (MO). We also created a dichotomous variable indicating any migraine history versus none. Women who reported experiencing migraine within the past year were also categorized according to the frequency of their attacks: migraine attacks less than six times per year, every other month, monthly, and weekly or more often.

Previous validation studies in the WHS have shown good agreement between self-reported migraine and the *International Classification of Headache Disorders II* criteria.²³

Hypertension assessment

At baseline, women were asked to self-report past or current history of hypertension, their current systolic and diastolic blood pressure, and current use of any antihypertensive medications. Women who self-reported at baseline either current or past history of hypertension, systolic blood pressure (SBP) ≥ 140 mmHg, diastolic blood pressure (DBP) ≥ 90 mmHg, or current antihypertensive treatment were excluded from this analysis.

Incident cases of hypertension were defined by meeting at least 1 of 3 criteria: self-report of a new physician diagnosis of hypertension, self-report of SBP ≥ 140 mmHg, or self-report of DBP ≥ 90 mmHg.²⁴ Women also reported the month and year of any new physician diagnosis of hypertension. If there was missing information on dates of physician diagnosis or hypertension defined by other criteria, the time of the event was assigned to a random date between questionnaires without and with hypertension. Women who first developed CVD events during follow-up prior to a hypertension diagnosis were censored to avoid the possible impact of the management of these conditions on blood pressure. A validation study within a random sample of the WHS observed that self-reported incident hypertension was confirmed in 48 of 50 (96%) women and absence of hypertension was confirmed in 45 of 50 (90%) women by telephone interview with the participant.²⁵

Due to concerns about antihypertensive medications being used to treat migraine, women were also censored if they self-reported initiation of antihypertensive treatment and were not considered incident hypertension cases. However, we performed a sensitivity analysis in which we included such women and evaluated its impact on our risk estimates.

Statistical Analysis

At baseline, the WHS enrolled 39,876 women. First, we excluded 119 women who did not answer the baseline migraine questions, 6 women with a history of CVD prior to baseline and 10,711 women with a baseline history of hypertension, leaving 29,040 women for this analysis. The prevalence of any migraine was higher among those with a baseline history of hypertension (19.7%) than among those without a baseline history of hypertension (18.0%).

Hazard ratios and 95% confidence intervals (CI) obtained from Cox proportional hazards models were used to estimate the relative risk (RR) of incident hypertension for women with any history of migraine compared to those without migraine. To test the assumption of proportional hazards, we included an interaction term between the log transformation of time and migraine status. No significant violation was found.

We performed age- and multivariable-adjusted analyses. Our multivariable analyses adjusted for randomized treatment assignment to aspirin and vitamin E plus the following potential confounders: age (continuous), BMI (<25, 25 – <30, ≥30 kg/m²), smoking (current, past, never), alcohol consumption (rarely/never, 1–3 drinks/month, 1–6 drinks/week, ≥7 drinks/week), physical activity (rarely/never, <1 time/week, 1–3 times/week, ≥4 times/week), postmenopausal status (premenopausal, postmenopausal, uncertain), hormone replacement therapy use (never, past, current), history of diabetes at baseline (yes/no), hypercholesterolemia (yes/no), and baseline treatment with cholesterol-lowering medication (yes/no).

Less than 100 women were missing information on each of the following covariates: smoking, alcohol consumption, physical activity, postmenopausal status, hormone replacement therapy use, history of diabetes, history of high cholesterol, and baseline treatment with cholesterol-lowering medication, and were assigned to the most frequent category. Less than 100 women were missing information on BMI and were assigned to the mean BMI (25.2 kg/m²).

To test whether the risk of incident hypertension differs according to migraine subtypes, we calculated age- and multivariable-adjusted RRs (95% CIs) of incident hypertension for migraine subtypes (MA, MO, and past history of migraine compared to no migraine).

To explore whether migraine attack frequency is associated with hypertension risk, we calculated age- and multivariable-adjusted RRs (95% CIs) for incident hypertension according to the reported number of migraine attacks among women with active migraine at baseline.

We also performed sensitivity analyses in which we included new reports of anti-hypertensive medication use as part of our incident hypertension definition. Finally, we explored potential effect modification by age (<55 versus ≥55 years of age), baseline SBP (<120 versus 120–139 mmHg) and DBP (<75 versus 75 to 89 mmHg).

Results

Among those eligible for these analyses, 23,819 (82.0%) reported no history of migraine and 5221 (18.0%) reported any history of migraine. Among women who reported any history of migraine 1516 (29.0%) reported MA, 2294 (43.9%) reported MO, and 1411 (27.0%) reported a past history of migraine. Baseline characteristics of the participants by migraine status can be seen in Table 1. Women who experience migraine with or without aura tended to be younger, more likely to have hypercholesterolemia, and less likely to be smokers or to consume alcohol compared to women with no history of migraine. In contrast, those with a past history of migraine tended to have a poorer cardiovascular disease risk factor profile compared to those with no history of migraine.

During a mean of 12.2 years of follow-up, 15,176 incident hypertension events occurred of which 2,868 events occurred among those with any history of migraine. The age-adjusted relative risk of developing incident hypertension was 1.16 (95% CI: 1.12, 1.21) comparing those with any history of migraine to those with no history of migraine. Results were similar after adjustment for potential confounders (RR=1.16; 95% CI: 1.11, 1.21). Table 2 presents the results for the relative risk of developing hypertension by migraine aura status. After adjusting for potential confounders, women with a past history of migraine had a 15% increase in their risk of developing hypertension (95% CI: 1.07, 1.23) compared to those with no history of migraine. Women who experience MA had a 9% increase in their risk of developing hypertension (95% CI: 1.02, 1.18) compared to those with no history of migraine. Women who experience MO had a 21% increase in their risk of developing hypertension (95% CI: 1.14, 1.28) compared to those with no history of migraine. In a post-hoc analysis, we observed that those who experience MO had a higher risk of incident hypertension (RR=1.10, 95% CI: 1.01, 1.20) than those who experience MA.

We performed a sensitivity analysis in which we additionally controlled for baseline categories of SBP and DBP and found similar results for women who experience MA, MO, or with a past history of migraine compared to women with no history of migraine (results not shown). Sensitivity analyses including new reports of antihypertensive medication use showed similar results to the main analyses (results not shown).

We also explored the association between migraine frequency and risk of hypertension among women who reported active migraine at baseline. We did not observe a clear pattern between increasing migraine frequency and increased risk of developing hypertension (Table 3).

We did not observe evidence of effect modification by baseline age (p for interaction=0.78), baseline SBP (p for interaction=0.74), or baseline DBP (p for interaction=0.43).

Discussion

In this large prospective cohort of middle-aged and older women, we observed that any history of migraine was associated with a 9% increase in the relative risk of developing hypertension compared to those with no history of migraine. Increases in the relative risk of developing hypertension ranged from 9% for women who experience MA to 21% for

women who experience MO. Women with a migraine attack frequency of at least weekly had a 30% increased risk when compared to those with <6 migraine attacks per year.

Our results agree with findings from a prospective cohort study from Finland which linked data from 52,739 participants in the population-based Health and Social Support (HeSSP) study with follow-up data obtained through a national medical registry.¹⁸ A self-reported physician diagnosis of migraine at baseline was associated with an approximately 1.4 fold increase risk of developing hypertension after adjusting for age, gender, occupational training, living alone, physical activity, body mass index and alcohol consumption. The results were similar when using self-reported hypertension outcome information (HR: 1.39, 95% CI 1.19–1.64) and the registry-based hypertension outcome definition (HR: 1.42, 95% CI: 1.13–1.77).

Other studies have evaluated the association between migraine and prevalent hypertension using cross-sectional and case-control study designs. The results of these studies are overall inconclusive, as some studies found positive associations^{8–12} while others observed an inverse association.^{13–17} With regard to migraine aura status, Scher et al. evaluated the cross-sectional association between migraine and prevalent hypertension among 5,755 participants in the Genetic Epidemiology of Migraine (GEM) study.⁸ Compared with participants without migraine, participants with migraine with aura had the highest odds ratios (ORs) of a self-reported physician diagnosis of hypertension (OR: 1.73, 95% CI: 1.2–2.4) and of elevated measured blood pressure at the clinic visit (OR: 1.18; 95% CI: 0.8–1.8). Odds ratios for migraineurs without aura were 1.62 (95% CI: 1.3–2.0) for a self-reported physician diagnosis of hypertension and 1.09 (95% CI: 0.8–1.5) for elevated blood pressure measurements. In another cross-sectional study of 1,338 participants in the Northern Manhattan Study, compared to participants without migraine, the odds for having hypertension was 1.86 (0.98–3.55) for those who experience migraine with aura and 1.72 (1.13–2.63) for those who experience migraine without aura.¹² In contrast to prior studies which found a higher risk of hypertension among those who experience MA, we observed a slightly higher risk of hypertension among those who experience MO compared to those who experience MA. Although the difference in risk observed in our study was small, this result was unexpected given the observation of a higher risk of hypertension among MA from prior studies and other evidence suggesting that MA has a stronger effect on the endovascular system.²⁶

Links between migraine and incident hypertension could be conceptually caused by two scenarios. First, shared factors which lead to both migraine and hypertension but at different time points may exist. As both conditions are associated with family history of these conditions, genetic markers play a role in the development of both conditions. While some of the genetic markers linked with migraine are associated with the vascular system or are involved in arterial and smooth muscle function,²⁷ no clear genetic marker leading to both conditions has been identified. Second, aspects or consequences of migraine pathophysiology may increase the propensity for developing hypertension. For example, migraine has been linked with endovascular dysfunction and arterial stiffening,²⁶ which may result in blood pressure increases and potentially even hypertension in some migraineurs. Some have also hypothesized that the renin-angiotensin system, which plays an important

role in blood pressure regulation, may be involved in migraine pathogenesis, although this hypothesis remains controversial.²⁸ Repetitive or chronic pain can also alter blood pressure and lead to hypertension.²⁹ Our results that the association between migraine and hypertension is strongest among those with the highest migraine attack frequency may support part of this hypothesis.

Despite the small to moderate increase in the relative risk of developing hypertension, our results have clinical implications given the high prevalence of migraine on the population level. Moreover, as patients with migraine are at increased risk to develop cardiovascular disease,⁵ detection of any additional vascular risk factor will assist in implementing a more individualized therapeutic regimen. While blood pressure is routinely measured in most physician's offices, patients with migraine may have to be followed more closely for the development of hypertension. As some blood pressure lowering medications have beneficial effects on migraine attack frequency and patients with the highest attack frequency had the highest risk estimates for developing hypertension, such drugs should be considered as prophylactic medication.³⁰ Findings of a recent study further suggest that any prophylactic medication may reduce arterial stiffness in patients with migraine,³¹ which may also influence blood pressure.

An important strength to this study was the prospective, longitudinal design, which allowed us to determine the temporal association between migraine and incident hypertension. Additionally, we were able to explore the association between migraine subtypes, including the presence of aura and migraine frequency, and risk of incident hypertension.

Despite these strengths, a few limitations should be noted when interpreting our results. First, migraine status, blood pressure, hypertension diagnosis, and use of antihypertensive medications are all self-reported, and misclassification of our exposure and outcome status is possible. However, as mentioned earlier, agreement between self-reported migraine and classification of migraine according to diagnostic criteria is good in this cohort.²³ While some misclassification of migraine status is possible, we would expect this misclassification to be nondifferential with respect to our outcome because information on incident hypertension was collected prospectively. A prior validation in WHS observed good agreement between self-reported hypertension status and hypertension as diagnosed through a structured telephone interview.²⁴ Another limitation may be observation bias. Patients with migraine may be seen more regularly by a physician which may make detection of hypertension more likely. This bias may be particularly relevant for the high migraine attack frequency group. Future research in this area can address this limitation by ensuring that screening for hypertension is performed with the same frequency for those with and without migraine. In our study, we only included migraine information at baseline and did not time-update migraine information. Another limitation may be the potential for reverse causation if elevated blood pressure at young ages leads to migraine and eventually to incident hypertension. However, we believe that this reverse causation is unlikely in our cohort of initially apparently healthy women. Another limitation may be residual confounding by unmeasured variables, for example gestational hypertension or pre-eclampsia. Finally, our study only enrolled middle-aged and older women which may impact the generalizability of our findings to men and younger adults.

In this large cohort of female health professionals, migraine was associated with a small to moderate increased risk of developing hypertension, which was strongest in the migraine without aura and high migraine attack frequency subgroups.

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References

- Schürks M, Rist PM, Bigal ME, et al. Migraine and cardiovascular disease: systematic review and meta-analysis. *BMJ*. 2009; 339:b3914. [PubMed: 19861375]
- Sacco S, Ricci S, Carolei A. Migraine and vascular diseases: a review of the evidence and potential implications for management. *Cephalalgia*. 2012; 32:785–795. [PubMed: 22711902]
- Kurth T, Gaziano JM, Cook NR, et al. Migraine and risk of cardiovascular disease in men. *Arch Intern Med*. 2007; 167:795–801. [PubMed: 17452542]
- Kurth T, Gaziano JM, Cook NR, et al. Migraine and risk of cardiovascular disease in women. *JAMA*. 2006; 296:283–291. [PubMed: 16849661]
- Kurth T, Winter AC, Eliassen AH, et al. Migraine and risk of cardiovascular disease in women: prospective cohort study. *BMJ*. 2016; 353:i2610. [PubMed: 27247281]
- Sacco S, Ornello R, Ripa P, et al. Migraine and risk of ischaemic heart disease: a systematic review and meta-analysis of observational studies. *Eur J Neurol*. 2015; 22:1001–1011. [PubMed: 25808832]
- Sacco S, Pistoia F, Degan D, et al. Conventional vascular risk factors: their role in the association between migraine and cardiovascular diseases. *Cephalalgia*. 2015; 35:146–164. [PubMed: 25505017]
- Scher AI, Terwindt GM, Picavet HSJ, et al. Cardiovascular risk factors and migraine: the GEM population-based study. *Neurology*. 2005; 64:614–620. [PubMed: 15728281]
- Kuo C-Y, Yen M-F, Chen L-S, et al. Increased risk of hemorrhagic stroke in patients with migraine: a population-based cohort study. *PLoS One*. 2013; 8:e55253. [PubMed: 23372843]
- Schwaiger J, Kiechl S, Stockner H, et al. Burden of atherosclerosis and risk of venous thromboembolism in patients with migraine. *Neurology*. 2008; 71:937–943. [PubMed: 18794497]
- Wang Y-C, Lin C-W, Ho Y-T, et al. Increased risk of ischemic heart disease in young patients with migraine: a population-based, propensity score-matched, longitudinal follow-up study. *Int J Cardiol*. 2014; 172:213–216. [PubMed: 24462142]
- Gardener H, Monteith T, Rundek T, et al. Hypertension and Migraine in the Northern Manhattan Study. *Ethn Dis*. 2016; 26:323–330. [PubMed: 27440971]
- Gudmundsson LS, Thorgeirsson G, Sigfússon N. Migraine patients have lower systolic but higher diastolic blood pressure compared with controls in a population-based study of 21 537 subjects. The Reykjavik Study. 2006. <http://onlinelibrary.wiley.com/doi/10.1111/j.1468-2982.2005.01057.x/full>
- Tronvik E, Stovner LJ, Hagen K, et al. High pulse pressure protects against headache: prospective and cross-sectional data (HUNT study). *Neurology*. 2008; 70:1329–1336. [PubMed: 18413586]
- Tzourio C, Gagnière B, El Amrani M, et al. Relationship between migraine, blood pressure and carotid thickness. A population-based study in the elderly. *Cephalalgia*. 2003; 23:914–920. [PubMed: 14616934]
- Wiehe M, Fuchs SC, Moreira LB, et al. Migraine is more frequent in individuals with optimal and normal blood pressure: a population-based study. *J Hypertens*. 2002; 20:1303–1306. [PubMed: 12131526]
- Winsvold BS, Hagen K, Aamodt AH, et al. Headache, migraine and cardiovascular risk factors: the HUNT study. *Eur J Neurol*. 2011; 18:504–511. [PubMed: 20825470]

18. Entonen AH, Suominen SB, Korkeila K, et al. Migraine predicts hypertension--a cohort study of the Finnish working-age population. *Eur J Public Health*. 2014; 24:244–248. [PubMed: 24065369]
19. Hagen K, Stovner LJ, Vatten L, et al. Blood pressure and risk of headache: a prospective study of 22 685 adults in Norway. *J Neurol Neurosurg Psychiatry*. 2002; 72:463–466. [PubMed: 11909904]
20. Merikangas KR, Fenton BT, Cheng SH, et al. Association between migraine and stroke in a large-scale epidemiological study of the United States. *Arch Neurol*. 1997; 54:362–368. [PubMed: 9109736]
21. Lee I-M, Cook NR, Gaziano JM, 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]
22. Ridker PM, Cook NR, Lee I-M, et al. A randomized trial of low-dose aspirin in the primary prevention of cardiovascular disease in women. *N Engl J Med*. 2005; 352:1293–1304. [PubMed: 15753114]
23. Schürks M, Buring JE, Kurth T. Agreement of self-reported migraine with ICHD-II criteria in the Women's Health Study. *Cephalalgia*. 2009; 29:1086–1090. [PubMed: 19735535]
24. Sesso HD, Buring JE, Rifai N, et al. C-reactive protein and the risk of developing hypertension. *JAMA*. 2003; 290:2945–2951. [PubMed: 14665655]
25. Wang L, Manson JE, Gaziano JM, et al. Fruit and vegetable intake and the risk of hypertension in middle-aged and older women. *Am J Hypertens*. 2012; 25:180–189. [PubMed: 21993367]
26. Liman TG, Bachelier-Walenta K, Neeb L, et al. Circulating endothelial microparticles in female migraineurs with aura. *Cephalalgia*. 2015; 35:88–94. [PubMed: 24715500]
27. Gormley P, Anttila V, Winsvold BS, et al. Meta-analysis of 375,000 individuals identifies 38 susceptibility loci for migraine. *Nat Genet*. 2016; 48:856–866. [PubMed: 27322543]
28. Ripa P, Ornello R, Pistoia F, et al. The renin-angiotensin system: a possible contributor to migraine pathogenesis and prophylaxis. *Expert Rev Neurother*. 2014; 14:1043–1055. [PubMed: 25115162]
29. Bruehl S, Chung OY, Jirjis JN, et al. Prevalence of clinical hypertension in patients with chronic pain compared to nonpain general medical patients. *Clin J Pain*. 2005; 21:147–153. [PubMed: 15722808]
30. Diener HC, Küper M, Kurth T. Migraine-associated risks and comorbidity. *J Neurol*. 2008; 255:1290–1301. [PubMed: 18958572]
31. Dogan A, Orselik O, Kocyigit M, et al. The effect of prophylactic migraine treatment on arterial stiffness. *Blood Press*. 2015; 24:222–229. [PubMed: 25860402]

Clinical Implications

- Women with migraine have a higher relative risk of developing hypertension compared to women without a history of migraine.
- Despite the small to moderate increase in the relative risk of developing hypertension, our results have clinical implications given the high prevalence of migraine on the population level.

Table 1

Baseline characteristics of women according to migraine status in the Women's Healthy Study (n=29,040).

Characteristic	No migraine (n=23,819)	Migraine with aura (n=1,516)	Migraine without aura (n=2,294)	Past history of migraine (n=1,411)
SBP, mmHg				
<110	20.1	20.7	20.6	19.8
110–119	37.1	37.3	38.5	34.4
120–129	28.2	28.0	27.6	31.3
130–139	13.1	13.0	12.2	12.7
DBP, mmHg				
<65	11.9	14.1	11.4	10.2
65–74	40.7	39.0	40.5	39.8
75–84	38.0	36.7	38.6	39.6
85–89	7.8	9.2	8.3	8.5
Mean age (SE), y	53.9 (6.7)	52.4 (5.6)	52.1 (5.3)	54.4 (6.9)
BMI, %				
<25 kg/m ²	57.4	55.3	56.4	59.8
25 – <30 kg/m ²	29.7	30.9	29.7	26.7
30 kg/m ²	12.9	13.8	14.0	13.5
History of high cholesterol [*] , %	24.1	26.6	25.6	28.5
Cholesterol lowering medication use, %	2.1	2.1	2.0	1.9
History of diabetes, %	1.4	1.0	0.9	1.1
Smoking status, %				
Never	50.4	53.0	55.0	47.8
Past	36.0	34.5	34.0	35.5
Current	13.6	12.3	10.9	16.6
Alcohol consumption, %				
Rarely/never	42.4	45.3	46.3	42.6
1–3 drinks/month	13.0	14.3	15.0	14.2
1–6 drinks/week	33.8	32.6	31.1	32.0
1+ drinks/day	10.7	7.8	7.5	11.3
Vigorous physical activity, %				
Rarely/never	36.0	35.8	35.4	38.1
<1/week	19.7	22.4	23.8	20.3
1–3 times/week	32.8	32.1	31.0	30.1
4 times/week	11.5	9.8	9.8	11.6

Characteristic	No migraine (n=23,819)	Migraine with aura (n=1,516)	Migraine without aura (n=2,294)	Past history of migraine (n=1,411)
Postmenopausal status, %				
Premenopausal	31.0	31.1	34.5	25.9
Postmenopausal	51.4	44.1	44.3	54.2
Uncertain	17.4	24.5	21.1	19.7
Hormone replacement therapy, %				
Never	52.1	45.6	49.2	48.1
Past	8.0	7.7	7.1	10.8
Current	39.8	46.4	43.6	40.8
Randomized treatment assignment to aspirin, %	50.1	48.6	49.8	47.6
Randomized treatment assignment to vitamin E, %	50.2	50.3	48.8	52.0

Note: Numbers may not add to 100% due to missing data.

* History of high cholesterol was defined as self-reported physician diagnosis of high cholesterol at baseline, self-reported total cholesterol ≥ 240 mg/dL, or use of cholesterol-lowering medications at baseline.

Table 2

Relative risk of developing hypertension by migraine aura status (N=29,040).

	Age-adjusted relative risk		Multivariable-adjusted* relative risk	
	No. of cases	RR* (95% CI)	No. of cases	RR* (95% CI)
No history of migraine	12308	1.00	12308	1.00
Migraine with aura	793	1.10 (1.03, 1.19)	793	1.09 (1.02, 1.18)
Migraine without aura	1284	1.22 (1.15, 1.29)	1284	1.21 (1.14, 1.28)
Past history of migraine	791	1.13 (1.06, 1.22)	791	1.15 (1.07, 1.23)

* Adjusted for age (continuous), BMI (<25, 25 – <30, 30 kg/m²), smoking (current, past, never), alcohol consumption (rarely/never, 1–3 drinks/month, 1–6 drinks/wk, 1 drink/day), physical activity (rarely/never, <1 time/week, 1–3 times/week, 4 times/week), postmenopausal status (premenopausal, postmenopausal, uncertain), postmenopausal hormone use (never, past, current), history of diabetes at baseline (yes/no), hypercholesterolemia (yes/no), baseline treatment with cholesterol-lowering medication (yes/no), and randomized assigned to aspirin and vitamin E.

Table 3

Relative risk of developing hypertension by migraine frequency among those with active migraine (N=3,761).

Attack frequency	Age-adjusted relative risk		Multivariable-adjusted* relative risk	
	No. of cases	RR* (95% CI)	No. of cases	RR* (95% CI)
Less than 6 times/year (n=2415)	1302	1.00	1302	1.00
Every other month (n=392)	228	1.16 (1.01, 1.34)	228	1.17 (1.01, 1.35)
Monthly (n=766)	407	1.04 (0.93, 1.16)	407	1.06 (0.94, 1.18)
Weekly or more often (n=188)	112	1.29 (1.06, 1.56)	112	1.30 (1.07, 1.58)
p-value for trend		0.04		0.02

* Adjusted for age (continuous), BMI (<25, 25 – <30, ≥30 kg/m²), smoking (current, past, never), alcohol consumption (rarely/never, 1–3 drinks/month, 1–6 drinks/wk, ≥1 drink/day), physical activity (rarely/never, <1 time/week, 1–3 times/week, ≥4 times/week), postmenopausal status (premenopausal, postmenopausal, uncertain), postmenopausal hormone use (never, past, current), history of diabetes at baseline (yes/no), hypercholesterolemia (yes/no), baseline treatment with cholesterol-lowering medication (yes/no), and randomized assigned to aspirin and vitamin E.