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Sleep Duration and Risk of Atrial Fibrillation (From the Physicians' Health Study)

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Abstract

While sleep quality and duration have been related to cardiovascular endpoints, little is known about the association between sleep duration and incident atrial fibrillation (AF). Hence, we prospectively examined the association between sleep duration and incident AF in a cohort of 18,755 US male physicians. Self-reported sleep duration was ascertained during 2002 annual follow-up questionnaire. Incident AF was ascertained through yearly follow-up questionnaires. Cox regression was used to estimate relative risks of AF. The average age at baseline was 67.7 (+8.6) years. During a mean follow up of 6.9 (±2.1) years, 1,468 cases of AF occurred. Using 7 hours of sleep as the reference group, multivariable adjusted hazard ratios (95% CI) for AF were 1.06 (0.92–1.22), 1.0 (ref), and 1.13 (1.00–1.27) from the lowest to the highest category of sleep duration (p for trend 0.26), respectively. In a secondary analysis, there was no evidence of effect modification by adiposity (p interaction =0.69); however, prevalent sleep apnea modified the relation of sleep duration with AF (p interaction =0.01): from the highest to the lowest category of sleep duration, multivariable adjusted hazard ratios (95% CI) for AF were 2.26 (1.26–4.05), 1.0 (ref), and 1.34 (0.73–2.46) for those with prevalent sleep apnea and 1.01 (0.87–1.16), 1.0 (ref), and 1.12 (0.99–1.27) for those without sleep apnea, respectively. Our data showed a modestly elevated risk of AF with long sleep duration among US male physicians. Furthermore, shorter sleep duration was associated with a higher risk of AF in people with prevalent sleep apnea.

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Keywords

Sleep; Atrial Fibrillation; Risk factors; Epidemiology

Atrial fibrillation (AF) is a highly prevalent cardiac arrhythmia in clinical practice, affecting more than 2 million people in the United States (US) and more than 4 million people across the European Union [1,2]. Since the prevalence of AF increases with advancing age [2], it is anticipated that the burden of AF will gradually increase with the aging US population. Data from prior studies have demonstrated beneficial effects of light-to-moderate physical activity on AF risk [3], positive associations with obesity [4], inflammation [5], sleep apnea [6], heavy alcohol consumption [7], hypertension (HTN) [7], type 2 diabetes (T2D) [8], and dyslipidemia [9]. Recent data suggest that too little sleep or too much sleep may be each associated with adverse health outcomes including obesity [10], inflammation [11], HTN [12], T2D [13], dyslipdemia [14,15], cardiovascular disease (CVD) [16], and total mortality [17]. However, the association between sleep duration and incident AF has not been investigated in a prospective cohort study. Therefore, the current study sought to prospectively assess the association of sleep duration with incident AF among US male physicians. Since adiposity and sleep apnea can have a negative impact on sleep quality [18], we also examined if sleep apnea modified the sleep duration-AF association.

METHODS

The Physicians' Health Study (PHS) I is a completed randomized, double-blind, placebo-controlled trial, designed to study the effects of low-dose aspirin (ASA) and beta-carotene on CVD and cancer among US male physicians. In 1997, PHS II trial enrolled 7,641 physicians from PHS I along with 7,000 new physicians to study the effects of vitamin on CVD and cancer. A detailed description of the PHS I and II has been published [19,20]. Self-reported sleep duration was ascertained during the 2002 annual follow-up questionnaire. Of the total 29,067 PHS subjects, we excluded people who died before sleep duration assessment (n=381), those with missing data on sleep duration (n=7,621), and those with prevalent AF (n=2,310). Thus, a final sample of 18,755 participants was used for current analyses. Each participant gave written informed consent and the Institutional Review Board at Brigham and Women's Hospital approved the study protocol.

For self-reported sleep duration, participants were asked: "On average, how many total hours of sleep do you get in typical 24-hour period?" Possible responses were "<5 hours", "6 hours", "7 hours", "8 hours", "9 hours", "10 hours", and "11+ hours".

Incident AF was ascertained through yearly follow-up questionnaires. In PHS, self-reported AF has been previously validated in a random sample of 400 PHS participants, using a more detailed questionnaire on the diagnosis of AF and the review of medical records by cardiologists [21].

Data on demographics, anthropometrics, exercise frequency, smoking, alcohol consumption, along with history of HTN, T2D, dyslipidemia, coronary heart disease (CHD), congestive heart failure (CHF), sleep apnea, and snoring were obtained at baseline. Age and body mass index (BMI) were used as continuous variables. Race was dichotomized as white vs. non-white. Exercise was classified as rarely/never, 1–3/month, 1–4/week, and 5–7/week. Smoking was classified as never, past, and current smokers. For alcohol consumption, subjects were asked the following question: "How often do you usually consume alcoholic beverages?" Possible responses were: rarely/never, 1–3 times/month, 1 time/week, 2–4 times/week, 5–6 times/week, daily, and ≥ 2 times/day. These responses were interpreted as

the number of alcoholic drinks consumed during the specified period. For current analyses, alcohol consumption was classified as 0–4, 5–7, and >7 drinks/week. HTN was defined as anyone who self-reported a diagnosis of hypertension, BP >140/90 mm Hg, or use of antihypertensive drugs. CHD diagnosis (angina, myocardial infarction (MI), and coronary artery bypass grafting (CABG)) was validated by the PHS Endpoint Committee [20]. CHF and T2D diagnoses were also self-reported and validated by detailed review of the medical records in a subsample [22]. Diagnosis of sleep apnea (yes vs. no) and snoring (rarely/never, few/occasionally, mostly/always, and unknown/missing) was based on self-reported information.

We classified each subject into one of the following categories of average sleep duration: ≤6, 7, and ≥8 hours. We computed person-time of follow up from the time when sleep duration was assessed until the first occurrence of a) AF, b) death, or c) the date of last available follow up. Baseline demographic variables were recorded and compared across categories of sleep duration.

We used Cox proportional hazard models to compute multivariable adjusted hazard ratios (HR) with corresponding 95% confidence intervals (CI) using participants reporting 7 hours of sleep duration as the reference group. Potential confounding was assessed for established risk factors of AF [4–9]. First, we adjusted for age and race in model 1. Second, we also controlled for BMI, exercise frequency, alcohol consumption, smoking status, sleep apnea, and snoring in model 2. Finally, in model 3, we adjusted for factors included in model 2 as well as potential mediators such as history of HTN, T2D, dyslipidemia, CHD, and CHF.

In secondary analyses, we evaluated whether there were statistically significant interactions between sleep duration and BMI or sleep apnea by using a product term of both variables in a hierarchical model. Assumptions for proportional hazard models were tested (by including main effects and product terms of sleep duration and logarithmic-transformed time factor) and were met (all P values > 0.05). All analyses were conducted using SAS, version 9.2 (SAS Institute, NC). Significance level was set at 0.05.

RESULTS

Table 1 shows baseline characteristics according to sleep duration. Mean age of the study participants at baseline was 67.7 ±8.6 years. Long (≥8 hours) sleep duration was associated with a lower prevalence of never smokers and a higher prevalence of >7/week alcohol consumption, HTN, T2D, dyslipidemia, and CHD.

Table 2 shows a comparison of the baseline characteristics between subjects with missing data on sleep duration (after excluding those who died before the assessment of baseline information and those with prevalent AF) and those with complete data on sleep duration. Overall, participants with missing data on sleep duration were older; had a higher prevalence of sleep apnea, current smokers, and sedentary lifestyle; and a lower prevalence of HTN, dyslipidemia, and CHF compared to people with complete data on sleep duration.

During a mean follow up of 6.9 (±2.1) years, 1,468 cases of AF occurred. Crude incidence rates of AF were 9.6, 9.9, and 14.9 cases/1,000 person-years for people reporting an average sleep duration of ≤6, 7, and ≥8 hours, respectively (Table 3). Using 7 hours of sleep as the reference group, multivariable adjusted hazard ratios (95% CI) for AF were 1.06 (0.92–1.22), 1.0 (ref), and 1.13 (1.00–1.27) from lowest to the highest category of sleep duration (p for trend 0.26), respectively (Table 3).

In a secondary analysis, adiposity did not modify the sleep duration-AF association (p value 0.69). There was evidence for an interaction between sleep duration and sleep apnea on the risk of incident AF (p=0.01, Table 4).

DISCUSSION

Our data showed a modestly elevated risk of AF with self-reported long sleep duration among US male physicians. In a secondary analysis, short sleep duration was associated with a higher risk of AF in people with sleep apnea but not in those without sleep apnea. To the best of our knowledge, this is the first large prospective study to assess the association between sleep duration and incident AF.

Mechanisms mediating adverse effects of long sleep duration on AF risk are not well established. Low socioeconomic status, depression, low level of physical activity, poor general health, and undiagnosed health conditions have all been associated with long sleep duration and could therefore confound the association of sleep duration with cardiovascular disease [23,24]. Prior studies have also demonstrated an association between abnormal sleep duration and obesity [10], inflammation [11], HTN [12], T2D [13], dyslipidemia [14,15], and CVD [16], all of which are considered as important risk factors for AF. However, in our study, we did not observe any significant attenuation of AF risk upon inclusion of potential mediating risk factors such as HTN, T2D, or CHD.

Currently available data do not elucidate potential mechanisms linking long sleep duration with AF. Heart rate variability (HRV) represents one of the most widely used method to study the effects of autonomic nervous system on cardiac function [25]. Prior studies of HRV changes during different sleep stages have demonstrated an increased parasympathetic activity during non-rapid eye movement (NREM) sleep and an increased sympathetic activity during rapid eye movement sleep [26]. NREM typically represents most of the total sleep in adults. Hence, sleep is generally considered to be a condition with a high parasympathetic and low sympathetic activity [27]. Increased vagal tone by itself, in both human and animal studies, has been associated with induction and maintenance of AF [28]. Based on the available evidence, we can postulate that people with long sleep duration have prolonged exposure to increased vagal tone and are more susceptible to develop AF.

In a secondary analysis, we observed a significantly higher risk of AF among people with sleep apnea and short sleep duration. Among individuals with long sleep duration and sleep apnea, there was a suggestive trend towards increased AF risk (non-statistically significant). These insignificant results may be due to a lack of adequate statistical power to detect a modest effect size. Results from prior studies have also demonstrated an association between sleep apnea and AF [6]. Among the proposed mechanisms, intermittent hypoxemia, hypercapnia, chemoreceptor excitation, and increased sympathetic drive have all been postulated to play a role [6].

Other studies have demonstrated effects of sleep deprivation on EKG parameters considered to be important AF predictors. Sari et al [29] demonstrated that sleep deprivation was associated with prolonged maximum P-wave duration and P-wave dispersion, 2 conditions known to represent inhomogeneous conduction of sinus impulses and thereby electrophysiologic predictors of AF. Esen et al [30] demonstrated that even one night of sleep deprivation is associated with a higher risk of atrial electromechanical delay (AEMD) in healthy young adults. AEMD, calculated from tissue doppler imaging has been shown to detect atrial impairment in paroxysmal AF.

Our study has some limitations. Information on average hours of sleep duration was self-reported. We did not have information to determine if reported sleep duration represented

time spent in bed or truly reflected sleep duration. Inaccurate recall, exposure misclassification, and inability to completely capture all episodes of snoring or sleep apnea could have biased our results. A single assessment of sleep duration might have been inadequate to evaluate the role of sleep duration on incident AF. We did not have data on the quality of sleep. Our inability to capture asymptomatic (subclinical) AF could have led to underestimation of incident AF in our study. We had a small number of individuals with sleep apnea and ≥8 hours of sleep duration, thereby limiting our ability to fully ascertain their relationships with incident AF. Furthermore, participants in this study were male and mostly Caucasian physicians, thereby limiting the generalizability of our findings to other ethnic groups or general population. In the absence of randomization, we cannot exclude chance, confounding by unmeasured factors, or residual confounding as possible explanation for our findings. Hence, we cannot claim a causal association between sleep duration and AF. Nevertheless, the large sample size, more than 5 years of follow up, a standardized and systematic collection of covariates, availability of a large number of covariates, and a validation of AF and comorbidities in the PHS are strengths of this study.

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REFERENCES

1. ACC/AHA/ESC 2006 Guidelines for the Management of Patients with Atrial Fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the European Society of Cardiology Committee for Practice Guidelines (Writing Committee to Revise the 2001 Guidelines for the Management of Patients With Atrial Fibrillation): developed in collaboration with the European Heart Rhythm Association and the Heart Rhythm Society. Circulation. 2006; 114:e257–e354. [PubMed: 16908781]
2. Go AS, Hylek EM, Phillips KA, Chang Y, Henault LE, Selby JV, Singer DE. Prevalence of diagnosed atrial fibrillation in adults: national implications for rhythm management and stroke prevention: the AnTicoagulation and Risk Factors in Atrial Fibrillation (ATRIA) Study. JAMA. 2001; 285:2370–2375. [PubMed: 11343485]
3. Mozaffarian D, Furberg CD, Psaty BM, Siscovick D. Physical activity and incidence of atrial fibrillation in older adults: the cardiovascular health study. Circulation. 2008; 118:800–807. [PubMed: 18678768]
4. Frost L, Hune LJ, Vestergaard P. Overweight and obesity as risk factors for atrial fibrillation or flutter: the Danish Diet, Cancer, and Health Study. Am J Med. 2005; 118:489–495. [PubMed: 15866251]
5. Aviles RJ, Martin DO, Apperson-Hansen C, Houghtaling PL, Rautaharju P, Kronmal RA, Tracy RP, Van Wagoner DR, Psaty BM, Lauer MS, Chung MK. Inflammation as a risk factor for atrial fibrillation. Circulation. 2003; 108:3006–3010. [PubMed: 14623805]
6. Gami AS, Pressman G, Caples SM, Kanagala R, Gard JJ, Davison DE, Malouf JF, Ammash NM, Friedman PA, Somers VK. Association of atrial fibrillation and obstructive sleep apnea. Circulation. 2004; 110:364–367. [PubMed: 15249509]
7. Hodgkinson JA, Taylor CJ, Hobbs FD. Predictors of incident atrial fibrillation and influence of medications: a retrospective case-control study. Br J Gen Pract. 2011; 61:e353–e361. [PubMed: 21801515]

8. Dublin S, Glazer NL, Smith NL, Psaty BM, Lumley T, Wiggins KL, Page RL, Heckbert SR. Diabetes mellitus, glycemic control, and risk of atrial fibrillation. J Gen Intern Med. 2010; 25:853–858. [PubMed: 20405332]
9. Watanabe H, Tanabe N, Yagihara N, Watanabe T, Aizawa Y, Kodama M. Association Between Lipid Profile and Risk of Atrial Fibrillation. Circ J. 2011; 75:2767–2774. [PubMed: 21914959]
10. Cappuccio FP, Taggart FM, Kandala N-B, Currie A, Peile E, Stranges S, Miller MA. Meta-analysis of short sleep duration and obesity in children, adolescents and adults. Sleep. 2008; 31:619–626. [PubMed: 18517032]
11. Miller MA, Cappuccio FP. Inflammation, sleep, obesity and cardiovascular disease. Curr Vasc Pharmacol. 2007; 5:93–102. [PubMed: 17430213]
12. Gangwisch JE, Heymsfield SB, Boden-Albala B, Buijs RM, Kreier F, Pickering TG, Rundle AG, Zammit GK, Malaspina D. Short sleep duration as a risk factor for hypertension: analyses of the first National Health and Nutrition Examination Survey. Hypertension. 2006; 47:833–839. [PubMed: 16585410]
13. Cappuccio FP, D'Elia L, Strazzullo P, Miller MA. Quantity and quality of sleep and incidence of type 2 diabetes: a systematic review and metaanalysis. Diabetes Care. 2010; 33:414–420. [PubMed: 19910503]
14. van den Berg JF, Miedema HM, Tulen JH, Neven AK, Hofman A, Witteman JC, Tiemeier H. Long sleep duration is associated with serum cholesterol in the elderly: the Rotterdam Study. Psychosom Med. 2008; 70:1005–1011. [PubMed: 18842743]
15. Bak YG, Park HS. Quality of sleep and serum lipid profile in patients with restless legs syndrome. J Korean Acad Nurs. 2011; 41:344–353. [PubMed: 21804343]
16. Ikehara S, Iso H, Date C, Kikuchi S, Watanabe Y, Wada Y, Inaba Y, Tamakoshi A. JACC Study Group. Association of sleep duration with mortality from cardiovascular disease and other causes for Japanese men and women: the JACC study. Sleep. 2009; 32:295–301. [PubMed: 19294949]
17. Kripke DF, Garfinkel L, Wingard DL, Klauber MR, Marler MR. Mortality associated with sleep duration and insomnia. Arch Gen Psychiatry. 2002; 59:131–136. [PubMed: 11825133]
18. Ho ML, Brass SD. Obstructive sleep apnea. Neurol Int. 2011; 3:e15. [PubMed: 22368774]
19. Christen WG, Gaziano JM, Hennekens CH. Design of Physicians' Health Study II--a randomized trial of beta-carotene, vitamins E and C, multivitamins, in prevention of cancer, cardiovascular disease, and eye disease, and review of results of completed trials. Ann Epidemiol. 2000; 10:125–134. [PubMed: 10691066]
20. Steering Committee of the Physicians' Health Study Research Group. Final report on the aspirin component of the ongoing Physicians' Health Study. N Engl J Med. 1989; 321:129–135. [PubMed: 2664509]
21. Aizer AGJ, Cook NR, Manson JE, Buring JE, Albert CM. Relation of Vigorous Exercise to Risk of Atrial Fibrillation. Am J Cardiol. 2009; 103:1572–1577. [PubMed: 19463518]
22. Djoussé L, Driver JA, Gaziano JM. Relation between modifiable lifestyle factors and lifetime risk of heart failure. JAMA. 2009; 302:394–400. [PubMed: 19622818]
23. Patel SR, Malhotra A, Gottlieb DJ, White DP, Hu FB. Correlates of long sleep duration. Sleep. 2006; 29:881–889. [PubMed: 16895254]
24. Krueger PM, Friedman EM. Sleep duration in the United States: a cross-sectional population-based study. Am J Epidemiol. 2009; 169:1052–1063. [PubMed: 19299406]
25. Heart rate variability. Standards of measurement, physiological interpretation, and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Eur Heart J. 1996; 17:354–381. [PubMed: 8737210]
26. Cabiddu R, Cerutti S, Viardot G, Werner S, Bianchi AM. Modulation of the Sympatho-Vagal Balance during Sleep: Frequency Domain Study of Heart Rate Variability and Respiration. Front Physiol. 2012; 3:45. [PubMed: 22416233]
27. Parmeggiani, PL.; Morrison, AR. Alterations in autonomic functions during sleep. In: Loewy, AD.; Spyer, KM., editors. Central Regulation of Autonomic Functions. New York, NY: Oxford University Press; 1990.
28. Zhang Y, Mazgalev TN. Arrhythmias and vagus nerve stimulation. Heart Fail Rev. 2011; 16:147–161. [PubMed: 20559719]

29. Sari I, Davutoglu V, Ozbala B, Ozer O, Baltaci Y, Yavuz S, Aksoy M. Acute sleep deprivation is associated with increased electrocardiographic P-wave dispersion in healthy young men and women. Pacing Clin Electrophysiol. 2008; 31:438–442. [PubMed: 18373762]

30. Esen O, Akçakoyun M, Açar G, Bulut M, Alızade E, Kargin R, Emıroğlu MY, Yazicioğlu MV, Gemıcı K, Esen AM. Acute Sleep Deprivation Is Associated with Increased Atrial Electromechanical Delay in Healthy Young Adults. Pacing Clin Electrophysiol. 2011; 34:1645–1651. [PubMed: 21834922]

Table 1

Baseline characteristic of 18,755 US male physicians according to average sleep duration

Variable	Average Sleep Duration (hours)		
	≤6.0 (n = 4,835)	7.0 (n = 7,773)	≥8.0 (n = 6,147)
Age [years] (±SD)	65 (8)	67 (8)	71 (9)
White	4,135 (86%)	7,087 (92%)	5,714 (93%)
Body Mass Index [kg/m^2] (±SD)	26 (4)	26 (4)	26 (4)
Exercise Frequency			
Rarely/Never	1,691 (36%)	2,474 (32%)	2,264 (37%)
1–3/month	172 (4%)	227 (3%)	134 (2%)
1–4/week	2,055 (43%)	3,646 (47%)	2,571 (42%)
5–7/week	846 (18%)	1,351 (18%)	1,138 (19%)
Smoker			
Never	2,819 (58%)	4,539 (59%)	3,205 (52%)
Past	1,879 (39%)	3,034 (39%)	2,717 (44%)
Current	130 (3%)	184 (2%)	216 (4%)
Alcohol Consumption (drinks/week)			
0–4	3,092 (64%)	4,470 (58%)	3,230 (53%)
5–7	1,029 (21%)	1,933 (25%)	1,444 (24%)
>7	689 (14%)	1,333 (17%)	1,451 (24%)
History of Snoring			
Rarely/Never	881 (18%)	1,481 (19%)	1,239 (20%)
Few/Occasionally	1,831 (38%)	3,169 (41%)	2,437 (40%)
Mostly/Always	1,734 (36%)	2,500 (32%)	1,921 (31%)
Unknown/Missing	389 (8%)	623 (8%)	550 (9%)
Sleep apnea	227 (5%)	270 (3%)	267 (4%)
Hypertension (by history)	2,328 (48%)	3,760 (48%)	3,599 (59%)
Diabetes Mellitus	367 (8%)	551 (7%)	615 (10%)
Dyslipidemia (by history)	2,429 (50%)	3,869 (50%)	3,220 (52%)
Prior Coronary Heart Disease	564 (12%)	939 (12%)	945 (15%)
Prior Congestive Heart Failure	42 (1%)	90 (1%)	135 (2%)

Missing variables: white = 105; exercise frequency = 186; smoking = 32; alcohol consumption = 84; sleep apnea = 18

Table 2

Comparison of baseline characteristics between those with missing and people with complete data on sleep duration

Variables	Missing Group n = 6,873	Non Missing group n = 18,755	p value
Age [years] (±SD)	70 (9.2)	68 (8.6)	<0.0001
White	4,458 (90%)	16,936 (91%)	0.345
Body Mass Index [kg/m^2] (±SD)	25 (4.1)	26 (3.7)	<0.0001
Exercise Frequency			
Rarely/Never	1,810 (45%)	6,429 (35%)	
1–3/month	284(7.1%)	533 (2.9%)	<0.0001
1–4/week	1,238 (31%)	8,272 (45%)	
5–7/week	663 (17%)	3,335 (18%)	
Smoker			
Never	1,918 (46%)	10,563 (56%)	
Past	2,028 (49%)	7,630 (41%)	<0.0001
Current	205 (4.9%)	530 (2.8%)	
Alcohol Consumption (drinks/week)			
0–4	2,398 (61%)	10,792 (58%)	
5–7	877 (22%)	4,406 (24%)	<0.006
>7	684 (17%)	3,473 (19%)	
History of Snoring			
Rarely/Never	127 (1.9%)	6,155 (33%)	
Few/Occasionally	151 (2.2%)	7,437 (40%)	<0.0001
Mostly/Always	72 (1.1%)	3,601 (19%)	
Unknown/Missing	6,523 (95%)	1,562 (8.3%)	
Sleep apnea	70 (5.4%)	764 (4.1%)	0.018
Hypertension (by history)	2,644 (38%)	9,687 (52%)	<0.0001
Diabetes Mellitus	552 (8.0%)	1,533 (8.2%)	0.712
Dyslipidemia (by history)	1,881 (27%)	9,518 (51%)	<0.0001
Prior Coronary Heart Disease	926 (13%)	2,448 (13%)	0.378
Prior Congestive Heart Failure	46 (0.7%)	267 (1.4%)	<0.0001

Table 3

Hazard ratios (95% CI) for atrial fibrillation according to average sleep duration in Physicians' Health Study

Sleep duration (hours)	Cases/person-years	Crude incidence rate (1,000 person-years)	Hazards Ratio (95% Confidence Interval)			
			Unadjusted	Model 1	Model 2	Model 3
≤6.0	325/33794	9.6	0.97 (0.85 – 1.12)	1.08 (0.94 – 1.24)	1.06 (0.92 – 1.22)	1.06 (0.92 – 1.22)
7.0	540/54651	9.9	1.0	1.0	1.0	1.0
≥8.0	603/40370	14.9	1.51 (1.35 – 1.70)	1.16 (1.03 – 1.31)	1.14 (1.01 – 1.28)	1.13 (1.00 – 1.27)
P (linear trend)			<0.0001	0.15	0.19	0.26

Model 1: Age and race adjusted

Model 2: Age, race, exercise frequency, body mass index, alcohol consumption, smoking category, sleep apnea, snoring

Model 3: Age, race, exercise frequency, body mass index, alcohol consumption, smoking category, history of hypertension, diabetes, dyslipidemia, sleep apnea, snoring, coronary heart disease, and congestive heart failure

Table 4

Hazard ratios (95% CI) for atrial fibrillation according to average sleep duration in Physicians' Health Study stratified by sleep apnea

Sleep duration (hours)	Sleep Apnea		No Sleep Apnea	
	Cases/person-years	Hazards Ratio (95% Confidence Interval)	Cases/person-years	Hazards Ratio (95% Confidence Interval)
≤6.0	33/1502	2.26 (1.26 – 4.05)	291/32247	1.01 (0.87 – 1.16)
7.0	18/1926	1.0	522/52699	1.0
≥8.0	30/1707	1.34 (0.73 – 2.46)	573/38642	1.12 (0.99 – 1.27)

Model adjusted for: Age, race, exercise frequency, body mass index, alcohol consumption, smoking category, history of hypertension, diabetes, dyslipidemia, snoring, coronary heart disease, and congestive heart failure