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Snoring and Insomnia are Not Associated with Subclinical Atherosclerosis in the Northern Manhattan Study (NOMAS)

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Abstract

Background and Aims—Sleep disordered breathing (SDB) is a risk factor for stroke, but its association with subclinical atherosclerosis remains controversial. Snoring and insomnia are frequently co-morbid with SDB and may contribute to stroke. Data on the relationship between snoring and insomnia with atherosclerotic disease is sparse. We investigated the relationship between insomnia, snoring and carotid intima-media thickness (IMT), a marker of subclinical atherosclerosis, in the Northern Manhattan Study (NOMAS).

Methods—A group of 1,605 participants (mean age 65 ± 8 years; 40% men; 61% Hispanic, 19% black, 20% white) who had carotid IMT measurements performed was assessed for self-reported sleep habits. Habitual snoring was defined as self-reported snoring > 4 times per week. Presence of insomnia was based on three items extracted from the Hamilton Rating Scale for Depression. Carotid IMT was expressed as a mean composite measure of IMT in the carotid bifurcation, common and internal carotid artery. Multivariate linear regression models were used to identify associations between snoring, insomnia and carotid IMT.

Results—Habitual snoring was present in 29% of the subjects and insomnia in 26%. There was a higher prevalence of self reported snoring (84%) and insomnia (66%) among Hispanics than non-Hispanics. The mean total carotid IMT was 0.95 ± 0.09 mm; among those with self reported snoring was 0.94 ± 0.09 mm; and among those with insomnia was 0.95 ± 0.08 mm. After controlling for age, sex, race-ethnicity, BMI and cardiovascular risk factors, snoring ($p = 0.986$) and insomnia ($p = 0.829$) were not significantly associated with increased carotid IMT.

Conclusion—Snoring and insomnia were not significantly associated with subclinical atherosclerosis in this population based community cohort.

Keywords

sleep; snoring; insomnia; African American; Hispanic; Intima-Media Thickness; Risk factors; Sonography; Ultrasound

INTRODUCTION

Sleep disordered breathing (SDB) is characterized by episodes of upper airway obstruction associated with intermittent hypoxemia, and loud and disruptive snoring which may lead to symptoms of excessive daytime sleepiness.(1) Habitual snoring affects up to 40% of the adult population (2) who may be susceptible to SDB. Epidemiological studies estimate the prevalence of sleep disordered breathing to be 3–7% overall, (3) with increased prevalence and severity in the elderly. (4)

Snoring and sleep disordered breathing are independent risk factors for stroke in middle-aged individuals (5) and in the elderly.(6) The strength of the association between snoring and stroke is similar to that of traditional risk factors.(7,8) Habitual snorers had a two-fold increased risk for stroke or ischemic heart disease compared to non-snorers (9,10). Excessive daytime sleepiness is frequently associated with sleep apnea. A recent report from our cohort showed that excessive daytime sleepiness as measured by the Epworth sleepiness scale is an independent risk factor for stroke and all vascular events (11).

Insomnia is defined as a subjective difficulty falling or maintaining sleep which is associated with daytime functional impairment (12). Multiple studies, including a large cohort from the Atherosclerosis Risk in Communities (ARIC) Study, have found that self-reported complaints of insomnia are associated with an increased risk of coronary heart disease, MI or death (12,13). In addition, individuals with sleep apnea frequently complain of insomnia (14).

Subclinical carotid atherosclerosis is a strong predictor of stroke and cardiovascular disease (15,16,17,18). Carotid intima-media thickness (IMT) is an ultrasound imaging marker of early subclinical atherosclerosis and may be a useful noninvasive and cost-effective imaging tool to detect high risk individuals beyond traditional Framingham risk factors.

Sleep disorders may increase risk of stroke and vascular disease through altered inflammatory, endocrine, and/or neural pathways (19,20,21). Associations between sleep disordered breathing and subclinical atherosclerosis have been reported, but the results are inconsistent (19,20,21,22) and data from population-based studies sparse. In addition, limited data exist on the association between the complaints of insomnia and subclinical atherosclerosis. The aim of our study was to examine the relation between self-reported snoring and insomnia with carotid IMT in a community-based multi-ethnic population.

METHODS

Study Population

NOMAS is an ongoing prospective population-based cohort study designed to determine stroke incidence, risk factors, and outcomes in a multi-ethnic population (23). The original NOMAS community cohort of 3298 subjects was assembled from a population-based, random sample based on the following eligibility criteria: (1) resident of Northern Manhattan for at least 3 months; (2) from a household with a telephone; (3) age 40 (changed to age 55 in 1998) or older at the time of first in-person assessment; and (4) no baseline history of stroke. From the baseline data collection (n=3298), a subset of subjects with both completed sleep questionnaires and measures of subclinical carotid atherosclerosis were analyzed (N=1605). Baseline data were collected through interviews of the participants, review of the medical records, and physical and neurological examinations.

Vascular Risk Factors

Diabetes mellitus was defined as fasting blood glucose greater than or equal to 126 mg/dl or the patient's self-report of such a history or use of insulin or hypoglycemic medications. Cigarette smoking was categorized as nonsmoker, former, or current smoker. Cardiac disease included history of angina, MI, coronary artery disease, atrial fibrillation, congestive heart failure, or valvular heart disease. Hypertension was defined as a systolic blood pressure 140 mm Hg or a diastolic blood pressure 90 mm Hg or a patient's self-report of a history of hypertension or use of antihypertensive medications. Mild to moderate alcohol use was defined as current drinking of up to 2 drinks per day. The study was approved by the Columbia University Medical Center Institutional Board Review and by the University of Miami Institutional Board Review, and all participants gave informed consent.

Sleep Variables

The key exposure variables were derived from the NOMAS sleep questionnaire and the Hamilton rating scale for depression. The questionnaires were available in English during the initial interview and translated to Spanish when needed. The NOMAS sleep questionnaire contained two questions about snoring, choking, or breathing pauses during sleep (i.e., "Do you know, or have you been told that you snore?" and "Do you experience, or have you been told that you have, choking or breathing pauses while you sleep?"). Possible responses ranged from 1 to 5 with 1= none and 5= every night. Habitual snoring was defined as a self-report of snoring > 4 times per week. Insomnia was based on 3 items from the Hamilton Rating Scale for Depression (HRSD), (24) assessing 1) difficulty falling asleep, 2) difficulty maintaining sleep, and 3) early morning awakenings. Each item was assigned 0, 1, or 2 points, and a total score was the summation of these three items. Total insomnia scores could range from 0 to 6. Individuals with a total score of 2 or higher were classified as having insomnia. They could meet this criterion by having at least 1 point on two separate items or 2 points on any single item. Based on the insomnia score distribution, our sample approximated the population distribution of insomnia symptoms. In addition, several factor analyses of the HRSD have shown that the insomnia items can be extracted an independent factor from the scale (25,26).

Carotid Ultrasound

Carotid IMT was assessed by high-resolution B-mode ultrasound according to standardized scanning and reading protocols, as previously described (17). The carotid IMT scanning protocol consisted of the near and the far wall of 3 carotid segments, defined as follows: (1) 10 to 20 mm proximal to the tip of the flow divider into the common carotid artery (CCA); (2) the carotid bifurcation beginning at the tip of the flow divider and extending 10 mm proximal to the flow divider tip; and (3) the proximal 10 mm of the internal carotid artery (ICA). IMT in all carotid segments was measured in areas free of plaque. Plaque was defined as an area of focal wall thickening 50% greater than surrounding wall thickness confirmed by marking and comparing plaque thickness with the thickness of the surrounding wall by electronic calipers. The total carotid IMT was calculated as a composite measure that combined the near and the far wall of the CCA IMT, the bifurcation IMT and the ICA IMT of both sides of the neck. Total carotid IMT was expressed as a mean of the maximum measurements of the 12 carotid sites.

Statistical Analysis

We performed a cross-sectional analysis between snoring and insomnia, respectively, and carotid IMT among 1605 participants. Approximate normality of total IMT was suggested by a visual inspection of the distribution plots. The relation between other demographic and risk factor covariates and snoring and insomnia was examined. For the categorical variables

(race-ethnicity, sex, diabetes, smoking, hypertension, history of cardiac disease) chi-square tests were conducted, and for the continuous variables (age, BMI, LDL, HDL) t-tests were conducted.

Associations between both snoring (categorized: >4 times/week vs. less) and insomnia (categorized: yes vs. no) and carotid IMT (continuous) were assessed by linear regression analyses. A univariate analysis was conducted for each exposure (model 1) as well as a multivariate linear regression analysis controlling for demographics only (age, sex, and race/ethnicity) (model 2), and for demographics and other cardiovascular risk factors including BMI (continuous), hypertension, diabetes, current smoking, LDL (continuous), HDL (continuous) and history of cardiac disease (model 3).

In secondary analyses, we examined the outcome (IMT) as a dichotomous trait using multiple logistic regressions. IMT was divided into quartiles, and those in the top quartile (N=411, IMT ≥ 1.00 mm) were compared to those in the lowest quartile (N=410, IMT ≤ 0.88 mm). This analysis was performed to examine whether the exposures of interest (snoring and insomnia) were associated with carotid IMT in a nonlinear manner, as well as to maximize the difference between the outcomes of interest (4th vs. 1st quartile of the IMT distribution). Also, stratified analyses by race-ethnicity were performed.

A p-value of less than 0.05 was regarded as statistically significant. All statistical analyses were performed using SAS version 9 (Cary, North Carolina).

RESULTS

The mean age of the cohort was 65 years ($\pm$ SD) with 40% men. Sixty one percent were Hispanic, 20% black and 19% white. Habitual snoring was reported by 29% of the subjects and insomnia reported by 26%. Of the subjects with self reported symptoms, there was a high prevalence of women with insomnia (67%, n=258) and snoring (58%, n=188). The mean IMT was 0.95 ± 0.08 mm. Table 1 shows the overall characteristics of the cohort. The mean IMT among those with snoring was 0.94 ± 0.09 mm vs. 0.95 ± 0.09 mm in those without snoring; and 0.95 ± 0.08 mm among those with insomnia vs. 0.95 ± 0.09 mm among those without insomnia. There was no significant association between either habitual snoring or insomnia with increased carotid IMT in univariate (model 1) or multivariate linear regression models (models 2 and 3). Similarly, when the outcome was dichotomized as carotid IMT in the 4th quartile vs. 1st quartile of IMT distribution, there was no significant association between habitual snoring, insomnia and increased carotid IMT (Table 2).

Differences in self reported snoring and insomnia by race-ethnicity were observed. A higher prevalence of snoring and insomnia was observed among Hispanics in comparison to non Hispanics. In analyses stratified by race-ethnicity, there was no association for either snoring or insomnia and IMT in Hispanics or Non-Hispanics.

DISCUSSION

We did not demonstrate an association between self-reported snoring and insomnia with carotid intima-media thickness, a measure of sub-clinical atherosclerosis. The lack of association may be explained by several reasons. First, self reported sleep complaints may be underreported and not sensitive enough to detect a true association. Second, the presence of cardiovascular risk factors in our population may account for the majority of the explained variance in carotid IMT (27) and therefore the addition of sleep symptoms may have a small effect which is difficult to detect because of the shared variance with traditional risk factors. Finally, the parent NOMAS study was not specifically designed to address sleep

complaints and risk of atherosclerosis and therefore detailed assessments of sleep habits and sleep test studies were not performed.

The lack of an association between sleep complaints and carotid IMT observed in our study has also been recently reported in the Sleep Heart Health Study (SHHS) cross sectional analysis (28). SHHS found no association between sleep disordered breathing (SDB) and subclinical atherosclerosis after adjusting for traditional vascular risk factors. Unlike in our study, SHHS used objective measures of sleep disordered breathing by performing polysomnography. Similar to SHHS, our study was population-based, but consisted of a diverse race-ethnic population of Hispanics, African Americans and whites. However, some studies have found evidence of increased carotid atherosclerosis in participants with heavy snoring and sleep apnea (19,20,21,29). Most of these studies involved selected small number of subjects referred to tertiary care centers with symptoms or previous diagnosis of moderate to severe SDB.

Snoring and insomnia are highly prevalent sleep complaints in the general population. Habitual snoring may affect up to 40% and chronic insomnia up to 15 % of the general population (2,30). In our study, 29% of subjects reported habitual snoring and 26% insomnia. The highest prevalence of self reported sleep complaints was observed among Hispanics, which in our cohort are predominantly Caribbean-Hispanics. This is in accordance with other population-based studies in which Hispanics of various countries of origin had a higher prevalence of self reported habitual snoring when compared to non Hispanic whites (31). We have also observed the highest prevalence of insomnia complaints among Hispanics. The high prevalence of self reported sleep complaints in Hispanics remains largely unexplained. This difference could be partly attributed to cultural variation in reporting sleep complaints and obesity.

The exact mechanism by which sleep disorders may increase risk for atherosclerosis, stroke and vascular disease is unknown. Postulated mechanisms include hypoxemia-reoxygenation causing oxidative stress to endothelial cells (32), increased levels of inflammatory markers in sleep apnea (33,34,35), and nocturnal arousals causing repeated sympathetic activation, which may cause “non-dipping” of BP during nighttime, vasoconstriction and hypertensive “surges” leading to the development of nocturnal hypertension and shear stress to the vessel walls (22,36,37). Alternatively, these changes may lead to impaired cerebral autoregulation and contribute to the increased risk of cerebral ischemia (38). The association between sleep disorders and subclinical atherosclerosis may be mediated by the presence of hypertension, obesity, and the severity of the sleep disorder. The amount of disease exposure and the severity of the sleep disorder may have a dose response relation with subclinical atherosclerosis. In our cohort, traditional risk factors were highly prevalent, and only limited information about the sleep exposure and the severity of the sleep complaint was available. Therefore, a lack of association between self-reported sleep complaints and IMT may be due to a lack of variability of these mediators and the “true” effects might have been biased towards null. Substantial evidence suggests that sleep disorders modify basic cardiovascular physiological regulatory mechanisms which lead to hypertension, (39) the most prominent independent risk factor for an increased IMT.

The strengths of our study include the evaluation of a large, multiethnic, community-based cohort that consists mainly of Caribbean Hispanics and African Americans who are considered to be at a higher risk of cardiovascular events compared to Caucasians. In spite, several limitations should be noted. First, self reported symptoms may account for inaccurate estimates because of a lack of awareness. Histories obtained from bed partners may be more informative. The complaints of insomnia do not exactly meet specific diagnostic criteria for an insomnia syndrome (30). In addition, we were not able to obtain

objective measures of sleep by polysomnography to diagnose and assess severity of sleep disordered breathing. The use of self reported snoring more than 4 times a week as a surrogate for sleep disordered breathing may dilute any effects on carotid IMT by including subjects with primary snoring (no apneas) or mild sleep disordered breathing. Also we did not obtained information about the loudness of the snoring which may be a better measure of upper airway resistance. Our current analysis is cross sectional which limits our ability to draw any causal inferences between sleep complaints and subclinical atherosclerosis. Further longitudinal analysis is necessary to clarify the role of large vessel subclinical atherosclerosis, sleep and cerebrovascular disease.

In conclusion, we found that subjects with self reported complaints of habitual snoring and insomnia were not more likely to have increased carotid IMT in comparison to those without self-reported snoring and insomnia.

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TABLE 1

Baseline sociodemographics, vascular risk factors, snoring, and insomnia among stroke-free 1,605 subjects from the Northern Manhattan Study

N (%)	Overall N=1605	Insomnia 387 (26)	Habitual snoring 325 (29)
Age (years)	66 ± 9	66 ± 8	63 ± 8
Men, n (%)	601 (40)	129 (33)	137 (42)
Race, n (%)			
White	278 (19)	57 (15)	23 (7)
Black	310 (20)	73 (19)	30 (9)
Hispanic	908 (61)	257 (66)	272 (84)
VASCULAR RISK FACTORS n (%)			
Hypertension	1065 (71)	284 (73)	236 (73)
Diabetes	225 (14)	80 (21)	56 (17)
Any cardiac disease	265 (17)	85 (17)	52 (16)
Current smoking	217 (14)	61 (22)	50 (15)
Body mass index (kg/m ²)	28 ± 5	29 ± 5	29 ± 5
Low-density lipoprotein	127 ± 35	129 ± 36	128 ± 32
High-density lipoprotein	46 ± 14	48 ± 15	43 ± 12
Mean IMT (mm)	0.95 ± 0.09	0.95 ± 0.08	0.94 ± 0.09

TABLE 2

Association of snoring and insomnia with carotid IMT (N=1,605)

Outcome: Carotid IMT		Outcome: 4 th vs. 1 st quartile of IMT distribution	
	Parameter estimate (β)	P value	OR (95% CI)
Snoring			
Model 1 ^a	-0.0088	0.127	0.79 (0.54 – 1.15)
Model 2 ^b	0.0009	0.878	1.15 (0.76 – 1.74)
Model 3 ^c	0.00009	0.986	1.06 (0.63 – 1.80)
Insomnia			
Model 1 ^a	-0.032	0.524	0.99 (0.71 – 1.37)
Model 2 ^b	0.0011	0.832	1.10 (0.77 – 1.57)
Model 3 ^c	-0.0012	0.829	1.08 (0.70 – 1.66)

^a unadjusted model.^b adjusted for age, sex, and race-ethnicity.^c adjusted for age sex, race LDL, HDL BMI hypertension, diabetes, current smoker and any cardiac disease.