Research letter

Pulmonology

Association between self-reported symptoms of obstructive sleep apnea and chronic obstructive pulmonary disease: a population-based study

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Obstructive sleep apnea (OSA) has been reported to aggravate the clinical manifestations of chronic obstructive pulmonary disease (COPD) by increasing inflammation in the lower respiratory tract [1, 2]. However, whether OSA is associated with the presence of COPD remains unclear. Thus, this study aimed to investigate the association between OSA and COPD according to the National Health and Nutrition Examination Survey 2017–2020 (NHANES).

This study adhered to the guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [3]. The exclusion criteria were as follows: 1) lack of information on COPD or OSA-related symptoms; 2) age under 20 years, pregnancy, or lack of data on key covariates. Data on OSA symptoms were collected via questionnaires, which assessed the following: 1) the frequency of snoring, categorized as never, rarely (1–2 times/week), occasionally (3–4 times/week), or frequently (≥ 5 times/week); 2) the frequency of snorting/stopping breathing, with the same categorical options; and 3) the frequency of sleepiness, categorized as never, rarely (1 time/month), sometimes (2–4 times/month), or often or almost always (≥ 5 times/month). The diagnosis of COPD was ascertained on the basis of the response to the following question: "Have you ever been told by a doctor that you have COPD?" Covariates were selected as follows: demographic characteristics (smoking status, body mass index (BMI), poverty-to-income ratio (PIR), education, race, age, sex and marital status); comorbidities (diabetes, cancer and hypertension); and uric acid level. Information on comorbidity diagnoses was obtained from the relevant questionnaire sections. Multivariable logistic regression analysis was carried out to assess the association between self-reported symptoms of OSA and COPD. Three models were constructed: 1) crude model, with no covariates adjusted for; 2) minimally adjusted model, adjusted for sex, age, and race; 3) fully adjusted model, adjusted for smoking status, BMI, PIR, education, race, age, sex, marital status, diabetes, cancer, hypertension, and uric acid level. Interaction tests and subgroup analyses were subsequently used to further investigate the associations between self-reported symptoms of OSA and COPD. The software R (4.0.4) was used to analyze the data. $P < 0.05$ was considered statistically significant.

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There were 5939 eligible participants in this study. The weighted baseline characteristics of the participants are shown in Supplementary Table SI. The results revealed statistically significant differences in most parameters between the non-COPD group and the COPD group, although no significant differences were found for sex ($p = 0.236$) or uric acid ($p = 0.285$).

Multivariable logistic regression analysis revealed that even after covariate adjustments, significant positive associations were observed for participants with frequent snoring (fully adjusted model: OR = 1.722, 95% CI: 1.018, 2.913, $p = 0.03$), frequent snorting/stopping breathing (fully adjusted model: OR = 3.346, 95% CI: 1.251, 8.948, $p = 0.017$), sometimes feeling sleepy (fully adjusted model: OR = 1.917, 95% CI: 1.303, 2.82, $p = 0.006$), and often or almost always feeling sleepy (fully adjusted model: OR = 3.352, 95% CI: 1.636, 6.87, $p = 0.006$). Although occasional snoring and occasional snorting/stopping breathing were positively correlated with COPD in the crude and minimally adjusted models, the associations were no longer statistically significant in the fully adjusted model (OR = 1.929, 95% CI: 0.827, 4.504, $p = 0.069$) (Table I).

The interaction analyses (Supplementary Tables SII) revealed that race ($p = 0.045$), education ($p < 0.001$), PIR ($p = 0.004$), hypertension ($p < 0.001$) and smoking ($p = 0.029$) significantly modified the association between snoring and COPD. PIR ($p < 0.001$) and smoking ($p < 0.001$) significantly modified the associations between snorting/stopping breathing and COPD. In addition, education ($p = 0.001$), diabetes ($p = 0.042$) and smoking ($p = 0.004$) significantly modified the association between sleepiness and COPD.

Subgroup analyses suggested that for participants of other races ($p = 0.02$), those with education above high school ($p = 0.02$), $1.3 \leq$ PIR < 3.5 ($p = 0.02$) and no hypertension ($p < 0.01$), frequent snoring was associated with higher odds of COPD. For participants with PIR < 1.3 ($p = 0.01$), no hypertension ($p = 0.01$) and current smoking ($p = 0.02$), occasional snoring was associated with a greater risk of COPD. For participants with $1.3 \leq$ PIR < 3.5 ($p < 0.01$) and never smokers ($p = 0.02$), frequent snorting/stopping breathing was associated with higher odds of COPD. For participants with $1.3 \leq$ PIR < 3.5 ($p = 0.04$) and current smokers ($p < 0.01$), occasional snorting/stopping breathing was associated with higher odds of

Table I. Association between self-reported symptoms of OSA and COPD in three models

Variables	Crude model OR (95% CI) *P*-value	Minimally adjusted OR (95% CI) *P*-value	Fully adjusted OR (95% CI) *P*-value
Snoring			
Never	Ref	Ref	Ref
Rarely (1–2/week)	0.987 (0.703, 1.385) 0.939	1.073 (0.766, 1.502) 0.686	1.172 (0.700, 1.964) 0.383
Occasionally (3–4/week)	1.444 (1.113, 1.874) **0.011**	1.396 (1.053, 1.851) **0.032**	1.295 (0.850, 1.972) 0.122
Frequently (≥ 5/week)	1.992 (1.415, 2.806) **< 0.001**	2.062 (1.408, 3.020) **0.002**	1.722 (1.018, 2.913) **0.030**
Snorting/stopping breathing			
Never	Ref	Ref	Ref
Rarely (1–2/week)	1.555 (0.989, 2.445) 0.055	1.769 (1.166, 2.682) **0.015**	1.640 (0.849, 3.168) 0.075
Occasionally (3–4/week)	2.067 (1.033, 4.137) **0.041**	2.172 (1.151, 4.099) **0.028**	1.929 (0.827, 4.504) 0.069
Frequently (≥ 5/week)	3.662 (1.916, 6.999) **< 0.001**	4.026 (2.008, 8.073) **< 0.001**	3.346 (1.251, 8.948) 0.017
Sleepiness			
Never	Ref	Ref	Ref
Rarely (1/month)	1.889 (1.106, 3.227) **0.029**	2.090 (1.206, 3.622) 0.017	2.067 (0.849, 5.033) 0.060
Sometimes (2–4/month)	1.990 (1.438, 2.754) **< 0.001**	2.229 (1.632, 3.043) **< 0.001**	1.917 (1.303, 2.820) **0.006**
Often or almost always (≥ 5/month)	3.946 (2.573, 6.051) **< 0.001**	4.599 (2.999, 7.050) **< 0.001**	3.352 (1.636, 6.870) **0.006**

Crude model: no covariates were adjusted. Minimally adjusted model: adjusted for sex, age, and race. Fully adjusted model: adjusted for sex, age, race, education status, marital status, PIR, BMI, smoking status, hypertension, diabetes, cancer, and uric acid. Significant results are presented in BOLD type.

COPD. Regardless of statistical significance, participants who often or almost always felt sleepy had higher odds of COPD than those who rarely felt sleepy in most subgroups.

The results of this cross-sectional study suggest that COPD assessment may warrant particular attention in individuals reporting frequent sleepiness, snorting/stopping breathing, or snoring. OSA is a prevalent sleep disorder characterized by recurrent partial or complete collapse of the upper airway during sleep, resulting in repeated apnea and hypopnea, usually accompanied by nocturnal hypoxia, sleep interruption, and daytime sleepiness [4]. Previous studies have reported that during rapid eye movement sleep, both tidal volume and respiratory rate decrease in healthy individuals, consequently reducing minute ventilation. This leads to a decrease of less than 2% in arterial oxygen saturation. While these physiological adaptations do not markedly affect gas exchange in healthy subjects, they could lead to hypoxia and hypercapnia during REM sleep in individuals with COPD [5]. There is evidence that OSA contributes to a more severe inflammatory state in the airways of COPD patients [6, 7]. Marin *et al.* reported that overlap syndrome, characterized by more severe intermittent nocturnal oxygen desaturation due to apneas and hypopneas [8, 9], is associated with increased mortality and COPD-related hospitalizations [10]. Their study also suggested that CPAP therapy, which directly addresses these desaturations, may improve survival and reduce exacerbation-related hospitalizations.

The results of the interaction tests revealed that race, education, PIR, hypertension and smoking modified the association between snoring and COPD; PIR and smoking significantly modified the association between snorting/stopping breathing and COPD; and education, diabetes, and smoking significantly modified the association between sleepiness and COPD (each $p < 0.05$). Overall, smoking status appeared to modify the associations between self-reported symptoms of OSA and COPD. Some studies have also investigated the roles of education and PIR in this relationship. Lee *et al.* reported that the prevalence of COPD was significantly greater in people living below the relative poverty line (OR = 1.40, 95% CI: 1.08–1.82) [11]. A prospective cohort study revealed that low household income and a low level of education were independently associated with incident COPD [12]. Ejike *et al.* reported that race (especially Black vs. White) significantly influences COPD onset and symptom phenotype. Their findings indicated that socioeconomic factors, including education level, income, and community poverty, accounted for a portion of these racial distinctions [13]. Furthermore, hypertension and diabetes have been reported as risk factors for COPD development but also as common comorbidities, as supported by previous studies [14, 15]. Given the multifactorial nature of COPD, the conclusions drawn from the present findings should be considered alongside comprehensive clinical information for each patient.

Several limitations should be noted. First, the cross-sectional design precludes causal inference, and longitudinal studies are needed. Second, reliance on questionnaire-based data may introduce recall bias. Third, residual confounding due to unmeasured variables cannot be excluded. Finally, the lack of COPD phenotype data limits further stratified analyses. In conclusion, the analysis of NHANES 2017–2020 data indicated that self-reported symptoms of OSA may be associated with higher odds of prevalent COPD, particularly at higher symptom frequencies. Screening for OSA symptoms may help identify individuals who warrant further assessment for COPD, although prospective studies are needed to confirm these findings.

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Tingting Zeng and Lian Liu contributed equally.

Availability of data and material

All data used in this study are available on the NHANES website (National Health and Nutrition Examination Survey Homepage, cdc.gov).

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Ethical approval

The study was approved by the Ethics Review Board of the National Center for Health Statistics (Protocol #2018-01 and Protocol #2011-17), and written informed consent was obtained from all NHANES participants.

Conflict of interest

The authors declare no conflict of interest.

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