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Research Paper

Impacts of Sleep Duration and Snoring on The Risk of Esophageal Squamous Cell Carcinoma

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Abstract

Background Sleep duration and snoring are correlated with tumorigenesis while their associations with esophageal squamous cell carcinoma (ESCC) are unclear. The purpose of this study is to investigate the impacts of night sleep duration and snoring on ESCC risk.

Methods This study included a total of 527 esophageal squamous cell carcinoma patients and 505 gender- and age- matched healthy controls from five hospitals in China. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated by conditional logistic regression models.

Results Subjects with sleep duration <7 h (adjusted OR 3.18, 95%CI 1.55-6.53) and regular snoring (adjusted OR 2.56, 95%CI 1.82-3.59) were exposed to high esophageal squamous cell carcinoma risk. After the multivariate models adjusted for body mass index (BMI), the results changed slightly. In the stratified analysis regarding gender, the similar trends occurred in both men and women, and BMI ≥25.0 kg/m^2 (adjusted OR 0.68, 95%CI 0.48-0.96) was associated with decreased esophageal squamous cell carcinoma risk in men. Additionally, the esophageal squamous cell carcinoma risk attributable to sleep duration <7 h and regular snoring could be completely or partially diminished in subjects with BMI ≥25.0 kg/m^2.

Conclusion In both genders, short sleep duration (<7h) and regular snoring were significantly related to increased risk of esophageal squamous cell carcinoma independently.

Key words: Sleep duration, Snoring, Esophageal squamous cell carcinoma, Cancer prevention, Epidemiology

Introduction

Esophageal cancer (EC) ranks the eighth most common cancer and the sixth cause of cancer-associated mortality in the whole world [1]. And esophageal squamous cell carcinoma (ESCC) cases account for the majority of the total EC amount, especially in developing countries [2]. Some recognized risk factors of ESCC include tobacco smoking, alcohol consumption, poor nutrition status and low uptake of vegetables and fruits [3]. However, the etiology of ESCC is still inconclusive and remains to be explored.

Sleep duration is reported to be associated with overall mortality [4], cardiovascular diseases [5] and several cancers, including breast cancer and colorectal cancer [6,7]. Studies confirm that short sleep duration could increase risks of cancers via multiple mechanisms, such as inflammatory process and melatonin suppression [8,9]. Moreover, recent

researches demonstrate that gastroesophageal reflux can promote carcinogenesis of ESCC [10,11], and short sleep duration shows significant associations with gastroesophageal reflux disease (GERD) [12,13]. However, the impacts of sleep duration on ESCC risk have not been explored yet.

As the cardinal symptom of obstructive sleep apnea (OSA), snoring has been broadly regarded as a surrogate of sleep disordered breathing (SDB) [7,14,15]. SDB or snoring could increase cancer incidence and mortality, and promote cancer development via sleep disturbance and intermittent hypoxemia [14,16,17,18]. Few studies report the correlation between disrupted breathing and site-specific cancer risks, and it is unknown whether SDB/snoring could influence the risk of ESCC yet.

This case-control study was firstly performed to investigate the relationship between sleep duration and snoring and ESCC risk. And we explored whether their impacts depend on body mass index (BMI) through adding BMI into the multivariate models. Then subgroup analyses according to gender or BMI were conducted to observe impacts of these factors on ESCC risk.

Methods

Subjects

Between July 2015 and January 2017, a total of 598 pathologically diagnosed ESCC patients were selected from Qilu Hospital of Shandong University, Shandong Cancer Hospital and Institute, the People's Hospital of Pingyi, Wuhan Union Hospital, and Sir Run Run Shaw Hospital. The patients inclusion criteria were: 1) patients who were pathologically diagnosed as ESCC; 2) patients who aged 30-90 years but with no gender restriction; 3) patients without cardial carcinoma or gastric cancer; 4) patients who belonged to Han ethnic group; 5) patients who were in hospital and receiving treatment so that our staff could perform the interview effectively. The exclusion criteria were: 1) patients refused our invitation; 2) patients with a family history of tumours; 3) patients treated with sedative drugs; 4) patients diagnosed with severe pulmonary diseases. Specially, patients who cannot recall the status before ESCC diagnosis were excluded. Finally 527 patients were included in our study (the participation rate was 88.1%). Meanwhile, 505 gender- and age-matched (frequency matching) controls were enrolled at an approximate 1:1 ratio. The controls were healthy people (62%) and other patients without ESCC-associated diseases, including dermatologic disorders (15%), osteoarthritis (11%), hernias (7%) and fracture (5%). And the controls were all hospital-based, and came from the same hospitals as the ESCC cases. Our study was performed in compliance with the standards of the Declaration of Helsinki and was approved by Ethics Committee of every participating hospital. Written informed consent was obtained from every participating subject.

Data collection

All the participants were interviewed by our trained staff to give responses to questions in the structured questionnaire, including weight (kg), height (cm), sleep duration (hours/day), snoring frequency, smoking status, drinking frequency, and dietary habits. All subjects were required to response the status before the ESCC diagnosis. Sleep duration and snoring were restricted to the status during the past 12 months before ESCC diagnosis to attenuate the influences of chronological change and recall bias. Additionally, the collected weight in this study was defined as the usual weight one year prior to diagnosis.

Considering the self-reported sleep time was well associated with the assessed sleep duration by sleep diaries [19], the self-reported sleep duration was adopted in the study. The self-reported sleep duration was defined as the average time from falling asleep at night to waking up in the morning, and was categorized to five groups according to previous studies: <6, 6-<7, 7-<8, 8-<9 and ≥9 h per 24 h [8]. 7-<8h had been confirmed to be related to the lowest morbidity and mortality in various diseases, then 7-<8h group was chosen as the reference group involved in sleep duration [19,20,21]. Due to the limited number of subjects who reported sleep duration <6h, we took <6h and 6-<7h as one category (<7h). If one had breath with relatively loud voice of vibration accompanied by disordered breath rhythm or even intermittent apnea during sleep, we recognized that he/she had snoring [22]. Information about snoring was collected from the participant or the spouse. Response categories of snoring included "never, occasional and regular". Never snorers were defined as individuals who reported never snoring during sleep. Occasional snoring referred to 1-3 nights with snoring per week, while snoring frequency ≥4 nights per week was classified as regular snoring.

Smoking status was classified as "never, former and current". Never smokers were subjects who never smoked or smoked less than 100 cigarettes in the life. Former smokers were defined as subjects who gave up smoking habit not less than 1 year before ESCC diagnosis. And current smokers referred to those who gave up smoking less than 1 year before ESCC development or still retained smoking in our study [23]. Drinking frequency included "never, occasional

and often" [24]. Drinking 0-1 times/month was regarded as never drinking, drinking 2-8 times/month was regarded as occasional drinking, and individuals who drank ≥9 times per month were defined as often drinkers. Special dietary habits referred to daily consumption of pickled vegetables, fried food, mouldy food or hot food. Value of dividing weight (kg) by height squared (m^2) was BMI. According to World Health Organization (WHO), people with a BMI of 25.0 kg/m^2 or higher were regarded as "overweight". Considering the small number of subjects with BMI <18.5 kg/m^2 and the cut-off of 25.0 kg/m^2 was used broadly in researches [25,26], we classified people as overweight (≥25.0 kg/m^2) and non-overweight (<25.0 kg/m^2) here.

Our collected parameters were listed as follows: sleep duration (short: <7 h; median: 7-<8 h; prolonged: 8-<9 h; long: ≥9 h), snoring (never/occasional/regular), smoking status (never/former/current), drinking frequency (never/occasional/often), BMI (non-overweight: <25.0 kg/m^2; overweight: ≥25.0 kg/m^2) and dietary habits (normal/special).

Statistical analysis

Student's *t* test was used for numerical variables while χ^2 test was adopted for categorical variables in the statistical analyses in our study. Odds ratios (ORs) and 95% confidence intervals (CIs) which could reflect relationships between ESCC risk and variables were obtained via conditional logistic regression models. The potential confounding factors were incorporated into statistical models, including smoking, drinking, dietary habits and BMI. The statistical processes were completed by STATA software (version 12, Stata, College Station, TX, USA). P values were all two-sided in our analyses, and <0.05 was considered statistically significant.

Results

A total of 527 ESCC patients and 505 gender- and age- matched healthy controls were included into the study. Table 1 summarized the baseline characteristics of all the participants. The gender and age showed no statistical difference between cases and controls (both $p>0.05$). The percentage of current smokers and often drinkers were higher in ESCC patients than in healthy controls (both $p<0.001$). Subjects who had special dietary habit were more common in ESCC patients ($p<0.001$). There was no statistical difference for the percentage of overweight subjects between cases and controls. ESCC patients tended to have shorter sleep duration (<7 h) than healthy subjects ($p<0.001$). Snoring occurred much more frequently in ESCC patients than controls ($p<0.001$).

Table 1 Characteristics of esophageal squamous cancer patients and controls

Characteristic	Cases (%) (n=527)	Controls (%) (n=505)	*p* value
Gender			
Male	81.78	80.40	0.570
Female	18.22	19.60	
Age (years)			
<40	2.27	1.98	0.785
40-49	9.11	11.09	
50-59	28.65	27.52	
60-69	40.43	36.24	
≥70	19.54	23.17	
Smoking status			
Never	33.97	68.71	<0.001
Former	11.20	11.88	
Current	54.83	19.41	
Drinking frequency			
Never	31.12	60.59	<0.001
Occasional	21.82	28.12	
Often	47.06	11.29	
BMI (kg/m^2)			
<25.0	65.09	65.54	0.877
≥25.0	34.91	34.46	
Dietary habit			
Normal	54.65	78.81	<0.001
Special	45.35	21.19	
Sleep duration (hours/day)			
<7	10.06	3.60	<0.001
7-<8	12.33	16.23	
8-<9	33.59	36.62	
≥9	44.02	43.55	
Snoring			
Never	44.59	65.54	<0.001
Occasional	15.56	17.62	
Regular	39.85	16.84	

ESCC, esophageal squamous cell carcinoma, BMI: body mass index
Values mean percentage (%)

The risks of ESCC in relation to sleep duration, snoring and other factors were shown in Table 2. Subjects with short sleep duration (adjusted OR (AOR) 3.18, 95% CI 1.55-6.53) were exposed to higher ESCC risk compared to those with median time. Prolonged (AOR 1.28, 95%CI 0.82-2.01) and long (AOR 1.37, 95%CI 0.89-2.12) sleep duration showed no association with ESCC risk in comparison with median sleep duration. Relative to no snoring, regular snoring (AOR 2.56, 95% CI 1.82-3.59) was significantly associated with higher ESCC risk. Current smoking (AOR 2.61, 95% CI 1.80-3.79) and often drinking (AOR 3.77, 95% CI 2.47-5.77) could significantly increase ESCC risk compared with no smoking and no drinking. Special dietary (AOR 2.38, 95% CI 1.75-3.24) habit was significantly associated with increased risk of ESCC compared with normal dietary habit. After adjusting for BMI, the AOR of ESCC for short sleep duration (from 3.18 to 3.21) and regular snoring (from 2.56 to 2.63) were slightly attenuated. High BMI (AOR

0.79, 95% CI 0.58-1.07) might be related to decreased ESCC risk in this study. However, we are unsure about this result due to its non-statistical significance.

Table 2 Odds ratio of ESCC according to sleep duration, snoring and other risk factors

Subjects	ESCC (n=527)	Controls (n=505)	Crude OR (95% CI)	Adjusted OR[a] (95 % CI)	Adjusted OR[b] (95 % CI)
Sleep duration (hours/day)					
<7	53	18	3.72 (1.99-6.95)	3.18 (1.55-6.53)	3.21 (1.57-6.60)
7-<8	65	82	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
8-<9	177	185	1.21 (0.82-1.77)	1.28 (0.82-2.01)	1.26 (0.80-1.97)
≥9	232	220	1.39 (0.92-1.93)	1.37 (0.89-2.12)	1.33 (0.86-2.07)
Snoring					
Never	235	331	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
Occasional	82	89	1.30 (0.92-1.83)	0.95 (0.64-1.42)	0.98 (0.66-1.45)
Regular	210	85	3.48 (2.57-4.71)	2.56 (1.82-3.59)	2.63 (1.87-3.70)
Smoking status					
Never	179	347	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
Former	59	60	1.91 (1.28-2.85)	1.56 (0.96-2.56)	1.55 (0.95-2.54)
Current	289	98	5.72 (4.27-7.65)	2.61 (1.80-3.79)	2.61 (1.80-3.78)
Drinking frequency					
Never	164	306	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
Occasional	115	142	1.51 (1.11-2.06)	1.19 (0.81-1.74)	1.19 (0.81-1.76)
Often	248	57	8.12 (5.75-11.46)	3.77 (2.47-5.77)	3.83 (2.50-5.87)
Dietary habit					
Normal	288	398	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
Special	239	107	3.09 (2.35-4.06)	2.38 (1.75-3.24)	2.40 (1.76-3.27)
BMI (kg/m²)					
<25.0	343	331	1.00 (Ref.)	-	1.00 (Ref.)
≥25.0	184	174	1.02 (0.79-1.32)	-	0.79 (0.58-1.07)

ESCC, esophageal squamous cell carcinoma, OR: odds ratio, 95% CI: 95% confidence interval, Ref: reference, BMI: body mass index

[a] In the multivariate model including sleep duration, snoring, smoking status, drinking frequency and dietary habits

[b] In the multivariate model including sleep duration, snoring, smoking status, drinking frequency, dietary habits and BMI

Because the incidence of EC and the lifestyles such as sleep duration differed significantly between men and women [3,27,28], we further analyzed the impacts of sleep duration, snoring and other factors on ESCC risk in men and women (Table 3). Short sleep duration (for men, AOR 2.75, 95% CI 1.19-6.36; for women, AOR 11.11, 95% CI 2.02-61.02) and regular snoring (for men, AOR 2.63, 95% CI 1.80-3.86; for women, AOR 3.96, 95% CI 1.58-9.94) were associated with increased ESCC risk in both genders. Overweight (AOR 0.68, 95% CI 0.48-0.96) in men showed statistical relationship with reduced ESCC risk. Current smoking and special dietary habit were correlated with higher risk of ESCC in both genders, especially in women. ESCC risk in male participants with often drinking (AOR 5.30, 95% CI 3.36-8.35) was significantly higher than those without drinking, while drinking frequency had no association with ESCC risk in female.

Table 3 Adjusted ORs of ESCC for sleep duration, snoring and other factors in men and women

Subjects	Men			Women		
	ESCC (n=431)	Controls (n=406)	Adjusted OR (95% CI)	ESCC (n=96)	Controls (n=99)	Adjusted OR (95% CI)
Sleep duration (hours/day)						
<7	41	14	2.75 (1.19-6.36)	12	4	11.11 (2.02-61.02)
7-<8	56	67	1.00 (Ref.)	9	15	1.00 (Ref.)
8-<9	145	152	1.09 (0.65-1.81)	32	33	3.22 (0.99-11.00)
≥9	189	173	1.21 (0.74-1.99)	43	47	2.91 (0.90-9.44)
Snoring						
Never	181	253	1.00 (Ref.)	54	78	1.00 (Ref.)
Occasional	70	77	0.99 (0.63-1.54)	12	12	0.93 (0.33-2.60)
Regular	180	76	2.63 (1.80-3.86)	30	9	3.96 (1.58-9.94)
Smoking status						
Never	105	257	1.00 (Ref.)	74	90	1.00 (Ref.)
Former	54	53	1.95 (1.14-3.33)	5	7	0.60 (0.13-2.80)
Current	272	96	2.94 (1.97-4.38)	17	2	9.05 (1.49-55.09)
Drinking frequency						
Never	92	221	1.00 (Ref.)	72	85	1.00 (Ref.)
Occasional	102	131	1.46 (0.95-2.24)	13	11	1.52 (0.47-4.95)
Often	237	54	5.30 (3.36-8.35)	11	3	0.53 (0.08-3.44)
Dietary habit						
Normal	236	316	1.00 (Ref.)	52	82	1.00 (Ref.)
Special	195	90	2.13 (1.49-3.03)	44	17	4.30 (2.05-9.03)
BMI (kg/m²)						
<25.0	279	251	1.00 (Ref.)	64	80	1.00 (Ref.)
≥25.0	152	155	0.68 (0.48-0.96)	32	19	1.79 (0.83-3.83)

ESCC, esophageal squamous cell carcinoma, OR: odds ratio, 95% CI: 95% confidence interval, Ref: reference, BMI: body mass index

In the multivariate model including sleep duration, snoring, smoking status, drinking frequency, dietary habits and BMI

Considering the possible relationship between BMI and ESCC risk, the preliminary risk estimate for sleep duration and snoring according to BMI was conducted (Table 4). AOR of ESCC for non-overweight people with short sleep duration was 6.33 (95% CI 2.22-18.06, p=0.001) while short sleep duration (AOR 1.71, 95% CI 0.61-4.79, p=0.305) was not associated with ESCC risk in overweight subjects. Subjects with regular snoring experienced 2.93-(p<0.001) and 2.19- (p=0.006) folds of ESCC risk than no snoring patients with BMI <25.0 and ≥25.0 kg/m², respectively.

Table 4 Adjusted odds ratio of ESCC for snoring and sleep duration according to BMI

Subjects	BMI<25.0				BMI≥25.0			
	Cases (n=343)	Controls (n=331)	AOR[a] (95% CI)	*p* value	Cases (n=184)	Controls (n=174)	AOR[a] (95% CI)	*p* value
Sleep duration (hours/day)								
<7	31	7	6.33 (2.22-18.06)	0.001	22	11	1.71 (0.61-4.79)	0.305
7-<8	35	48	1.00 (Ref.)	-	30	34	1.00 (Ref.)	-
8-<9	125	119	1.69 (0.94-3.05)	0.080	52	66	0.74 (0.36-1.53)	0.419
≥9	152	157	1.57 (0.89-2.78)	0.122	80	63	1.08 (0.53-2.18)	0.839
Snoring								
Never	162	238	1.00 (Ref.)		73	93	1.00 (Ref.)	
Occasional	56	45	1.24 (0.75-2.06)	0.401	26	44	0.61 (0.31-1.20)	0.152
Regular	125	48	2.93 (1.90-4.54)	<0.001	85	37	2.19 (1.25-3.84)	0.006

ESCC, esophageal squamous cell carcinoma, AOR: adjusted odds ratio, 95% CI: 95% confidence interval, Ref: reference, BMI: body mass index

[a] In the multivariate model including sleep duration, snoring, smoking status, drinking frequency and dietary habits

Discussion

Lifestyle factors play dominant roles in the development of ESCC [3,29]. As the first study to assess the association between sleep duration and snoring and the ESCC risk, we found that short sleep duration or regular snoring was associated with increased risk of ESCC compared with median sleep duration or no snoring. The same trends occurred in both genders, particularly in women. Short sleep duration was not associated with high risk of ESCC in overweight people according to the subgroup analysis.

Although no previous studies revealed the relationship regarding short sleep duration and ESCC risk, its association with other cancers had been reported. Ruesten et al explored the correlation of overall cancer risk and sleep duration, suggesting that participants with short sleep duration (<6 h) were confronted with increased risk of developing cancer [8]. Various researchers found that short sleep duration was significantly associated with high risk of breast cancer while long sleep duration displayed the opposite effect [6,30,31]. Sleep duration <6 h could increase epithelial ovarian cancer risk while >7 h was a protective factor in a prospective cohort [32]. Besides, prior studies reported that relationship between sleep duration and mortality might be in a "U" shape [4,19]. In this study, only short sleep duration exhibited statistical association with high ESCC risk compared with median sleep duration.

We noticed that short sleep was related to increased risk of obesity, which acted as a mediator in cancer development [33,34]. In the present study, shorter sleep was also correlated to higher BMI (p=0.007). However, studies suggested that BMI was inversely associated with ESCC risk [25,35]. We also observed the correlation between high BMI and reduced ESCC risk. Additionally, when BMI was added into the multivariate models, AOR of ESCC for short sleep duration changed slightly (from 3.18 to 3.21), and short sleep duration was still a risk factor.

First, melatonin is a hormone that is involved in enhancing immune response and inhibiting carcinogenesis [36,37]. Sleep deprivation and nocturnal light exposure will suppress melatonin secretion. Consequently, these individuals are likely to be confronted with immune suppression and larger possibility of cancer development [38]. Second, sleep loss could lead to cell damages, including DNA and protein damages, promoting carcinogenesis [39]. Third, as recently proved to be associated with ESCC risk [10,11], GERD symptoms show relations with short sleep duration [12]. Besides, people with short sleep duration may spend more time on working and experience higher stress in life, which will weaken one's immune state. It is complex to explain this phenomenon, and further researches are needed.

Disrupted breathing during sleep would cause sleep disturbance and intermittent hypoxemia. Sleep disturbance could diminish immune function and stimulate the secretion of inflammatory cytokines, and thus increase gastro-esophageal reflux and the risk of cancers [17,38]. Intermittent hypoxemia showed tight associations with high levels of interleukin-6 (IL-6) and tumor necrosis factor-α (TNF-α), and could activate inflammatory signal pathways [40,41]. Therefore, intermittent hypoxemia might play important roles in inflammatory process initiation. In animal models, intermittent hypoxemia could promote tumor growth [42,43]. As described, snoring was the main symptom of OSA and could act as the surrogate of SDB. However, there are insufficient clinical researches on the correlation of snoring and site-specific cancers.

Zhang et al reported a positive association between colorectal cancer risk and snoring [7]. In the current study, regular snoring was clearly related to high ESCC risk independently. Individuals with regular snoring displayed an approximately 2.63-folds ESCC risk than those with no snoring, after adjusting for BMI. The results were positive in both genders, and it appeared that the impacts of snoring were stronger in women. Previous studies

demonstrated that snoring and OSA were associated with GERD [44,45], which may help to explain our findings partially.

Considering the possible protective values of high BMI and the relationship between sleep duration and overweight in our study, we further conducted the risk estimate according to BMI (as Table 4 showed). The same trends existed for short sleep duration and snoring on ESCC risk when BMI<25.0 kg/m^2. Interestingly, we found that the impacts of short sleep duration and regular snoring on increasing ESCC risk were completely or partially diminished in subjects with BMI ≥25.0 kg/m^2.

Our findings suggested that BMI ≥25.0 kg/m^2 might be a protective factor for ESCC, which was consistent with previous studies. Two meta-analyses showed the protective roles of increasing BMI in ESCC development [26,35]. Lindkvist et al conducted a large prospective study observing a significant inverse dose-response association between BMI and ESCC risk [25]. They found that the relative risk (RR) was 0.67 for BMI 25-29.9 kg/m^2 and 0.47 for BMI ≥30 kg/m^2 when the reference was BMI 18.5-24.9 kg/m^2. Furthermore, this study demonstrated that the significant association between high BMI and reduced ESCC risk existed in current smokers. This might explain why overweight showed protective values in men but not in women considering that the proportion of current smokers in men (43.9%) was much higher than that in women (9.7%) in our study. Additionally, people with high BMI tended to uptake more nutrients and own better nutritional status, which were closely related to ESCC incidence [3,46]. Together, our results indicated that the impacts of short sleep and snoring on ESCC risk were stronger in non-overweight subjects than in overweight subjects. The underlying mechanisms are unclear, and need to be explored further.

In line with previous studies, both smoking and drinking [47], as well as special dietary habits [48,49], were demonstrated to increase ESCC risk. Relationship between drinking and the risk of ESCC was not observed in women, and we have doubt about this result due to the small sample of women.

Strengths of our study include the gender- and age-matched healthy controls at an approximately 1:1 ratio with ESCC patients. And participants were invited from five hospitals in both northern and southern cities of China. Moreover, we firstly explored the impacts of sleep duration and snoring in esophageal cancer and obtained a substantial amount of data revealing their associations with ESCC risk. Some limitations exist in the study. Firstly, it is a retrospective study and the objective measurements of snoring and sleep duration were not obtained, which may influence the information accuracy and cause misclassification. Secondly, this cohort enrolled a relatively small number of participants, but our major results were significant and in agreement with the overall analysis. Thirdly, sleep duration is different everyday, which may render biases. Fourthly, other potential confounding factors such as sleep quality were not included fully. Larger prospective studies are needed to confirm our results.

Conclusion

In conclusion, the current study reveals that in both genders, short sleep duration and regular snoring are associated with increased risk of ESCC, even when BMI is adjusted for. And the risk of ESCC attributable to short sleep duration and snoring can be completely or partially attenuated in subjects with BMI ≥25.0 kg/m^2, respectively. The results provide more indicative evidence implying that sleep duration and snoring can be important factors for ESCC risk which need to be changed or treated for cancer prevention.

Abbreviations

EC: esophageal cancer; ESCC: esophageal squamous cell carcinoma; GERD: gastroesophageal reflux disease; OSA: obstructive sleep apnea; SDB: sleep disordered breathing; BMI: body mass index; WHO: World Health Organization; ORs: odds ratios; AOR: adjusted OR; CIs: confidence intervals; IL-6: interleukin-6; TNF-α: tumor necrosis factor-α; RR: relative risk.

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Authors' contributions

Pengxiang Chen, Qingxu Song and Yufeng Cheng designed the study; Pengxiang Chen, Tong Chen, Jinxiu Jiang, Xiaoli Zhang and Jiaqi Xu performed the study and collected the information; Pengxiang Chen, Cong Wang and Jianfeng Cui analyzed the data; Pengxiang Chen drafted the manuscript firstly; Cong Wang and Yufeng Cheng

revised the manuscript. All authors contributed to the study, and they had reviewed and approved the manuscript.

Competing Interests

The authors have declared that no competing interest exists.

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