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Original Article

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Relationship between Obstructive Sleep Apnea and Self-assessed Oral Health Status: An Internet Survey

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Abstract

The purpose of this study based on a cross-sectional internet survey was to investigate the relationship between risk of obstructive sleep apnea (OSA) and self-assessed oral health status. The participants, who comprised individuals registered with an online research company, were required to complete a self-reported questionnaire. Those answering in the affirmative to both of the following two questions were placed in the OSA-risk group, while those answering in the negative were assigned to the control group: 'Have other people noticed pauses in your breathing while you are sleeping?' and 'Do you feel excessively sleepy during the daytime?'. A total of 493 were included in the OSA-risk group and 2,560 in the control group. Among the total 3,053 respondents, the highest prevalence for OSA risk in men was in the 50–59-year age range, although this tended to level off after age 60 years. No such trend was observed in women, however. Multiple logistic regression analysis was performed to identify the relationship between risk of OSA and self-assessed oral health status. Significant correlations were observed with the following parameters: difficulty in opening mouth (odds ratio [OR]: 2.66; 95% confidence interval [CI]: 1.647–4.311), dry mouth (OR: 2.11; CI: 1.544–2.876), bad breath (OR: 1.69; CI: 1.309–2.186), gingival bleeding (OR: 1.48; CI: 1.134–1.932), and gingival swelling (OR: 1.44; CI: 1.046–1.981). These results suggest a relationship between risk of OSA and self-assessed oral health status, indicating that treating OSA might improve oral health status. Further study is needed to demonstrate a causal relationship between OSA and self-assessed oral health status, however.

Key words: Obstructive sleep apnea — Oral health — Sleep disorders — Internet survey

Introduction

According to the American Academy of Sleep Medicine, sleep disorders, which are becoming increasingly common, fall into seven diagnostic categories: insomnia, sleep-related breathing disorders, central disorders of hypersomnolence, circadian rhythm sleep-disorders, parasomnias, sleep-related movement disorders, and other sleep disorders (International Classification of Sleep Disorders-3)[16].

Obstructive sleep apnea (OSA) is characterized by recurrent episodes of complete or partial obstruction of the upper airway during sleep, and has been reported to be associated with increased likelihood of motor vehicle accidents, decreased quality of life, hypertension, insulin resistance, and cardiovascular disease[2,10,11,14,21]. In addition, aging, male gender, smoking, and obesity have been identified as risk factors for OSA, all factors which are also relatively common in periodontitis[1,6,18,22]. A number of studies have investigated the relationship between OSA and periodontitis[4,12,17]. However, few reports have discussed the relationship between OSA and other oral health variables.

Our hypothesis was that there was an association between OSA and oral health status. If confirmed, this might suggests ways in which to improve preventive dental care and treatment in such patients.

The purpose of the present study was to investigate the relationship between risk of OSA and self-assessed oral health status *via* an internet survey.

Materials and Methods

1. Participants

The internet survey was conducted in Japan between February and March 2015. Participants were selected from among individuals registered with an online research company, Macromill (http://www.macromill.com/global/index.html). The respondents were required to complete a questionnaire after they had agreed to participate in the online survey. The total number of valid respondents was 5,820. An affirmative answer to both of the following two questions mean the respondent would be categorized as at risk of OSA: 'Have other people noticed pauses in your breathing while you are sleeping?' and 'Do you feel excessively sleepy during the daytime?'. A negative answer placed the respondent in the control group. Any other response meant exclusion from the analysis. Various parameters were compared between the two groups of respondents. In the final analysis, the OSA-risk group comprised 493 individuals and the control group 2,560, making a total of 3,053.

2. Questionnaire items

The respondents were required to complete a self-reported questionnaire. The following items associated with risk of OSA were selected after referring to the Epworth Sleepiness Scale[5]: 'Have other people noticed pauses in your breathing while you are sleeping?' and 'Do you feel excessively sleepy during the daytime?'. The answers were categorized as affirmative or negative ('Yes' or 'No'). The following items addressed additional factors reported to be associated with OSA[10,14,21,23]: height and weight ('How tall are you?' and 'How much do you weigh?'); body mass index (BMI), calculated and categorized as <18.5, 18.5–25, or $\geq 25\,kg/m^2$; hypertension status (yes or no); and smoking history, in which the Brinkman Index (BI) score was calculated by the number of cigarettes smoked per day multiplied by number of smoking years and categorized as <200, ≥ 200, or non-smoker[3,20]. With regard to self-assessed oral health status, questions were also asked regarding the presence or absence of the following symptoms: gingival bleeding, gingival swelling, dry mouth, bad breath, difficulty in opening mouth, and tooth mobility.

3. Analysis

First, a chi-squared test (or Fisher's exact test in cases where there were fewer than five cells in the contingency table) was used to determine which respondent characteristics were associated with risk of OSA. Multiple

logistic regression analysis was then performed with risk of OSA as the dependent variable and other factors selected to adjust for possible confounders. Sex, age, BMI, BI score, hypertension, and self-assessed oral health status were used as independent variables. The multiple logistic regression analyses were developed using a forced entry method.

The data were analyzed using the computerized statistical package SPSS, version 22.0 (SPSS Japan Inc., Tokyo, Japan). Significance was set at a level of 5%. This study was approved by the Ethics Committee of Tokyo Dental College (Approval number: 602).

Results

The distribution of the 3,053 respondents based on sex and age are shown in Fig.1. In men, the highest prevalence for risk of OSA was in the 50–59-year age range, although it tended to level off after age 60 years. No such trend was observed in women, however.

The characteristics of the participants at risk of OSA are shown in Table 1. Significant differences in age ($p<0.001$), BMI ($p<0.001$), hypertension ($p<0.001$), BI score ($p<0.001$), gingival bleeding ($p<0.001$), gingival swelling ($p<0.001$), dry mouth ($p<0.001$), bad breath ($p<0.001$), difficulty in opening mouth ($p=0.018$), and tooth mobility ($p=0.002$) were observed between the groups.

Table 2 shows the results of the multiple logistic regression analysis with the prevalence of OSA risk as the dependent variable. The results from five models are presented: the first included only the self-assessed oral health status of the respondents; the second adjusted for age and sex; the third controlled for BMI; the fourth controlled for BI score; and the fifth controlled for hypertension. In the second model, significant differences were found in all self-assessed oral health status components, with the exception of tooth mobility. The odds ratio (OR) remained essentially unchanged after adjustment for BMI, BI score, and hypertension. In the fifth model, the highest OR was observed for difficulty in opening mouth (OR: 2.66; confidence interval [CI]: 1.647–4.311), followed by dry mouth (OR: 2.11; CI: 1.544–2.876), bad breath (OR: 1.69; CI: 1.309–2.186), gingival bleeding (OR: 1.48; CI: 1.134–1.932) and gingival swelling (OR: 1.44; CI: 1.046–1.981).

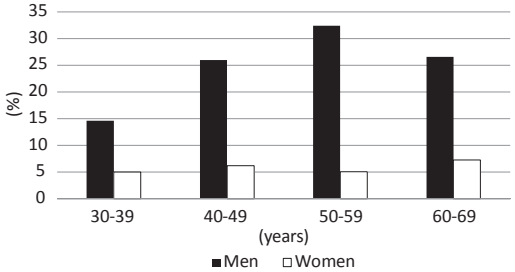

Fig. 1 Frequency of risk of obstructive sleep apnea by age and sex

Discussion

The results of the present study revealed that self-assessed oral health status was associated with risk of OSA, as significant correlations were observed in every model, even after adjusting for possible confounding variables. The prevalence of risk of OSA was highest in men aged 50–59 years. Lee *et al.* reported that the prevalence of risk of OSA was greater in men than in women, also noting that it tended to level off after age 65 years[10]. These trends were also observed in the present study.

Several studies have indicated a relationship between self-assessed oral health status and OSA. One prospective cohort study of adults aged 18–44 years found that OSA symptoms preceded the initial onset of temporomandibular disorders (TMDs) based on an affirmative response to 'Difficulty in opening mouth'[15]. In the present study, the same relationship was observed between risk of OSA and TMDs. In addition, other studies have observed a tendency towards mouth breathing in patients with OSA[9,13], suggesting that the TM joint (TMJ) is under a high load in

Table 1 Distribution of factors associated with risk of obstructive sleep apnea

			At risk of obstructive sleep apnea		
		n_1	n_2	%	p-value
Sex	Men	1,651	413	25	<0.001
	Women	1,402	80	5.7	
Age group (years)	30–39	815	80	9.8	<0.001
	40–49	849	144	17	
	50–59	850	168	19.8	
	60–69	539	101	18.7	
Body Mass Index	<18.5	290	12	4.1	<0.001
	18.5–25	2,128	267	12.5	
	≥25	635	214	33.7	
Hypertension	Yes	433	146	33.7	<0.001
	No	2,620	347	13.2	
Brinkman index score	Non-smorkers	1,473	150	10.2	<0.001
	<200	569	85	14.9	
	≥200	1,011	258	25.5	
Gingival bleeding	Yes	544	139	25.6	<0.001
	No	2,509	354	14.1	
Gingival swelling	Yes	341	89	26.1	<0.001
	No	2,712	404	14.9	
Dry mouth	Yes	335	96	28.7	<0.001
	No	2,718	397	14.6	
Bad breath	Yes	594	153	25.8	<0.001
	No	2,459	340	13.8	
Difficulty in opening mouth	Yes	140	33	23.6	0.018
	No	2,913	460	15.8	
Tooth mobility	Yes	134	35	26.1	0.002
	No	2,919	458	15.7	

n_1: total number of participants for each item, n_2: number of participants at risk of sleep disorders

such cases. This suggests that decreasing load on the TMJ during sleep might be effective in treating patients with OSA.

Mouth breathing can cause dry mouth. The present study revealed a relationship between dry mouth and risk of OSA. In addition, it has been reported that low salivary flow influences bad breath[7,8]. Therefore, drying of the mouth during sleep may be associated with bad breath. Moreover, Tsuda *et al.* showed that 30% patients with OSA using continuous positive airway pressure to treat OSA complained of bad breath[19]. This suggests the need to treat dry mouth in patients at risk of OSA.

Several studies have reported an association between periodontitis and OSA[4,12,17]. Moreover, Seo *et al.* reported that OSA patients who complained of excessive mouth breathing were at a higher risk of developing periodontal disease than those who did not. Mouth breathing has also been associated with periodontitis[17]. Similarly, periodontitis based on affirmative responses to 'gingival bleeding' and 'gingival swelling' was significantly associated with risk of OSA. Drying of the saliva leads to bacterial colonization and the binding of bacterial cells to tissue sur-

Table 2 Results of adjusted odds ratio for risk of obstructive sleep apnea

		①Self-assessed oral health status			② ①＋Age and sex			③ ②＋Body Mass Index			④ ③＋Brinkman Index			⑤ ④＋Hypertension		
		OR	CI	p-value	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value	OR	CI	p-value
Gingival bleeding	No	1			1			1			1			1		
	Yes	1.667	1.312–2.117	<0.001	1.551	1.200–2.005	0.001	1.507	1.157–1.962	0.002	1.514	1.163–1.972	0.002	1.48	1.134–1.932	0.004
Gingival swelling	No	1			1			1			1			1		
	Yes	1.388	1.042–1.850	0.025	1.456	1.068–1.983	0.017	1.487	1.084–2.040	0.014	1.459	1.062–2.002	0.02	1.44	1.046–1.981	0.025
Dry mouth	No	1			1			1			1			1		
	Yes	1.803	1.369–2.374	<0.001	2.136	1.581–2.887	<0.001	2.141	1.573–2.915	<0.001	2.159	1.585–2.941	<0.001	2.107	1.544–2.876	<0.001
Bad breath	No	1			1			1			1			1		
	Yes	1.686	1.339–2.123	<0.001	1.813	1.415–2.325	<0.001	1.762	1.366–2.273	<0.001	1.733	1.342–2.236	<0.001	1.692	1.309–2.186	<0.001
Difficulty in opening mouth	No	1			1			1			1			1		
	Yes	1.282	0.842–1.951	0.247	2.425	1.522–3.863	<0.001	2.681	1.664–4.318	<0.001	2.645	1.639–4.267	<0.001	2.664	1.647–4.311	<0.001
Tooth mobility	No	1			1			1			1			1		
	Yes	1.406	0.926–2.135	0.110	1.08	0.689–1.691	0.737	1.108	0.701–1.750	0.66	1.076	0.680–1.703	0.755	1.109	0.700–1.759	0.659

OR: Odds ratio, CI: Confidence interval

faces[6]. Therefore, drying of the mouth may be associated with periodontitis in individuals at risk of OSA.

The results of the present study were based on a large-scale, self-reported internet survey. However, the present study had several limitations. First, the survey was a self-reported questionnaire; therefore, the answers for each question may have contained incorrect information. Second, internet surveys can be a source of selection bias. Third, not all of the items contained in the Epworth Sleepiness Scale were included as it was feared that this might discourage participation. Fourth, no questions were asked regarding other possible causes of mouth breathing, such as allergic rhinitis, which again may have confounded the results. Finally, this was a cross-sectional study. Therefore, further research is required to demonstrate a causal relationship between OSA and oral health status.

In conclusion, the present study revealed associations between risk of OSA and self-assessed oral health status. The findings indicate that treating OSA may improve oral health status. However, further research is needed to establish a causal relationship between OSA and oral health.

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