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Prevalence and Related Factors for High-Risk of Obstructive Sleep Apnea in a Large Korean Population: Results of a Questionnaire-Based Study

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Background and Purpose A population-based door-to-door study of cross-sectional methods for assessing the prevalence and factors related to a high risk of obstructive sleep apnea (OSA) was conducted using the Korean version of the Berlin Questionnaire (K-BQ).

Methods Pooled data collected from Community Health Surveys by the Korea Center for Disease Control and Prevention were analyzed. Of 8,140 respondents from the population, 7,955 were finally included in this study.

Results Of the 7,955 included subjects, 15.7% of the men and 9.8% of the women were at high risk of OSA. Significant differences were found in the following factors between the subjects with a high risk of OSA: gender, age, marital status, educational level, occupation, and presence of smoking, harmful alcohol use, and chronic diseases. Male sex, harmful alcohol use, and the presence of chronic diseases were identified as factors independently associated with a high risk of OSA.

Conclusions This is the first study to confirm the usefulness of the K-BQ to study the prevalence of OSA in the Korean general population. The findings demonstrate that harmful alcohol use and chronic diseases are very common characteristics among those with a high risk of OSA.

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Key Words Berlin Questionnaire, obstructive sleep apnea, epidemiology, questionnaire-based study, general population.

Introduction

Obstructive sleep apnea (OSA) is a common disease characterized by repetitive episodes of airflow cessation or airflow reduction that occur during sleep as a consequence of collapse of the upper airway.¹ It is an important medical condition that causes excessive daytime sleepiness, snoring, and nocturnal hypoxemia during sleep,² and is strongly associat-

ed with hypertension, glucose intolerance, cardiovascular disorders, and cerebrovascular disorders.³⁻⁶ One epidemiologic study that used polysomnography (PSG) to establish the prevalence of sleep-disordered breathing (SDB) and OSA in Korea found that the prevalence of SDB was 27% in men and 16% in women,⁷ and was similar to that of other countries.^{8,9} PSG is generally considered a gold-standard diagnostic tool for the evaluation of OSA. However, it has been utilized in a very limited manner in population-based epidemiologic studies because it is an expensive and time-consuming method.

The Berlin Questionnaire (BQ) was first introduced in 1996 at the Conference on Sleep in Primary Care in Berlin, Germany. It was validated as a means of identifying patients with

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a high risk of OSA,^{10,11} and comprises three categories: snoring, wake-time sleepiness or tiredness, and the presence of obesity or hypertension.¹¹ The BQ has been used in screening for OSA and in epidemiologic studies, and is known to be a convenient and inexpensive tool.¹²⁻¹⁴ The usefulness of the Korean version of the BQ (K-BQ) as a screening tool for OSA has been confirmed in one study; it enables the prioritization of subjects with a high risk of OSA in the Korea general population.¹⁵

To the best of our knowledge, no previous studies have used the BQ to establish the prevalence of OSA in a Korean population. The purpose of this study was therefore to estimate the prevalence of OSA using the K-BQ and to determine the factors related to a high risk of OSA in a Korean population.

Methods

Study sample

Pooled data collected from Community Health Surveys conducted by the Korea Center for Disease Control and Prevention and the public health centers of ten counties in the Gyeongnam province of Korea in 2011 were analyzed in this study. The target area of this study was the west area of Gyeongnam province, consisting of two urban communities and seven rural communities. The community health survey was conducted by a randomized sampling method of adults aged 19 years or older living in each area. The participants were 8,140 community-dwelling adults age ≥ 19 years; of these, 185 participants who did not provide the complete information were excluded, thus ultimately 7955 participants were included. Informed consent to participate was obtained from all subjects. The study was approved by the Institutional Review Board of Kyungpook National University Hospital.

Measures

The participants were interviewed in their homes by trained interviewers using a closed-ended, structured questionnaire. The interviews typically lasted 45 minutes. If the participant was absent from home, the interviewer revisited on at least three other occasions at different times of the day. The questionnaires consisted of queries regarding sociodemographic characteristics, health behavior, presence of chronic diseases, and work, and the K-BQ.¹⁵

Demographic data (e.g., age, sex, and marital status) and socioeconomic measures (education and occupation) were analyzed. The participants were grouped according to age, as follows: 19-44, 45-64, 65-75, and >75 years. Marital status was divided into three groups: single, married, and divorced/separated/widowed. Education was classified into five groups: no education, elementary school, middle school, high school,

and above high school. The interview collected detailed occupational information, including job title, duration of employment, and working schedules. Occupation was categorized to six subtypes according to the sixth version of the Korea Standard Classification of Occupation (KSCO).¹⁶ The KSCO is a tool for organizing jobs into a clearly defined set of groups according to the tasks and duties undertaken in the job to earn money (economic activities). Participants were divided into four self-reported occupational groups based on the KSCO: farmers, white-collar workers, blue-collar workers, and others. Blue-collar workers included craft and related-trades workers, plant/machine operators and assemblers, and elementary occupations, while white-collar workers included legislators, senior officials and managers, professionals, technicians and associated professionals, clerks, service workers, and sales staff. Shift work was defined to refer in general to a way of organizing daily working hours in which different persons or teams work in succession to cover more than the usual 8-hour working day, up to and including the entire 24 hours.

Smoking, alcohol, and exercise were surveyed as living habits and health behavior. Being a smoker was defined as smoking currently and having smoked at least 100 cigarettes. The Alcohol Use Disorders Identification Test (AUDIT) was used to identify persons with hazardous and harmful patterns of alcohol consumption.¹⁷ The AUDIT was developed by the World Health Organization (WHO) as a simple method of screening for excessive drinking and to assist in brief assessments,¹⁷ and it comprises ten questions about recent alcohol use, alcohol-dependence symptoms, and alcohol-related symptoms. Subjects score their responses to the ten questions on a scale from 0 to 4, and a total score of ≥ 8 is considered to indicate hazardous and harmful alcohol use, as well as possible alcohol dependence. Physical exercise was assessed by asking the participants how many days per week they did each of the following activities for at least 30 minutes at a time during the past year: walking, hiking, bicycling, aerobics or calisthenics, swimming, water aerobics, weight training or stretching, or other exercise. The frequency of exercise was calculated according to the number of times per week that participants engaged in any of these forms of exercise. The subjects were then divided into two groups: exercise and non-exercise. Participants who regularly engaged in physical exercise more than five times per week were placed into the exercise group; all others were assigned to the nonexercise group.

The presence of chronic diseases was ascertained using the lead-in statement: "We are interested in chronic diseases that have lasted or are expected to last 6 months or longer and that have been diagnosed by a health professional." Individual chronic diseases were selected based on a priori interest in

the snorer's health and by surveying a sufficient number of cases; these included hypertension, diabetes mellitus, and musculoskeletal diseases (osteoarthritis, rheumatoid arthritis, osteoporosis, fibromyalgia, and back pain).

The BQ contains three categories:

1. Category 1 addresses snoring and witnessed apnea. Subjects were asked to score their snoring.

2. Category 2 investigates daytime fatigue and sleepiness during daily activities.

3. Category 3 focuses on the history of high blood pressure or a high body mass index (BMI).

Categories 1 and 2 were assumed to be positive if the total score was ≥ 2 . Category 3 was considered positive if the subject had hypertension or a BMI of ≥ 30 kg/m². Accordingly, subjects were stratified as "high risk" if they had two or more categories with positive scores.¹¹ The validated K-BQ was used in this study.¹⁵ Each patient's risk profile for OSA was calculated by following all of the original BQ instructions except for BMI,¹¹ because the WHO Western Pacific Regional

Office proposed modified BMI cutoff values of 23 kg/m² and 25 kg/m² to define being overweight and obese, respectively, in Asian populations; the latter modified cutoff point for BMI (≥ 25 kg/m²) was implemented in category 3.¹⁸

Statistical analyses

All statistical analyses were conducted with SPSS for Windows (version 12, SPSS, 2005). Comparison between the groups was achieved using the *t* test for continuous variables and the chi-square test for discrete variables. Logistic regression models were applied to identify the overall and independent clinical determinants in relation to high risk of OSA. Multiple logistic and regression analyses were conducted to evaluate the factors influencing the probability of a high risk of OSA.

Results

Of the 8140 respondents from the target population, 7955

Table 1. Demographic information and socioeconomic measures of the participants ($n=7955$) and comparison of these characteristics with the high-risk group for obstructive sleep apnea (OSA), as assessed using the Korean version of the Berlin Questionnaire (K-BQ)

Variable	Number	High risk of OSA		<i>p</i> *
		Number	(%)	
Gender				
Male	3559	558	15.7	
Female	4396	431	9.8	<0.001
Age (years)				
19–44	2165	193	8.9	
45–64	3057	414	13.5	
65–75	1768	289	16.3	
>75	965	92	9.5	<0.001
Marital status				
Not married	650	43	6.6	
Married/living as married	5468	718	13.1	
Divorced/separated/widowed	1837	225	12.2	<0.001
Educational level				
None	1795	222	12.4	
Elementary school	1883	289	15.3	
Middle school	1093	140	12.8	
High school	2028	225	11.1	
Above high school	1156	113	9.8	<0.001
Occupation				
White collar	955	102	10.7	
Blue collar	1059	142	13.4	
Farmer	2243	311	13.9	
Others	3698	434	11.7	0.023
Shift work				
Yes	522	62	11.9	
No	7433	927	12.5	0.691
Total	7955	989	12.4	

*Analysis by chi-square test.

Table 2. Distribution of responses by risk group (i.e., high and low risks of OSA)

Question	Low risk of OSA	High risk of OSA	p*
	Number (%)	Number (%)	
A) Category 1			
Has your weight changed in the last 5 years?			
Increased	88 (1.3)	52 (5.3)	<0.001
Decreased	301 (4.3)	166 (16.8)	
No change	6571 (94.4)	771 (78.0)	
Do you snore?			<0.001
Yes	1603 (23.0)	929 (93.9)	
No	4793 (68.8)	54 (5.5)	
Do not know	570 (8.2)	6 (0.6)	
Snoring loudness			<0.001
As loud as breathing	448 (28.0)	125 (13.5)	
As loud as talking	893 (55.7)	376 (40.5)	
Louder than talking	189 (11.8)	295 (31.8)	
Very loud	72 (4.5)	133 (14.3)	
How often do you snore?			<0.001
Almost every day	199 (12.4)	380 (40.9)	
3–4 times/week	224 (14.0)	326 (35.1)	
1–2 times/week	604 (37.7)	140 (15.1)	
1–2 times/month	565 (35.3)	83 (8.9)	
Never or almost never	10 (0.6)	0 (0.0)	
Has your snoring ever bothered other people?			<0.001
Yes	271 (16.9)	425 (45.7)	
No	1332 (83.1)	504 (54.3)	
Has anyone noticed that you stop breathing during your sleep?			<0.001
Almost every day	23 (1.4)	76 (8.2)	
3–4 times/week	23 (1.4)	97 (10.4)	
1–2 times/week	110 (6.9)	94 (10.1)	
1–2 times/month	825 (51.5)	402 (43.3)	
Never or almost never	621 (38.8)	260 (28.0)	
B) Category 2			
How often do you feel tired or fatigued after sleeping?			<0.001
Almost every day	184 (2.6)	271 (27.4)	
3–4 times/week	143 (2.1)	262 (26.5)	
1–2 times/week	474 (6.8)	144 (14.6)	
1–2 times/month	1062 (15.3)	230 (23.3)	
Never or almost never	5096 (73.2)	82 (8.3)	
During your waking time, do you feel tired, fatigued, or not up to par?			<0.001
Almost every day	137 (2.0)	251 (25.4)	
3–4 times/week	145 (2.1)	277 (28.0)	
1–2 times/week	555 (8.0)	173 (17.5)	
1–2 times/month	1014 (14.6)	207 (20.9)	
Never or almost never	5108 (73.4)	81 (8.2)	
Have you ever nodded off or fallen asleep while driving a vehicle?			<0.001
Yes	158 (2.3)	174 (17.6)	
No	6808 (97.7)	815 (82.4)	
If yes, how often has this occurred?			<0.001
Almost every day	3 (1.9)	35 (20.1)	
3–4 times/week	24 (15.2)	64 (36.8)	

Table 2. Continued

Question	Low risk of OSA	High risk of OSA	p*
	Number (%)	Number (%)	
1–2 times/week	59 (37.3)	63 (36.2)	
1–2 times/month	72 (45.6)	12 (6.9)	
C) Category 3			
Do you have high blood pressure?			<0.001
Yes	1157 (16.6)	462 (46.7)	
No	5809 (83.4)	527 (53.3)	

*Analysis by chi-square test.

OSA: obstructive sleep apnea.

Table 3. Living habits, health behavior, and chronic diseases of the participants (n=7955) and comparison of these characteristics with the high-risk group for OSA

Variable	Number	High risk of OSA		p*
		Number	(%)	
Living habits & health behavior				
Smoking				
Yes	1774	267	15.1	
No	6181	722	11.7	0.001†
Harmful alcohol use				
Yes	1454	265	18.2	
No	6501	724	11.1	<0.001‡
Physical exercise				
Nonexercise	6403	777	12.1	
Exercise	1552	212	13.7	0.102§
Chronic diseases				
Musculoskeletal diseases				
Yes	2025	316	15.6	
No	5930	673	11.3	<0.001¶
Diabetes mellitus				
Yes	572	141	24.7	
No	7383	848	11.5	<0.001¶
Hypertension				
Yes	1619	462	28.5	
No	6336	527	8.3	<0.001¶

*Analysis by chi-square test, †Significantly different from nonsmokers, ‡Significantly different from those with normal alcohol use, §Not significantly different from those with exercise, ¶Significantly different from those with no chronic diseases.

OSA: obstructive sleep apnea.

(age 55 ± 16 years, mean \pm SD) were ultimately included in this study. Of these, 3559 (44.7%) were men and 4396 (55.3%) were women, aged 55 ± 16 years and 56 ± 16 years, respectively. The demographic information (e.g., age, sex, and marital status) and socioeconomic measures (education and occupation) of the 7955 subjects are given in Table 1. The participants were classified according to the risk categorization yielded by the BQ. Of the entire study population, 989 (12.4%) were categorized as having a high risk of OSA. In addition, the demographic information and socioeconomic measures were compared among those with a high risk of OSA by BQ (Table 1). Significant differences were found between members of the high-OSA-risk group when they were further

stratified according to gender, age, marital status, educational level, and occupation. However, the type of work schedule (i.e., shift vs. nonshift) was not a significant factor for a high risk of OSA.

The distribution of responses according to OSA risk group (i.e., high vs. low) is given in Table 2. Snoring was present in 929 (93.9%) of those with a high risk of OSA. Among these 929 snoring participants, 428 (46.1%) reported that their snoring was louder than normal speech, 706 (76.0%) reported snoring at least 3 times per week, and 425 (45.7%) reported that their snoring bothered other people. In 173 (18.6%) respondents, breathing pauses during sleep were observed by others more than 3 times per week, 533 (53.9%) stated that

Table 4. Factors related to a high risk of OSA

Factor	Unadjusted			Adjusted*		
	OR	95% CI		OR	95% CI	
		Lower	Upper		Lower	Upper
Sex (male/female)	1.711 [†]	1.496	1.957	1.810 [†]	1.502	2.182
Age (reference value, 19–44 years)						
45–64 years	1.600 [†]	1.336	1.917	0.991	0.791	1.243
65–74 years	1.996 [†]	1.643	2.424	0.947	0.713	1.257
≥75 years	1.077	0.830	1.398	0.457 [†]	0.320	0.651
Educational level (reference value, none)						
Elementary school	1.283 [†]	1.063	1.549	1.103	0.888	1.370
Middle school	1.040	0.829	1.304	0.945	0.717	1.246
High school	0.883	0.725	1.076	0.907	0.684	1.202
Above high school	0.767 [†]	0.603	0.974	0.892	0.627	1.268
Occupation (reference value, others)						
White collar	0.899	0.716	1.130	1.103	0.838	1.452
Blue collar	1.165	0.951	1.427	1.198	0.954	1.505
Farmer	1.211 [†]	1.036	1.415	1.046	0.877	1.247
Shift work (yes/no)	0.946	0.719	1.244	1.022	0.762	1.371
Living habits & health behavior						
Smoking status (yes/no)	1.340 [†]	1.151	1.559	1.081	0.901	1.297
Harmful alcohol use (yes/no)	1.778 [†]	1.525	2.074	1.566 [†]	1.302	1.884
Exercise (yes/no)	1.146	0.973	1.349	1.130	0.947	1.348
Chronic diseases						
Musculoskeletal diseases (yes/no)	1.444 [†]	1.250	1.669	1.411 [†]	1.185	1.681
Diabetes mellitus (yes/no)	2.521 [†]	2.058	3.089	1.615 [†]	1.292	2.017
Hypertension (yes/no)	4.401 [†]	3.827	5.063	4.941 [†]	4.200	5.812

*Analysis by logistic regression model (adjusted for the other variables), [†] $p < 0.001$, [‡] $p < 0.05$.
OR: odds ratio, CI: confidence interval.

they did not feel rested after a night's sleep at least 3 times per week, and 528 (53.4%) reported that they experienced wake-time tiredness or fatigue at least 3–4 times per week. Nodding off or falling asleep while driving was reported by 174 respondents (17.6%); of these, 99 (56.9%) reported that they nodded off at the wheel at least 3 times per week. Hypertension was present in 462 (46.7%) of the snoring participants. There were significant differences between the high- and low-OSA-risk groups for all questions.

Comparisons of living habits, health behavior, and the presence of chronic diseases among those with a high risk of OSA revealed significant differences for the presence of smoking, harmful alcohol use, and chronic diseases (Table 3). The amount of physical exercise did not differ significantly between the high- and low-risk groups. Multiple logistic regression analysis was performed to identify which factors were independently related to a high risk of OSA. Table 4 lists the odds ratios and 95% confidence intervals for a high risk of OSA in relation to sex, age, educational level, occupation, living habits, health behavior, and presence of chronic diseases. Adjusted analyses revealed that male sex, harmful alcohol use,

and presence of chronic disease were associated with a high risk of OSA.

Discussion

This is the first report on the prevalence of individuals with a high risk of OSA in a large Korean population using the K-BQ, which is a widely used, simple, and validated tool for the prediction of the risk of sleep apnea.¹¹ In the present study the estimated prevalence of individuals with a high risk of OSA was 12.4%, which is lower than that found in a US-population-based study presented by The National Sleep Foundation poll, also using the BQ,¹³ but higher than that reported for a Persian population.¹⁴ The former was based on telephone interviews of a representative sample of US adults.¹³ Furthermore, the present study included many more participants than these two previous studies,^{13,14} and its dropout rate was quite low because the participants were interviewed using a door-to-door method and revisited on up to at least three more occasions if they were absent at the first visit. The population sample in this study should be representative of the entire

Korean total population because of the randomized selection design.

A well-designed and extensive prevalence study of SDB in Korea⁷ investigated a random sample of 457 men and women among a total of 5,020 adults aged 40–69 years via full overnight PSG in order to determine the prevalence of SDB [defined as an apnea-hypopnea index (AHI) of ≥ 5]; this was found to be 27% in men and 16% in women. The survey in the present study was conducted using a standardized and random sampling method of adults aged ≥ 19 years. The prevalence of a high risk of OSA was 15.7% for the men and 9.8% for the women. A previous study revealed that high-risk grouping based on the K-BQ predicted on AHI ≥ 5 had a sensitivity of 0.69 and a specificity of 0.83.¹⁵ Given the sensitivity of the K-BQ, the prevalence of a high risk of OSA found in the present study is similar to that obtained previously in Korea.⁷ These results demonstrate the usefulness of the K-BQ for studying the prevalence of OSA in the general population.

The overall and independent clinical determinants in relation to a high risk of OSA were also examined in this study. It is well known that the prevalence of OSA varies with gender.¹⁹ As in a previous study,²⁰ the frequency of a high risk of OSA in the present study was significantly higher in men. In the present study the K-BQ-based frequency of subjects with a high risk of OSA tended to increase with age in those younger than 75 years; this finding has also been reported elsewhere.²¹ Age-related differences in the prevalence of a high risk of OSA may be attributable to the prevalence of snoring, which is age-dependent. Interestingly, the risk of OSA appeared to decline in those older than 75 years. Some previous work^{19,22} has indicated that the risk of sleep apnea increases linearly with aging, but other studies^{23,24} have demonstrated a decline after midlife. The inclusion of fewer subjects aged >75 years in the present study could have been responsible for the bell-shaped relationship between age and a high risk of sleep apnea. Although there were significant differences in educational level and occupation among the subjects for high risk of OSA (according to the chi-square test), that significance disappeared after adjusting for confounding factors. There was a tendency for highly educated people and white-collar workers in the community to have lower frequency of OSA. A similar association between educational level and OSA was also found in a previous study.¹⁴ Furthermore, another study found no association between occupational factors and SDB.²⁵ It has also been reported that nighttime work or night-shift work may worsen the OSA index.^{26,27} This could be expected, but no such relationship was found in the present study; however, this finding may be attributable to the small number of subjects in shift work.

Population-based cross-sectional epidemiologic studies

have not consistently demonstrated significant associations between self-reported typical alcohol consumption and OSA, with some finding significant associations with OSA²⁸ but others failing to demonstrate any associations.^{7,29,30} Some studies demonstrated an independent association between sleep apnea and hypertension.^{7,31} Moreover, it was reported that the presence of diabetes was associated with a high risk of OSA.¹³ Several studies have shown an association between OSA and musculoskeletal diseases such as arthritis, fibromyalgia, and back pain.^{32–34} The correlation between OSA and musculoskeletal diseases may be due to disruption in slow-wave sleep, resulting in unrefreshing sleep, diffuse musculoskeletal pain, and fatigue.³⁴ There is also a relationship between osteoporosis and OSA. Hypoxia, inflammation, and oxidative stress, which are well-known pathophysiological features of OSA, are known to affect bone metabolism and may be considered risk factors for osteoporosis.³⁵ The results of the present study also suggest that harmful alcohol use and chronic diseases such as musculoskeletal diseases, diabetes mellitus, and hypertension are associated with a high risk of OSA.

To the best of our knowledge, no previous general-population-based studies have used the K-BQ to investigate the prevalence of a high risk of OSA in Koreans. Key strengths of this study include its use of a large population-based sample, and the relatively high participation rate. However, two limitations of the study are the method used to estimate the prevalence of OSA and its questionnaire-based design. The data were collected from a large number of participants to overcome this limitation. Another limitation is that the sampling areas were not nationwide. However, the target area of this study comprised two urban communities and seven rural communities, and the survey was conducted by applying a standardized and random sampling method to adults aged ≥ 19 years. Thus, the prevalence found in this study should be representative of the general population in Korea. However, further study with nationwide sampling is also needed.

In general, the BQ is a useful screening tool for identifying those with a high risk of OSA. The findings of the present study demonstrate that this questionnaire can be useful for prevalence studies of OSA in the general population. Furthermore, it was found that harmful alcohol use and chronic diseases such as musculoskeletal diseases, diabetes mellitus, and hypertension are very common among those with a high risk of OSA, and might thus be factors associated with a high risk of OSA. Efforts to diagnose and treat effectively both the OSA itself and its related factors may thus be very important in public healthcare management.

Conflicts of Interest

The authors have no financial conflicts of interest.

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