The Prevalence of and Risk Factors for Sleep-Disordered Breathing in an Elderly Korean Population

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Key Words

Apnea/hypopnea index · Body mass index · Elderly ·
Polysomnography · Sleep-disordered breathing · Snoring

Abstract

Background: There are just a few epidemiological studies on sleep-disordered breathing (SDB) in the elderly, and the results are inconsistent. **Study Objectives:** We sought to investigate the prevalence of and risk factors for SDB in a representative elderly population with the use of attended nocturnal polysomnography (NPSG). **Methods:** Among 6,959 individuals aged ≥ 60 years living in Yongin City, Korea, 696 subjects were selected using random sampling. All the subjects were invited to visit a hospital for NPSG, and SDB was defined as an apnea-hypopnea index ≥ 15 . **Results:** Of the 696 participants investigated, 348 participants completed the sleep study and clinical evaluation. SDB was observed in 127 of the 348 participants, and the prevalence of SDB was 36.5% (52.6% in males and 26.3% in females). A body mass index ≥ 25 was associated with SDB in both male and female subjects, particularly in males, whereas snoring was independently associated with SDB in female participants only. In male participants, SDB was a significant risk factor for hypertension ($p = 0.025$). **Conclusions:** SDB was

found to be common among elderly Koreans, and it was more prevalent and severe in male than in female subjects. Health consequences of SDB in the elderly need to be further explored.

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Introduction

Sleep-disordered breathing (SDB) is a common sleep disorder [1, 2] associated with significant health problems of the cardiovascular system, cognitive function and daytime alertness [3–8]. SDB is frequently observed with aging and can result in unwanted effects on the well-being of the elderly; however, only a few studies have been carried out on the prevalence of SDB in the elderly and its risk factors, and their results are inconsistent. In the middle-aged population, SDB was defined as an apnea-hypopnea index (AHI) ≥ 5 and daytime sleepiness, and prevalence was around 4% in men and 2–3% in women [1, 9, 10]. Obesity, male gender, snoring and alcohol consumption have been identified as risk factors for SDB in middle-aged subjects [11–13]. On the other hand, the prevalence of SDB in the elderly, defined as AHI ≥ 15 or 20, ranged from 13.3 to 57% [13–16], and controversies re-

garding risk factors for SDB in the elderly, such as body weight, male gender and snoring, still remain.

Previous studies on the prevalence of SDB in the elderly have several limitations. Although they were the first to report the prevalence of SDB in a representative sample of elderly subjects, Ancoli-Israel et al. [14] did not measure oxygen saturation and determine arousals, but evaluated respiratory events only from airflow. In other studies with a two-stage design, a small proportion of the original samples participated in the second stage of the study [15, 17–19]. Young et al. [13] reported that snoring and witnessed apnea were not useful for screening SDB in the elderly, and so selecting subjects on the basis of snoring might not be appropriate for the elderly population. Using home-based polysomnography (PSG) was another limitation in the evaluation of SDB [13, 16], as there are some discrepancies between AHI determined by home-based and attended laboratory PSG, particularly in severe SDB [20, 21].

Thus, we need to perform a prevalence study on SDB in the elderly overcoming the limitations of previous studies. The purpose of this study was to investigate the prevalence of SDB and its related factors in the elderly Korean population. For this purpose, elderly people randomly selected from the community were evaluated during attended full-night PSG in a one-stage design.

Materials and Methods

Study Subjects

This study was part of the Korean Longitudinal Study on Cognitive Aging and Dementia, a population-based prospective cohort study of cognitive function with aging and dementia in the Korean elderly population aged ≥ 60 years. We conducted the study from January 2010 to February 2011 on old adults living in Jukjeon-dong, a district of Yongin City, Korea. Among the 6,959 residents of Jukjeon-dong aged ≥ 60 years, 10% ($n = 696$) were randomly selected based on the residential roster. As we expected the prevalence of elderly SDB to be 30–40% in the Korean elderly population, the calculated sample size was 323–369 at the precision of 0.05 [22]. Thus, the sample size of 696 with the expected response rate of 50–60% could represent the elderly Korean population. All the subjects were invited to visit the Seoul National University Bundang Hospital for clinical evaluation and nocturnal PSG (NPSG). This study was approved by our institutional review board, and all subjects who had clinical evaluations provided written informed consent themselves or via their legal guardians.

Clinical Evaluation

Anthropometric evaluation included height, weight, and neck, waist and hip circumferences. Snoring and witnessed apnea events were assessed by the STOP questionnaire [23], which includes the following two questions: ‘Do you snore loudly (louder than talking or loud enough to be heard through closed doors)?’ and ‘Has any-

one observed you stop breathing during your sleep?’ Subjects who answered ‘yes’ to each question were regarded positive for snoring or witnessed apnea. The Pittsburgh sleep quality index (PSQI) was used to measure subjective sleep complaints, and the Epworth Sleepiness Scale (ESS) was applied to assess daytime sleepiness, which was defined as ESS score >10 . Diabetes mellitus was defined as fasting blood glucose >126 mg/dl and hypertension was defined as systolic blood pressure >140 mm Hg or diastolic blood pressure >90 mm Hg or both, or current use of antihypertensive drugs. Cardiac diseases other than hypertension included coronary artery disease, angina pectoris, congestive heart failure, cardiac tumors and other cardiac diseases. After clinical evaluation, subjects were recommended to participate in NPSG on another day.

Nocturnal Polysomnography

One night of attended PSG was done. We used Embla™ N7000 (Embla, Reykjavik, Iceland). Electroencephalography electrodes were placed at C4/A1, C3/A2, O1/A2 and O2/A1, and two electro-oculography electrodes were applied at the sides of both eyes to record horizontal and vertical eye movements. Electromyography electrodes were positioned at the submental muscles and both anterior tibialis muscles. Strain gauges were used for recording chest and abdominal respiratory movements, and nasal pressure cannulas were employed to record airflow. Oxygen saturation was measured using a pulse oximeter applied to the index finger. Based on the criteria of Rechtschaffen and Kales [24], sleep was scored at every 30-second epoch of the NPSG. Apnea was defined as complete cessation of airflow for at least 10 s. It was further divided into obstructive, central and mixed apnea. Hypopnea was defined as a clear decrease in airflow ($>50\%$) for at least 10 s or a discernible reduction in airflow for at least 10 s associated with electroencephalographic arousal or oxygen desaturation ($\geq 4\%$) [25]. The AHI was defined as the total number of apneas and hypopneas per hour of sleep, and the oxygen desaturation index was calculated as the number of oxygen desaturations ($\geq 4\%$) per hour of sleep. The criterion for SDB was AHI ≥ 15 , and data for three AHI cutoff values (5, 15, and 30) are presented.

Statistical Analysis

Prevalence rates were calculated by gender (men/women) and age (60–64/65–69/75–89 years) strata. Standardized prevalence rates of older Koreans were estimated using a direct standardization method in which the prevalence rates were adjusted by age and gender to the total Korean population based on the 2011 national census. Comparison between groups was done with the independent *t* tests for continuous variables and Pearson’s χ^2 test for discrete variables. Multiple logistic regression analysis for SDB was employed with gender, age, body mass index (BMI) and snoring being predictors. All significance tests were two sided, and $p < 0.05$ was considered statistically significant. All analyses were done with SPSS version 18.0 for Windows (SPSS Inc., Chicago, Ill., USA).

Results

Of the 696 subjects, 466 participated in the clinical evaluation and 354 of them underwent NPSG. Of the 354 participants, 6 subjects were excluded from analysis be-

cause of insufficient sleep time (total sleep time <180 min). Thus, 348 subjects were analyzed, and the final response rate was 50.0%. Comparing the 348 study subjects with the 348 subjects without NPSG, no difference was observed in the gender ratio ($p = 0.943$), but the latter were older than the study subjects (71.6 ± 8.7 vs. 68.4 ± 6.2 years, $p < 0.001$). Among subjects who underwent clinical evaluation, NPSG participants were younger (68.3 ± 5.6 vs. 71.3 ± 7.5 years, $p < 0.01$), and reported a higher frequency of witnessed apneic events during sleep (14.1 vs. 5.0% , $p < 0.01$) and PSQI score (6.6 ± 3.7 vs. 6.3 ± 3.0 , $p < 0.05$) than non-NPSG participants. However, the percentage of male participants, anthropometric variables and ESS scores were not different between participants and non-NPSG participants. Table 1 shows characteristics of the NPSG participants and results of the sleep study. Mean (SD) age was 68.3 (5.6) years, there were more female participants (135 male and 213 female participants) and their BMI was 23.7 ± 2.7 . Among apnea episodes, most of them were obstructive or mixed apneas with the mean central apnea index being <1.

The crude prevalence of SDB in the elderly sample was 71.8, 36.5 and 15.5% at cutoff values of AHI ≥ 5 , ≥ 15 and ≥ 30 , respectively. Age-specific prevalence of SDB by the various cutoff points for AHI is presented in table 2, and there is no difference in SDB prevalence according to age at any cutoff value. The prevalence of SDB of male subjects was higher than that of female subjects at every cutoff value. The male/female ratio increases with increasing cutoff value. When the cutoff was 5, the male/female ratio was 1.24 ($p < 0.01$); at 15, it was 2.00 ($p < 0.01$), and at 30, it was 2.91 ($p < 0.01$). An age- and gender-standardized prevalence estimate of SDB in the elderly Korean population was 73.0, 38.1 and 17.2% at cutoff values of AHI ≥ 5 , ≥ 15 , and ≥ 30 , respectively.

A comparison between participants with and without SDB in both genders is presented in table 3. In both genders, the BMI was higher in subjects with SDB. Waist and neck circumferences, and the waist/hip ratio were only larger in males with SDB. Snoring was reported more often in females with SDB. In the male group, there were more subjects with hypertension in those with SDB after controlling for age and obesity. Diabetes mellitus occurred twice as often among SDB participants, although it was not statistically significant after controlling for obesity. No difference was observed in daytime sleepiness or prevalence of dyslipidemia and cardiac diseases other than hypertension between participants with and without SDB in both males and females. The results of multiple regression analysis are presented in table 4. Generally,

Table 1. Characteristics of the study participants (range) and results of the sleep study

Characteristics of the study participants		
Participants, n	348	–
Age, years	68.3 ± 5.6	60–88
Males, n (%)	135 (38.8)	–
BMI, kg/m ²	23.7 ± 2.7	16.0–32.2
Neck circumference, cm	37.7 ± 3.7	30–56
Waist circumference, cm	85.1 ± 8.0	66–110
Waist/hip ratio	0.90 ± 0.08	0.74–1.23
ESS	6.7 ± 4.1	0–20
PSQI	6.6 ± 3.7	1–18
Findings of the sleep study		
Total sleep time, min	374 ± 67	195–518
Sleep efficiency, %	76.9 ± 13.4	38.0–96.5
Stage 1 sleep, %	13.8 ± 7.3	2.8–58.7
Stage 2 sleep, %	46.2 ± 11.6	10.9–81.1
Stage 3–4 sleep, %	6.6 ± 2.8	0.0–25.9
REM sleep, %	15.0 ± 5.8	0.0–32.5
AHI	15.1 ± 14.6	0.0–83.5
Obstructive apnea index	5.7 ± 8.2	0.0–74.8
Central apnea index	0.6 ± 2.0	0.0–26.2
Mixed apnea index	0.7 ± 2.8	0.0–34.8
Lowest O ₂ saturation, %	86.0 ± 5.6	55.0–95.0
Time with O ₂ saturation <90%, %	1.5 ± 4.3	0.0–53.0
Oxygen desaturation index	10.9 ± 12.8	0.0–96.6

male gender and BMI were significant risk factors for SDB. BMI ≥ 25 was associated with SDB in both males and females, with obesity having more impact on males than females (odds ratio: 8.82 vs. 2.54). In females, snoring was significantly related to SDB. Age was not a significant risk factor in any model.

Discussion

The estimated prevalence of SDB in the elderly Korean population was 73.0, 38.1 and 17.2% at the different AHI cutoff values (≥ 5 , ≥ 15 and ≥ 30 , respectively). These values exceed the results of other studies [13, 15, 19] apart from the report of Ancoli-Israel et al. [14] and the more recent study by Sforza et al. [16]. The high SDB prevalence in our study might be explained in several ways. First, we employed a nasal pressure transducer as a sensor for monitoring respiratory events whereas previous studies used thermistors [13, 15, 17]. Nasal pressure transducers are known to be more sensitive to detect respiratory events, especially hypopnea. Thus, nasal pressure transducers detect 15–95% more respiratory events than thermistors [26–29]. Secondly, we used a broader defini-

Table 2. Age-specific prevalence of SDB using various cutoff points for AHI

	Participants, n	Prevalence, % (95% confidence interval)		
		AHI ≥5	AHI ≥15	AHI ≥30
Men				
60–64 years	36	69.4 (54.4–84.5)	38.9 (23.0–54.8)	19.4 (6.5–32.4)
65–69 years	74	87.8 (80.4–95.3)	59.5 (48.3–70.7)	25.7 (15.7–35.6)
75–89 years	25	80.0 (64.3–95.7)	52.0 (32.4–71.6)	36.0 (17.2–54.8)
Total	135	81.5 (74.9–88.0)	52.6 (44.2–61.0)	25.9 (18.5–33.3)
p value		0.065	0.128	0.348
Women				
60–64 years	64	62.5 (50.6–74.4)	25.0 (14.4–35.6)	4.7 (–0.5–9.9)
65–69 years	122	65.6 (57.1–74.0)	25.4 (17.7–33.1)	9.0 (3.9–14.1)
75–89 years	27	74.1 (57.5–90.6)	33.3 (15.6–51.1)	18.5 (3.9–33.2)
Total	213	65.7 (59.4–72.1)	26.3 (20.4–32.2)	8.9 (5.1–12.8)
p value		0.568	0.672	0.107

Statistical analysis by χ^2 test for differences in SDB prevalence according to age.

Table 3. Comparison of males/females with and without SDB

	Male		Female	
	AHI <15	AHI ≥ 15	AHI <15	AHI ≥ 15
Subjects, n	64	71	157	56
Age, years	68.3 $\pm$ 5.6	69.2 $\pm$ 5.9	67.9 $\pm$ 6.0	68.5 $\pm$ 5.3
AHI per hour of sleep ^{a, b}	6.9 $\pm$ 3.9	33.2 $\pm$ 14.2	5.8 $\pm$ 4.1	27.7 $\pm$ 10.9
BMI (kg/m ²) ^{a, b}	22.8 $\pm$ 2.4	24.6 $\pm$ 2.6	23.5 $\pm$ 2.5	24.4 $\pm$ 3.2
Neck circumference, cm ^a	39.4 $\pm$ 2.9	40.8 $\pm$ 3.3	35.9 $\pm$ 3.4	36.7 $\pm$ 2.4
Waist circumference, cm ^a	84.8 $\pm$ 7.0	89.1 $\pm$ 7.4	83.2 $\pm$ 8.0	85.3 $\pm$ 8.8
Waist/hip ratio ^a	0.90 $\pm$ 0.05	0.91 $\pm$ 0.05	0.89 $\pm$ 0.10	0.90 $\pm$ 0.09
ESS	6.4 $\pm$ 3.6	7.0 $\pm$ 4.3	6.5 $\pm$ 4.2	6.0 $\pm$ 4.1
PSQI	5.6 $\pm$ 3.0	5.5 $\pm$ 3.3	7.2 $\pm$ 4.0	7.2 $\pm$ 3.8
SDB-related symptoms, n (%)				
Snoring ^b	17 (26.6%)	27 (38.0%)	28 (17.8%)	24 (42.9%)
Daytime sleepiness	8 (12.5%)	16 (22.5%)	27 (17.2%)	12 (21.4%)
Witnessed apneic events	15 (23.4%)	17 (23.9%)	11 (7.0%)	6 (10.9%)
Comorbidities ^c				
Hypertension ^a	21 (33.9%)	39 (55.7%)	72 (46.5%)	31 (55.4%)
Diabetes	7 (10.9%)	17 (24.6%)	24 (25.1%)	6 (35.3%)
Dyslipidemia	28 (43.8%)	38 (53.55%)	73 (46.5%)	26 (46.4%)
Cardiac diseases	8 (12.5%)	7 (9.9%)	21 (13.4%)	4 (7.1%)

Daytime sleepiness is defined as ESS >10. Cardiac diseases include coronary artery disease, angina pectoris, congestive heart failure, cardiac tumors and other cardiac diseases.

^a $p < 0.05$ (males). ^b $p < 0.05$ (females). ^c Presence of comorbidities was analyzed by multiple logistic regression with age and obesity as covariates. $p = 0.025$ (hypertension in males).

tion of hypopnea than previous studies. In this study, hypopnea was defined as a clear decrease in airflow (>50%) for at least 10 s or a discernible reduction in airflow for at least 10 s associated with oxygen desaturation ($\geq 4\%$) or arousals, whereas other studies counted respiratory

events as hypopnea only when they were accompanied by a $\geq 4\%$ decrease in oxygen. Thirdly, subjects with sleep-related breathing difficulties might more willingly participate in this study than subjects without them. This explanation could be supported by the finding that more

Table 4. Odds ratios (95% confidence intervals) of clinical variables for SDB estimated by multiple logistic regression models

	Total	Male	Female
Gender (male vs. female)	3.54 (2.16–5.83)		
Age (vs. 60–64 years)			
65–74 years	1.32 (0.75–2.32)	2.17 (0.89–5.32)	0.82 (0.39–1.72)
75–89 years	1.51 (0.71–3.20)	1.74 (0.55–5.53)	1.11 (0.39–3.13)
BMI (kg/m ²) (vs. <23.0)			
23.0–24.9	1.08 (0.59–1.97)	0.92 (0.40–2.10)	1.53 (0.66–3.55)
≥25.0	3.28 (1.84–5.84)	8.42 (2.77–25.64)	2.26 (1.07–4.78)
Snoring (snorers vs. nonsnorers)	2.29 (1.36–3.86)	1.67 (0.72–3.85)	3.22 (1.61–6.44)

witnessed apneic events were reported in NPSG participants than in non-NPSG participants. In addition, elderly people prefer home-based study to visiting laboratories because of their physical conditions and reluctance to sleep in uncomfortable environments. On the other hand, for the high SDB prevalence of 57% in the study by Sforza et al. [16], they explained that the use of ambulatory polygraphy might result in overestimation of apneas and hypopneas by including respiratory events during wakefulness.

In this study, SDB was more prevalent among males. The male/female ratio was 2.00 when SDB was defined as AHI ≥15, 2.91 for AHI ≥30 and 1.24 for AHI ≥5. The increase in the male/female ratio with increasing AHI cut-off value was also observed in previous studies in both middle-aged and elderly subjects [13, 18]. Thus, considering the relationship between cardiovascular and neurobehavioral complications of SDB and the severity of SDB, male gender is a significant risk factor both for more severe SDB and its adverse effects. Several other risk factors for SDB are known in the middle-aged population, such as age, obesity and snoring. Among these risk factors, we found an association between obesity and SDB in both males and females, but snoring was independently associated with SDB in females only. A high BMI had more impact on males than females regarding the occurrence of SDB: the adjusted odds ratio of BMI ≥25.0 for SDB was 8.42 in males and 2.26 in females. The stronger relationship between BMI and SDB in men is anticipated from findings of previous studies. Men are more prone to develop SDB at the same BMI than women, because of differences in the fat distribution between the genders, i.e. more fat accumulation in the upper body, including the tongue, in men than in women [30]. Jordan et al. [31] suggested that female gender alone was protective against SDB, i.e. female gender was equivalent to a 11.7 kg/m²

BMI decrease. In addition, a 5-year longitudinal cohort study reported that the relationship between weight changes and an increase or decrease in SDB was more prominent in men than in women [32]. Unexpectedly, snoring was a risk factor for SDB in women only in this study. However, Young et al. [13] reported a decrease in the dose-response association between snoring frequency and SDB in men compared to women, suggesting that men may overreport snoring. Thus, gender differences in the relationship between snoring and SDB need to be further explored.

The finding that the prevalence of SDB was not increased in our participants >60 years was consistent with results from previous studies. In most studies exploring the relationship between age and prevalence of SDB, SDB prevalence increased with age up to 60 or 65 years and thereafter it plateaus [13, 15, 18]. The higher SDB prevalence in the elderly compared with middle-aged subjects may be explained by a tendency to increased upper airway collapse, which might be partly due to lengthening of the soft palate and upper airway fat pad deposition [33]. These age-related upper airway changes may not progress further after 60 years of age, resulting in a minor increase in SDB prevalence in those >60 years.

There have been some controversies regarding cardiovascular morbidity and mortality of SDB in the elderly. In studies on the association of elderly SDB and hypertension, hypoxemia [5] and the respiratory disturbance index [34] were found to be related with the prevalence of hypertension, but the association was weaker than in middle-aged subjects. In a separate analysis by gender, we found that hypertension was more prevalent in male subjects with than without SDB, whereas the prevalence of hypertension was not dependent on the presence of SDB in female subjects. This finding is in contrast to the study by Sforza et al. [16], in which hypertension was associated

with SDB in females. The discrepancies between these two studies may be explained by much lower number of females with SDB compared to females without SDB in our study, and more risk factors for hypertension, such as high BMI, diabetes and smoking, in female SDB subjects of their study than in our study.

No difference was observed in daytime sleepiness between participants with and without SDB in our study. Daytime sleepiness was found to be less prevalent with age in the general population [35, 36], and a weaker or no association between SDB and daytime sleepiness has been reported in the elderly compared to the middle-aged population [37, 38]. Several studies still showed that SDB could be a major risk factor for daytime sleepiness in the elderly [39, 40], but the results need to be interpreted with caution. In the report by Endeshaw [39], a significant association between SDB and daytime sleepiness was observed only in women, and a much higher proportion of elderly subjects with excessive daytime sleepiness was included in the study of Pack et al. [40] than in this study. In summary, SDB might have no demonstrable impacts on daytime sleepiness in community-dwelling elderly, but SDB should be considered in elderly subjects with excessive daytime sleepiness.

This study has several limitations. First, the response rate of 50% was not high. Inviting elderly subjects to a sleep clinic for overnight PSG might decrease participation rate, considering difficulties in the elderly such as gait disturbances, reluctance to sleep in an unfamiliar environment and avoidance of sleeping with PSG equipment attached. Using portable monitoring might increase response rate, but it could be also meaningful to use stan-

dard attended PSG for more detailed examination of SDB. Second, the possibility cannot be excluded that more elderly subjects with than without sleep problems participated in the study, resulting in relatively high prevalence of SDB. However, this selection problem is somewhat expected in studies asking participants to spend time and to tolerate discomfort. Third, to improve response rate, all of the subjects were recruited from a relatively small area located near the hospital, and this recruitment method may compromise the representativeness of the subjects of this study. Future studies should include a larger sample from an area with a larger population. Nevertheless, this study tried to overcome limitations of previous epidemiological studies. SDB was quite prevalent among our elderly population, and hypertension was associated with SDB in males. Further studies on cardiovascular and neurobehavioral consequences of elderly SDB might be needed to prevent adverse effects of SDB in the elderly.

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Financial Disclosure and Conflicts of Interest

The authors have no conflict of interest to declare in relation to this work.

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