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# Sleep Quality of Morbidly Obese Patients After Bariatric Surgery

**Yoonhong Kim**[1], **Ae Ri Yang**[2], **Kwangwook Koh**[3,4], **Kyung Won Seo**[1], **Ki Hyun Kim**[1]

[1]Department of Surgery, Kosin University, College of Medicine, Busan, Korea
[2]Department of Nursing, Kosin University Gospel Hospital, Busan, Korea
[3]Department of Healthcare Administration, Graduate School of Public Health, Kosin University, Busan, Korea
[4]Department of Preventive Medicine, College of Medicine, Kosin University, Busan, Korea



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**Corresponding author:**
**Ki Hyun Kim**
Department of Surgery, Kosin University, College of Medicine, 262 Gamcheon-ro, Seo-gu, Busan 49267, Korea.
Tel: +82-51-990-6782
Fax: +82-51-246-6093
Email: linus.kkh@gmail.com



**ORCID iDs**
Yoonhong Kim
https://orcid.org/0000-0003-1611-5390
Ae Ri Yang
https://orcid.org/0009-0007-9484-1255
Kwangwook Koh
https://orcid.org/0000-0002-3897-4359
Kyung Won Seo
https://orcid.org/0000-0002-5771-3832
Ki Hyun Kim
https://orcid.org/0000-0002-8296-3307

## ABSTRACT

**Purpose:** Obesity is a major risk factor for obstructive sleep apnea (OSA), associated with conditions like type 2 diabetes, hypertension, stroke, cancer, and premature death. OSA involves sleep-breathing interruptions, with over 60% of obese individuals diagnosed through polysomnography. This study explores sleep issues in individuals considering bariatric surgery.
**Materials and Methods:** We retrospectively analyzed sleep study records and questionnaires of 137 obese patients undergoing metabolic surgery at Kosin University Gospel Hospital between January 1, 2019, and September 30, 2022. Statistical tests, including Student's t-test and logistic regression, assessed subjective and objective characteristics.
**Results:** Most subjects, predominantly female with comorbidities, exhibited poor sleep quality. Positive correlations between polysomnography and subjective evaluation indicated poor results. Logistic regression revealed increased OSA likelihood with higher Apnea–Hypopnea Index, with associations to sex, age, and body mass index (BMI).
**Conclusion:** Regardless of BMI, most patients with a BMI ≥30 kg/m$^2$ undergoing bariatric surgery were diagnosed with OSA, experiencing poor subjective and objective sleep quality. Correlations between subjective and objective evaluations were significant, with sex, advanced age, and high BMI identified as significant OSA risk factors.

**Keywords:** Bariatric surgery; Morbid obesity; Polysomnography; Obstructive sleep apnea; Sleep questionnaire

## INTRODUCTION

Obesity is a significant global health issue with approximately 650 million people worldwide having an excessive accumulation of fat compared to normal [1]. Obesity is a risk factor for various chronic diseases, including type 2 diabetes, hypertension, stroke, and cancer, and it can also lead to premature death and disability [2]. According to data analysis from the Global Burden of Disease Study, the worldwide prevalence of obesity, defined by a body mass index (BMI) of ≥30 kg/m$^2$, has steadily increased from 7% in 1980 to 12.5% in 2015 [3].

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**Conflict of Interest**

None of the authors have any conflict of interest.

**Author Contributions**

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In South Korea, based on an analysis of data from the 2013–2014 National Health and Nutrition Examination Survey, the prevalence of grade 2 obesity, defined by a BMI of ≥30 kg/m$^2$, was 5.3% in men and 4.3% in women, respectively [4].

Obesity and obstructive sleep apnea (OSA) are closely related. OSA is a condition in which breathing temporarily stops or becomes shallow during sleep, leading to reductions in the quantity and quality of sleep and symptoms such as fatigue and daytime drowsiness. OSA can lead to serious complications, such as acute respiratory distress syndrome and heart failure, and may even become a cause of death. Obesity is one of the major risk factors for the development of OSA. Obesity causes changes in the structure and function of the respiratory system, particularly by increasing fat in the upper airway, leading to narrowing problems in the upper airway. Furthermore, obesity induces abnormal constriction of upper airway muscles during sleep, further promoting breathing interruptions. Therefore, sleep disorders like OSA are common in obese patients, and the risk of OSA in obese patients is greater than that in non-obese individuals [5].

This study sought to examine the quality of sleep in individuals considering bariatric surgery, assess the severity and types of sleep problems, and understand the relationship between sleep issues and obesity. Through this, we intend to establish effective intervention plans for improving sleep and to provide the fundamental data necessary for developing intervention plans to enhance sleep quality.

## MATERIALS AND METHODS

### 1. Research design

This study was a retrospective research investigation aimed at assessing the quality of sleep in individuals who were candidates for bariatric surgery. Prior to the commencement of this study, approval for exemption from consent was obtained from the Ethics Review Committee of Kosin University Gospel Hospital, to ensure the anonymity of the subjects, and the study was conducted in accordance with the approved research plan (Institutional Review Board approval No. 2022-11-004).

### 2. Study population

We retrospectively analyzed the medical records, including polysomnography reports, sleep study questionnaires, and other medical record information, of 137 patients who underwent bariatric surgery at Kosin University Gospel Hospital Department of Surgery from January 1, 2019 to September 30, 2022.

### 3. Research tools

*1) General characteristics and disease-related characteristics*

General characteristics were assessed using a basic information questionnaire, while disease-related characteristics were obtained from medical records and medical history information sheets.

*2) Sleep quality assessment tools*

(1) Korean version of the Pittsburgh Sleep Quality Index (K-PSQI)

The PSQI, a widely used measure of sleep quality in various clinical settings, was developed by Buysse and colleagues in 1989. It is a subjective assessment tool that measures the quality of sleep in terms of quantity, depth, and peace of mind over the course of 1 month [6]. The Korean version, K-PSQI, also had the same 7 subdomain scores and total scores, and its reliability was verified with a Cronbach's α value of 0.84, demonstrating both reliability and validity [7].

(2) Korean version of the Insomnia Severity Index (ISI-K)

The ISI is a reliable scale for quantifying the perceived severity of insomnia. It is a self-report questionnaire consisting of 7 items that measure a patient's perception of insomnia within the past 2 weeks. The ISI score reflects the severity of insomnia, with higher scores indicating greater severity; a score of 0–7 points indicates "no clinically significant insomnia," that of 8–14 points corresponds to "subthreshold insomnia," that of 15–21 points represents "moderate insomnia," and that of 22–28 points indicates "severe insomnia." A threshold of ≥15 points is used to define clinically significant insomnia, and scores of <8 points are used to define remission after treatment [7].

*3) Daytime sleepiness assessment tool*

(1) Stanford Sleepiness Scale (SSS)

The SSS is a self-assessment scale that allows for a simple evaluation of the degree of sleepiness experienced in everyday life. It is particularly suitable for repeated use in research or intervention processes, such as evaluating the degree of sleepiness in individuals with sleep disorders, assessing sleepiness for driving and traffic safety, and in occupational roles like airplane pilots where monitoring sleepiness is crucial [8].

(2) Korean version of the Epworth Sleepiness Scale (KESS)

The KESS is a self-report questionnaire used to detect sleep disorders and is the Korean version of the aforementioned ESS. This tool is very useful for identifying daytime sleepiness in patients and is also used in patients with sleep-disordered breathing [9]. The validity of KESS in assessing sleep-related issues and sleepiness has been confirmed [10]. The internal consistency of KESS has been confirmed with a Cronbach's α of 0.86, indicating that it is a highly reliable tool.

*4) Depression assessment tools: Korean version of the Beck Depression Inventory, Second Edition (K-BDI-II)*

The BDI-II is a depression assessment tool used to measure the severity of depression. It is recognized worldwide as a cost-effective tool applicable in research and clinical settings [11]. In this study, the Korean version of the BDI-II was used, and it demonstrated excellent internal consistency, item homogeneity, and convergent validity. The reliability, measured by Cronbach's alpha, was 0.946, confirming its reliability and validity [12].

*5) Quality of life assessment tool: Korean version of the World Health Organization (WHO) Quality of Life-BREF (WHOQOL-BREF)*

The concept of measuring the quality of life has remained uncertain, and traditional quality of life scales have typically been evaluator-centered, mainly reflecting functional aspects. To address these issues, the WHO has defined quality of life as "an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards, and concerns." The WHO also developed a self-report assessment tool called WHOQOL [13].

*6) Polysomnography*

Polysomnography is an objective diagnostic test used to assess and accurately diagnose sleep disorders. It primarily records and analyzes various parameters during a patient's sleep cycle, including brain waves, eye movements, electromyography of the limbs and jaw, electrocardiography, chest and abdominal respiratory movements, oxygen saturation in the blood, and respiratory airflow [14,15]. It is a valuable tool for diagnosing and evaluating conditions such as snoring, OSA, insomnia, narcolepsy, periodic limb movement disorder, and abnormal sleep behaviors. For the diagnosis of the most common sleep-related breathing disorder, OSA, the diagnostic criteria proposed by the American Academy of Sleep Medicine in 1999 remain widely used. OSA is diagnosed when the Apnea–Hypopnea Index (AHI) in a polysomnography test shows more than 5 events per hour, along with the presence of 2 or more of the following symptoms: repeated awakening during daily life; episodes of choking or gasping during sleep; and persistent daytime fatigue, reduced concentration, or other related symptoms. The severity of OSA is assessed using the AHI, with an AHI of 5–15 points indicating mild, 15–30 points indicating moderate, and >30 points indicating severe OSA, respectively [16].

### 4. Statistical analysis

Statistical analysis was performed using SPSS software (version 22.0 for Windows; IBM Corporation, Armonk, NY, USA). For continuous variables, the independent Student's *t* test was used, while, for categorical variables, either the chi-squared test or Fisher's exact test was employed. Subjective and objective characteristics based on the subjects' BMI were analyzed using t-tests and analysis of variance, with post hoc tests conducted using the Tukey method. The correlation between objective and subjective indicators was assessed using the Pearson correlation coefficient. Risk analysis was conducted using binary logistic regression analysis. The goodness of fit of the regression model was verified using the Hosmer–Lemeshow test. Statistical significance was defined by P<0.05.

## RESULTS

### 1. General characteristics of the study participants

The general characteristics of the study population are as follows. A total of 137 patients were analyzed, with an average age of 38.29±10.85 years. There were 50 male patients (36.5%) and 87 female patients (63.5%). The average BMI of all patients was 40.59±7.66 kg/$m^2$. At the time of the survey, 34 patients (24.8%) were smokers, and 60 patients (43.8%) reported alcohol consumption. Ninety-four patients (68.6%) reported daily coffee consumption, while 20 patients (14.6%) reported the use of sleeping pills. Among the enrolled patients, 62 (45.3%) had comorbid hypertension, and 55 (40.1%) had type 2 diabetes. Additionally, 55 patients (40.1%) had other comorbid conditions alongside hypertension and diabetes (**Table 1**).

### 2. Comparison of patient characteristics according to WHO obesity grades

All study participants were classified into 3 groups based on the WHO obesity classification [17]. The patient groups classified by WHO obesity grade exhibited differences in age. The class 1 obesity group showed a higher age range compared to the class 3 obesity group (42.13±13.24 vs. 35.92±8.97 years, P=0.03). Among the patient groups classified by WHO obesity grade, there were differences in alcohol consumption: the class 3 obesity group had a higher proportion of alcohol consumption compared to the class 1 obesity group, and the class 2 obesity group also had a higher alcohol consumption rate compared to the class 1 obesity group (7 [22.6%] vs. 21 [45.7%] vs. 32 [53.3%], P<0.01). There were no differences in sex, smoking history, caffeine consumption, and the use of sleeping pills among the patient

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**Table 1.** Study participants' general characteristics

| Characteristics | All patients (n=137) |
|---|---|
| Age (years) | 38.29±10.85 |
| Sex | |
| Male | 50 (36.5) |
| Female | 87 (63.5) |
| BMI (kg/m$^2$) | 40.59±7.66 |
| Current smoking | 34 (24.8) |
| Alcohol use | 60 (43.8) |
| Caffeine use | 94 (68.6) |
| Hypnotics drug use | 20 (14.6) |
| History of comorbidity | |
| Hypertension | 62 (45.3) |
| DM | 55 (40.1) |
| Other diseases | 55 (40.1) |

Values are presented as mean ± standard deviation or number (%).
BMI = body mass index, DM = diabetes mellitus.

groups classified by WHO obesity grade. Similarly, there were no statistically significant differences in comorbid conditions (**Table 2**).

### 3. Subjective sleep assessment results according to WHO obesity grades

We analyzed the survey results of patients classified by WHO obesity grades. All patient groups classified by WHO obesity grades had a K-PSQI score of ≥5 points, indicating poor sleep quality (8.45±4.55 vs. 7.73±2.98 vs. 7.82±3.90 points). The ISI-K results showed no differences among the patient groups classified by WHO obesity grades, with all of them falling within the range of 7–15 points, indicating a borderline level of insomnia (12.42±7.34 vs. 11.80±6.49 vs. 10.93±6.14 points). The SSS showed that all patient groups classified by WHO obesity grades exhibited levels of "slight drowsiness" to "normal drowsiness" (2.81±0.83 vs. 2.81±0.75 vs. 2.83±0.87 points). The KESS scale indicated that the class 3 obesity group among patients classified by WHO obesity grades had persistent drowsiness of ≥10 (10.97±4.68 points). The K-BDI-II scale showed that all patient groups classified by WHO obesity grades had mild depression (19.29±9.40 vs. 17.91±9.37 vs. 19.43±10.76 points). The WHOQOL-BREF scale revealed low scores for all patient groups classified by WHO obesity grades. However, there were no statistically significant differences between the groups in the evaluation of sleep quality (K-PSQI), ISI-K, daytime sleepiness assessment

**Table 2.** Comparison of patient characteristics according to World Health Organization obesity grades

| Variables | Class 1 obesity[a] (n=31) | Class 2 obesity[b] (n=46) | Class 3 obesity[c] (n=60) | P value | Post hoc |
|---|---|---|---|---|---|
| Age (years) | 42.13±13.24 | 38.80±10.74 | 35.92±8.97 | 0.03 | a > c, b |
| Sex | | | | 0.75 | |
| Male | 10 (32.3) | 18 (39.1) | 22 (36.7) | | |
| Female | 21 (67.7) | 28 (60.9) | 38 (63.3) | | |
| BMI (kg/m$^2$) | 32.50±1.52 | 37.54±1.53 | 47.11±1.89 | <0.01 | c > b > a |
| Current smoking | 6 (19.4) | 14 (30.4) | 14 (23.3) | 0.90 | |
| Alcohol use | 7 (22.6) | 21 (45.7) | 32 (53.3) | <0.01 | c > a, b > a |
| Caffeine use | 19 (61.3) | 30 (65.2) | 45 (75.0) | 0.16 | |
| Hypnotic drug use | 7 (22.6) | 6 (13.0) | 7 (11.7) | 0.22 | |
| History of comorbidity | | | | | |
| Hypertension | 14 (45.2) | 20 (43.5) | 28 (46.7) | 0.91 | |
| DM | 16 (51.6) | 19 (41.3) | 20 (33.3) | 0.09 | |
| Other diseases | 14 (45.2) | 21 (45.7) | 20 (33.3) | 0.23 | |

Values are presented as mean ± standard deviation or number (%).
BMI = body mass index, DM = diabetes mellitus.
[a]BMI 30–34.9 kg/m$^2$ ; [b]BMI 35–39.9 kg/m$^2$ ; [c]BMI ≥40 kg/m$^2$.

**Table 3.** Subjective sleep assessment results according to World Health Organization obesity grades

| Variables | Class 1 obesity[a] (n=31) | Class 2 obesity[b] (n=46) | Class 3 obesity[c] (n=60) | P value |
|---|---|---|---|---|
| K-PSQI (points) | 8.45±4.55 | 7.73±2.98 | 7.82±3.90 | 0.68 |
| ISI-K (points) | 12.42±7.34 | 11.80±6.49 | 10.93±6.14 | 0.56 |
| SSS (points) | 2.81±0.83 | 2.81±0.75 | 2.83±0.87 | 0.35 |
| KESS (points) | 8.45±4.52 | 9.93±4.27 | 10.97±4.68 | 0.04 |
| K-BDI-II (points) | 19.29±9.40 | 17.91±9.37 | 19.43±10.76 | 0.72 |
| WHOQOL-BREF (points) | | | | |
| Physical domain | 11.39±2.99 | 11.01±2.98 | 10.61±2.89 | 0.47 |
| Psychological domain | 10.82±2.38 | 11.10±2.81 | 10.33±2.46 | 0.30 |
| Social domain | 11.40±2.98 | 12.75±3.06 | 12.58±2.48 | 0.09 |
| Environmental domain | 12.27±2.49 | 12.66±2.53 | 12.16±2.60 | 0.59 |

On the K-PSQI, ≥5 points indicates poor sleep quality. On the ISI-K, ≤7 points means no insomnia, while ≥15 points indicates the presence of insomnia. For the SSS, the specific point-in-time sleepiness measurement was taken (stage 1 is "awake," stage 2 is "slightly drowsy," stage 3 is "normal drowsiness," stage 4 is "slightly worse drowsiness," stage 5 is "strong drowsiness," stage 6 is "very strong drowsiness," and stage 7 is "uncontrollable drowsiness"). For the KESS, following daytime sleepiness measurement, if the total score is ≥10 points, there is persistent drowsiness. On the BDI-II, the higher the score, the more severe the depression (mild depression, 17 points; major depression, 23 points). On the WHOQOL-BREF, the higher the score, the better the quality of life.
K-PSQI = Korean version of the Pittsburgh Sleep Quality Index, ISI-K = Korean version of the Insomnia Severity Index, SSS = Stanford Sleepiness Scale, KESS = Korean version of the Epworth Sleepiness Scale, K-BDI-II = Korean version of the Beck Depression Inventory, Second Edition, WHOQOL-BREF = Korean version of the World Health Organization Quality of Life-BREF.
[a]Obesity Class 1: BMI of 30 to <35; [b]Obesity Class 2: BMI of 35 to <40; [c]Obesity Class 3: BMI of 40 or higher.

(SSS, KESS), anxiety assessment (K-BDI-II), and quality of life assessment (WHOQOL-BREF) based on WHO obesity grades (**Table 3**).

### 4. Objective sleep assessment results via polysomnography according to WHO obesity grades

There were no statistically significant differences among the subjects in total sleep time, sleep onset latency, REM sleep onset latency, sleep efficiency, and wake after sleep onset according to the polysomnography results. However, there were statistical differences among the subjects in terms of the AHI, minimum oxygen saturation index, and respiratory disturbance index (RDI). As body weight increased and the obesity class according to BMI became higher, the AHI also significantly increased (30.34±25.25 vs. 33.84±25.65 vs. 56.22±36.87 points, P<0.01). Additionally, class 3 obesity showed lower values in the minimum oxygen saturation index compared to class 1 and class 2 obesity (73.80±13.41 vs. 83.71±6.60 points and 73.80±13.41 vs. 81.39±6.85 points, P<0.01). In the RDI, class 3 obesity had higher values compared to class 1 and class 2 obesity (57.29±36.79 vs. 33.09±26.60 points and 57.29±36.79 vs. 35.41±25.91 points) (**Table 4**).

### 5. Correlation between objective and subjective sleep assessments according to WHO obesity grades

The results of the analysis of the relationship between objective and subjective sleep assessments in the study subjects are shown in **Table 5**. Objective sleep assessment variables, such as the AHI, which evaluates sleep quality, showed statistically significant positive

**Table 4.** Objective sleep assessment results via polysomnography according to World Health Organization obesity grades

| Variables | Class 1 obesity[a] (n=31) | Class 2 obesity[b] (n=46) | Class 3 obesity[c] (n=60) | P value | Post hoc |
|---|---|---|---|---|---|
| Total sleep time (minutes) | 276.10±49.28 | 288.75±38.72 | 282.96±42.72 | 0.45 | |
| Sleep latency (minutes) | 16.75±25.72 | 11.07±10.74 | 10.42±13.06 | 0.19 | |
| REM sleep latency (minutes) | 92.84±53.98 | 103.85±61.98 | 121.00±82.11 | 0.16 | |
| Sleep efficiency (%) | 82.94±13.41 | 85.51±9.16 | 83.84±9.57 | 0.54 | |
| WASO (%) | 12.36±10.46 | 11.26±8.32 | 13.53±9.56 | 0.47 | |
| AHI (/hour) | 30.34±25.25 | 33.84±25.65 | 56.22±36.87 | <0.01 | c > b > a |
| Lowest $SatO_2$ (%) | 83.71±6.60 | 81.39±6.85 | 73.80±13.41 | <0.01 | a > c, b > c |
| RDI (/hour) | 33.09±26.60 | 35.41±25.91 | 57.29±36.79 | <0.01 | c > a, c > b |

WASO = Wakefulness After Sleep Onset, AHI = Apnea–Hypopnea Index, RDI = respiratory disturbance index.

**Table 5.** Correlation between objective and subjective sleep assessments according to World Health Organization obesity grades

| Variables | AHI | K-PSQI | ISI-K | SSS | KESS | K-BDI-II | WHOQOL-BREF |
|---|---|---|---|---|---|---|---|
| AHI | - | 0.19 (0.03) | 0.20 (0.02) | 0.15 (0.09) | 0.29 (<0.01) | 0.19 (0.03) | −0.28 (<0.01) |

Values are presented as r (P value).
AHI = Apnea–Hypopnea Index, K-PSQI = Korean version of the Pittsburgh Sleep Quality Index, ISI-K = Korean version of the Insomnia Severity Index, SSS = Stanford Sleepiness Scale, KESS = Korean version of the Epworth Sleepiness Scale, K-BDI-II = Korean version of the Beck Depression Inventory, Second Edition, WHOQOL-BREF = Korean version of the World Health Organization Quality of Life-BREF.

**Table 6.** Percentage of patients with OSA according to World Health Organization obesity grades

| OSA severity | Class 1 obesity (n=31) | Class 2 obesity (n=46) | Class 3 obesity (n=60) |
|---|---|---|---|
| Normal (AHI < 5 points) | 4 (12.9) | 3 (6.5) | 1 (1.7) |
| Mild OSA (5 ≤ AHI < 15 points) | 4 (12.9) | 7 (15.2) | 9 (15.0) |
| Moderate OSA (15 ≤ AHI < 30 points) | 9 (29.0) | 16 (34.8) | 10 (16.7) |
| Severe OSA (AHI ≥ 30 points) | 14 (45.2) | 20 (43.5) | 40 (66.7) |

Values are presented as number (%).
OSA = obstructive sleep apnea, AHI = Apnea–Hypopnea Index.
P value=0.03.

**Table 7.** Factors affecting the diagnosis of severe obstructive sleep apnea using binary logistic regression analysis

| Independent variable | B | SE | Wald | P value | OR | 95% CI | |
|---|---|---|---|---|---|---|---|
| | | | | | | LLCI | ULCI |
| Sex (male) | 1.76 | 0.47 | 14.20 | <0.01 | 5.79 | 2.32 | 14.45 |
| Age | 0.09 | 0.02 | 15.00 | <0.01 | 1.09 | 1.04 | 1.14 |
| BMI | 0.15 | 0.04 | 17.70 | <0.01 | 1.16 | 1.08 | 1.24 |

SE = standard error, OR = odds ratio, CI = confidence interval, LLCI = lower limit confidence interval, ULCI = upper limit confidence interval, BMI = body mass index.

correlations with PSQI, ISI, and ESS (r=0.19, P=0.03; r=0.20, P=0.02; r=0.29, P<0.01). Conversely, the SSS test did not show a statistically significant correlation. Meanwhile, the BDI-II test, which evaluates anxiety, showed a statistically positive correlation (r=−0.1, P=0.03), and the WHOQOL-BREF test, which evaluates quality of life, showed a negative correlation (r=−0.28, P<0.01) (**Table 5**).

Based on the AHI, it is possible to classify patients into normal, mild, moderate, and severe OSA groups, respectively. Severe OSA was observed in 14 (45.2%) and 20 (43.5%) of patients with class 1 and class 2 obesity, respectively. Among class 3 obesity patients, 40 of them had OSA, accounting for a rate of 66.7% (**Table 6**).

### 6. Factors influencing the diagnosis of severe OSA using binary logistic regression analysis

The results of the binary logistic regression analysis to identify the factors influencing the diagnosis of severe OSA (AHI ≥30 points) are presented in **Table 7**. The regression analysis was conducted using the general characteristics of the subjects, and results indicated that the likelihood of being diagnosed with severe OSA with an AHI of ≥30 points was 5.79 times greater in men than in women. Additionally, for every 1-year increase in age, the likelihood increased by 1.04 times, and, for every one-unit increase in BMI, the likelihood increased by 1.08 times (**Table 7**).

## DISCUSSION

OSA is a common sleep disorder that affects a significant portion of the global population. It is characterized by partial (hypopnea) or complete (apnea) closure of the upper airway during sleep, leading to oxygen desaturation, increased respiratory effort, arousal, and sleep fragmentation. Patients typically experience episodes of apnea, loud intermittent snoring, and excessive daytime sleepiness. OSA is associated with reduced quality of life, cognitive impairment, and an increased risk of road traffic accidents, and it is also linked to conditions such as hypertension, coronary artery disease, stroke, heart failure, arrhythmias, metabolic syndrome, and type 2 diabetes. Obesity is a well-established major risk factor for OSA, and numerous studies have reported a strong association between obesity and OSA [18-21]. This study was conducted with patients who underwent bariatric surgery, focusing on sleep and OSA in Korean patients with a BMI of ≥30 kg/m$^2$.

In this study, the WHO obesity classification was applied, and patients with a BMI of 30–39.0 kg/m$^2$ had the characteristic of being older on average than those with a BMI of ≥40 kg/m$^2$. Typically, it is reported that BMI increases with age up to the age of 70 years [17]. However, it should be noted that the study participants in this study represent a specially selected group of patients who underwent bariatric surgery. Apart from age, there were no significant differences observed between groups in terms of sex, smoking history, caffeine consumption, and the use of sleeping pills. Additionally, the prevalence of comorbidities was similar among the groups.

In the results of the subjective sleep evaluation conducted in patient groups classified according to WHO obesity grades, the overall sleep quality and quality of life were both found to be poor. This suggests that, regardless of BMI values, all study participants experienced discomfort in terms of sleep and quality of life. In the sleep quality assessment, a score exceeding 5 points on the K-PSQI indicated poor sleep quality, and all 3 groups exhibited average scores exceeding 5 points. The ISI-K considers a score of ≥8 points as indicative of insomnia, and all 3 groups had average scores exceeding 8 points. The scales used to measure daytime sleepiness, SSS and KESS, yielded average values, and the degree of daytime sleepiness did not appear to be particularly high. Moreover, there were no significant statistical differences among the groups. The K-BDI-II test considers scores of 14–19 points as indicative of mild depression, and all 3 groups fell within this category. It can be concluded therefore that bariatric surgery patients experience mild feelings of depression. In the analysis of the WHOQOL-BREF, no significant differences were observed among the 3 groups, but, overall, they exhibited lower scores. This suggests our patients had a lower quality of life compared to bariatric surgery patients in other studies [22]. However, this is an indirect comparison, and it is considered important to evaluate quality of life after surgery in the future.

Among the objective sleep evaluation results, it was confirmed that the AHI increases with increasing BMI. This result has also been reported by other authors [23], and this study provided statistical significance to confirm this trend. Furthermore, for patients with class 3 obesity (BMI ≥40 kg/m$^2$), it was observed that their minimum oxygen saturation ($SpO_2$) was lower than that in patients with lower BMIs. This trend has been observed in other work [24] and, in this study, it was particularly prominent in patients with BMIs of ≥40 kg/m$^2$. The RDI, which represents the average number of breathing events per hour, was significantly greater in patients with BMIs of ≥40 kg/m$^2$. Generally, an RDI of ≥5 points is used to diagnose sleep apnea. The average RDI values for all 3 groups in this study were relatively high, which corresponds with findings of previous research suggesting that higher BMIs are associated with higher RDIs [25]. According to studies evaluating demographic and sleep study data, Asians with OSA exhibit more severe OSA symptoms compared to Caucasians with OSA, even when age, sex, and BMI are similar. However, recent meta-analyses have proposed that neck circumference may be a more reliable and actual risk factor for OSA in both Asian and Caucasian patients [26]. To better understand this aspect and derive conclusive results, further research is necessary.

When analyzing the correlation between the objective and subjective sleep evaluation factors examined earlier, the items assessing sleep quality, such as PSQI and ISI, showed a positive correlation with AHI. However, the scales assessing daytime sleepiness, SSS and ESS, revealed only ESS to have a positive correlation. BDI-II, evaluating depression, also displayed a positive correlation, while WHOQOL-BREF, assessing quality of life, showed a negative correlation. In summary, when patients exhibit OSA, it implies a greater likelihood of having issues related to sleep quality, depression, and quality of life.

We could also observe differences in the severity of OSA among different BMI groups. Patients with higher BMIs tended to show a higher frequency of OSA with an AHI of ≥5 points. Particularly, in patients with BMIs of ≥40 kg/m$^2$, there was a 66.7% prevalence of severe OSA with an AHI of ≥30 points. The risk factors for such severe OSA were confirmed through binary logistic regression analysis. In the case of men, the odds ratio was 5.79, indicating a high likelihood, and it was found that, for each additional year of age, there was a 1.04-fold increase in odds, while, for each additional unit of BMI, there was a 1.08-fold increase in odds. Recent meta-analysis studies have also identified significant risk factors contributing to OSA, such as age of >35 years, BMI of >25 kg/m$^2$, and alcohol consumption [27].

As the severity of OSA increases, the risk of coronary artery disease, heart failure, cardiac arrest, and stroke also grows. Therefore, identifying risk factors for severe OSA, such as in the case of class 3 obesity patients, holds clinical significance. Recent meta-analysis studies have investigated important risk factors contributing to OSA, including age of >35 years, BMI of >25 kg/m$^2$, and alcohol consumption.

The limitations of this study include its retrospective nature and use of data from a single institution, which might introduce selection bias in patient composition. However, having focused on patients with BMIs of ≥30 kg/m$^2$ in Korea, this study provides unique insights into the characteristics of sleep apnea in patients undergoing bariatric surgery. If more extensive data from a larger patient population or prospective data collection can be secured in the future, this limitation can be addressed. We are preparing for additional cohort enrollment and analysis, intending to scrutinize observations both before and after surgery. Through further analysis, we aim to review areas requiring effective intervention plans.

## CONCLUSION

It has been confirmed that the majority of patients with BMIs of ≥30 kg/m$^2$ who undergo bariatric surgery in Korea exhibit OSA. Furthermore, the subjective symptoms reported by patients indicated poor sleep quality in all patients, while objective findings evaluated through sleep polysomnography showed a relatively higher AHI in patients with BMIs of ≥40 kg/m$^2$. Significant correlations were observed between subjective and objective symptoms, confirming that patients' symptoms accurately reflected the presence of OSA. Risk factors for severe OSA include sex, older age, and higher BMI. These results provide insights into the prevalence and risk factors for OSA in patients with BMIs of ≥30 kg/m$^2$ who underwent bariatric surgery.

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