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Relationship between various anthropometric measures and apnea-hypopnea index in Korean men☆

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ABSTRACT

Objective: Body mass index (BMI) has been shown to be strongly correlated with severity of OSA. However, BMI has not been shown to be correlated with sleep apnea in all patients studied. The purpose of this study was to evaluate the relationship between various anthropometric measures and severity of OSA according to BMI in men.

Methods: We conducted a retrospective analysis of the medical records of patients who visited for evaluation of OSA. Polysomnography results, height, weight, neck circumference, waist circumference, and hip circumference were obtained in all subjects. BMI, body adiposity index, waist to hip ratio, and waist to height ratio were also calculated.

Results: A total of 195 male participants were included in the final analysis. BMI showed the strongest correlation with AHI in all subjects. In 125 participants with a BMI of 25 or more, BMI was most strongly correlated with high AHI compared to other measurements. However, waist to hip ratio showed the strongest correlation with AHI in 70 participants with a BMI of less than 25 and, in this group, BMI did not show significant correlation with AHI.

Conclusion: Considerations about anthropometric measurements in OSA patients should differ according to degree of obesity or BMI.

1. Introduction

Obstructive sleep apnea (OSA) is known to be a common cause of chronic health problems such as hypertension and cardiovascular disease, and is associated with high morbidity and, possibly, high mortality [1]. OSA is a common disorder found in approximately 24% and 9% of middle-aged men and women, respectively [2]. Several studies have previously been conducted into various factors related to OSA, including sex, obesity, and narrowing of the upper airway [3]. The strong association between obesity and OSA is well known. The prevalence of OSA among obese patients is thought to be as high as 50–98%, and many studies have indicated that weight gain is associated with an increased risk of developing OSA and exacerbation of OSA symptoms, whereas weight reduction has been shown to improve symptoms [4]. Therefore, the evaluation and proper control of obesity is key to the prevention of OSA.

Various measurement tools, including body mass index (BMI), body adiposity index (BAI), neck circumference (NC), and waist circumference (WC) have been used to evaluate obesity. Among the various anthropometric measurements of obesity, BMI is the most commonly used, and there have been numerous reports that high BMI is a risk factor of OSA.

☆ The institutional review board of Severance Hospital approved this study.

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However, there exist OSA patients with a BMI of less than 25 (lower than the threshold for clinical obesity or overweight). Furthermore, BMI may not be precisely representative of obesity in some cases. For example, athletes who have elevated lean body mass due to increased muscle mass might have a higher BMI [5]. Also, previous studies have shown that the association between BMI and OSA differs by ethnicity, and previous studies have been focused to Western population [6]. It is not clear which of the various anthropometric measurements show the strongest correlation with severity of OSA in East Asian population.

In this study, we evaluated the correlation between various anthropometric measurements and severity of OSA according to degree of obesity in men.

2. Materials and methods

We reviewed the clinical data of OSA patients who visited the otorhinolaryngology department at Severance Hospital, Seoul, Korea, between January 2010 and December 2011. During that period, a total of 393 patients visited our hospital for suspected sleep apnea. Among them, 371 were men and 22 were women, and 91 patients refused further evaluation including polysomnography. Number of women subjects was too small to analyze the effect of sex. Therefore, we excluded women and also subjects aged less than 18 years. Among the 302 patients who underwent polysomnography, 195 male patients were included in the study. The institutional review board of Severance Hospital approved this study.

2.1. Polysomnography

An overnight in-lab diagnostic polysomnography (PSG) (Comet-PLUS®XL, Grass Technologies, Warwick, RI, USA) was performed for all participants. PSG included a recording electroencephalogram, electrooculogram, submental electromyogram, bilateral anterior tibialis electromyogram, electrocardiogram, chest and abdominal wall movement measurement by inductance plethysmography, and airflow measurement by a nasal pressure transducer. The equipment was supplemented with an oral thermistor and finger pulse oximeter. PSG scoring was performed according to internationally agreed criteria [7]. Briefly, apnea was defined as a cessation of nasal flow lasting 10 s or longer. Hypopnea was defined as a 30% decrease in nasal flow lasting at least 10 s or a discernible decrease leading to an at least 3% oxygen desaturation or electroencephalographic arousal [7]. Apnea hypopnea index (AHI) was the number of apneas and hypopneas per hour.

2.2. Anthropometric measure

Anthropometric measurements were taken by a qualified sleep technician on the night of the PSG and included: height, weight, NC, WC, and hip circumference (HC). Height was measured with the subject standing without shoes and weight was measured with the subject wearing light clothes. NC was measured at the level of the cricothyroid membrane in an upright position. WC was from midway between the lower rib and anterior superior iliac spine in a standing position at the end of expiration. HC was measured at the maximum circumference of the buttocks with the subject in an upright position.

Waist to hip ratio (WHR), waist to height ratio (WHtR), BMI, and BAI were calculated using the following formulae:

WHtR = WC (cm)/height (m).

WHR = WC (cm)/HC (cm) × 100

BMI = weight (kg)/height^2 (m^2)

BAI = HC (cm)/height (m) $\sqrt{\text{height(m)}} - 18$ [5]

The BMI cut-off points of $\geq$25 kg/m^2 for overweight and $\geq$30 kg/m^2 for obesity were used [8].

2.3. Statistical analysis

Statistical analyses were performed using SPSS 17.0 software (SPSS Inc., Chicago, IL, U.S.A.). We tested the normality of the distribution of the variables using the Kolmogorov–Smirnov test. AHI, BMI, height, weight, WC, WHtR, and BAI all were all normally distributed, whereas NC, HC, and WHR were not. Therefore, we used non-parametric analytic methods in this study. A Mann–Whitney test was performed to compare median values of variables between groups. Spearman's correlation test was used to analyze the correlation between the various variables and AHI.

3. Results

Demographic data on all 195 participants are shown in Table 1. When we compared the median values of variables between the group with a BMI of less than 25 and the group with a BMI of 25 or more, the latter showed significantly higher values for BMI, BAI, NC, WC, HC, AHI, WHR, and WHtR (Table 2). Median age did not differ between the 2 groups.

We tested the correlation between AHI and anthropometric variables using Spearman's correlation test (Table 3). When all participants were included in the analysis, all variables were significantly correlated with AHI. Among these, BMI had the highest correlation coefficient (Spearman's rho (R) = 0.465, $p < 0.001$). NC showed the least significant correlation with AHI compared with other variables (R = 0.252, $p < 0.001$). In

Table 1
Demographic data of study participants.

	Mean ± SD
Age (years)	47.9 ± 11.9
Height (cm)	172.4 ± 5.3
Weight (Kg)	78.8 ± 10.8
BMI (kg/m2)	26.5 ± 3.2
BAI	25.7 ± 2.8
Neck circumference (cm)	40.1 ± 4.5
Waist circumference (cm)	92.5 ± 9.9
Hip circumference (cm)	98.9 ± 6.1
AHI	47.9 ± 22.9
Waist to hip ratio	94.4 ± 7.0
Waist to height ratio	53.7 ± 5.7

BMI: body mass index, BAI: body adiposity index, AHI: apnea hypopnea index.
SD: standard deviation.

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