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Research Article

# Metabolic Syndrome in South Korean Patients with Chronic Obstructive Pulmonary Disease: A Focus on Gender Differences

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ABSTRACT

*Purpose:* This study investigated the relationship between chronic obstructive pulmonary disease (COPD) and metabolic syndrome (MetS), focusing on gender differences and using large-scale data on the Korean general population.
*Methods:* The total sample included 9,079 eligible participants aged ≥ 40 years who participated in the fifth Korea National Health and Nutrition Examination Survey, conducted between 2010 and 2012. Complex sampling methods, including strata sampling, clustering, and sample weighting were used to allow generalization of the findings to the Korean population. For the bivariate analysis, chi-square tests were conducted to compare differences in general/behavioral characteristics, individual MetS components, the prevalence of COPD, and the number of MetS components according to the presence or absence of COPD and gender. Finally, a multiple logistic regression analysis adjusted for variables was conducted.
*Results:* The prevalence rates of COPD and MetS were 13.6% and 26.0%, respectively. The prevalence rate of MetS in the COPD group was 23.0% for the total sample, 18.5% for men, and 38.5% for women. After sample weighting and adjusting for covariates, there were no significant relationships among COPD, MetS, and the individual MetS components.
*Conclusion:* Although MetS components were not significantly associated with COPD, the results indicate that health care professionals should recognize that two conditions, respiratory symptoms and MetS, may coexist in patients, women in particular, or healthy general populations encountered even if a patient has a normal body mass index and does not drink or smoke at all.


## Introduction

Chronic obstructive pulmonary disease (COPD) involves chronic inflammatory reactions in the airways and lungs that are accompanied by persistent airflow limitation [1]. COPD is the fifth leading cause of death worldwide, and it is estimated that it will be among the top three causes of death in 2030 [2]. The prevalence of COPD in individuals older than 40 years of age is approximately 11.7% worldwide, but it is higher, at 13.1–17.2%, in Korea [3,4]. In addition, the prevalence rate of COPD is continuously rising due to increases in the elderly population and excessive exposure to risk factors; its mortality rate is also steadily climbing, whereas those of other chronic diseases are gradually decreasing [5]. This emphasizes that health care professionals should prioritize the systematic prevention and management of COPD.

The symptoms of COPD are often accompanied by respiratory inflammatory responses such as dyspnea, chronic cough, and sputum, as well as systemic symptoms such as physical inactivity, fatigue, sleep disturbances, depression, and anxiety. These comorbidities render implementation of therapeutic interventions and maintenance of daily life activities difficult and, as a result, patient quality of life is decreased [1]. COPD is a progressive and degenerative disorder and ongoing management is necessary due to its high comorbidity with cardiovascular disease (CVD), diabetes, hypertension, osteoporosis, depression, anxiety, and anemia [6]. CVD and type 2 diabetes are the most common comorbidities of COPD [1,6], but it has also been reported that the metabolic risk factors associated with COPD are related to each other and, when present

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together, increase the risk of CVD, exacerbate other risk factors, and increase the overall mortality rate [1,6]. To prevent CVD and type 2 diabetes in patients with COPD, it will be necessary to better understand the risk factors of systemic inflammation, and their interactions, as well as the most protective lifestyle factors.

Metabolic syndrome (MetS) is a cluster of the most dangerous CVD risk factors, and is characterized by abdominal obesity, impaired glucose intolerance, dyslipidemia, and hypertension [7]. The most salient predictors of MetS include cigarette smoking and a sedentary lifestyle, which are similar to the risk factors of COPD [8,9].

The important relationship between decreased pulmonary function and MetS has been reported clinically [10]. The decreased pulmonary function affects the extrapulmonary manifestations in addition to lung itself. In biological mechanism, the decline in physical activities is noted in early stages of patients with COPD, which leads to weight gain, and the obesity becomes a risk factor for MetS in patients with COPD [11]. Moreover, the resistance to insulin increases as the pulmonary functions decline, and the hypoxia affects the insulin secretion [12]. In the case of increased COPD severity, patients experience cachexia because of skeletal muscle weakness and muscle wasting which accelerates the insulin metabolic disorders and systemic inflammatory reaction [13]. Furthermore, cytokines such as interleukine-6 (IL-6), IL-8, IL-1β, and tumor necrosis factor alpha, and the systemic inflammatory reaction profiles such as C-reactive protein, fibrinogen, and oxidative stress increase in patients with COPD [10,14]. These low-grade systemic inflammatory responses are often observed in patients with MetS [10,11]. In addition, inhaled steroids commonly used by patients with COPD are associated with early systemic inflammatory reaction [15]. Thus, it has been hypothesized that the prevalence of MetS in patients with COPD is higher than in the healthy general population. The prevalence of MetS in adults is approximately 20.0–25.0% worldwide [16], and a recent systematic review reported a mean prevalence of MetS of 34% among patients with COPD [17]; however, rates may vary somewhat by geographical region.

Although a number of studies have investigated the effects of COPD on the development of MetS and systemic inflammatory responses, controversy remains regarding the link between COPD and MetS. Some studies have shown that the prevalence of MetS is high in patients with COPD [6,17], whereas others have reported that the prevalence of MetS in patients with COPD without CVD does not differ from that in the general population [18]. The relationship between COPD and MetS has not been established.

Several differences in the physical, functional, and health behaviors of men and women have been found in relation to COPD and MetS. Compared with men, women have fewer alveoli and their airway diameter is relatively small compared with the size of the lungs [19]; thus, lung function tends to decrease sharply as cardiovascular risk factors, such as obesity, increase [20]. Moreover, changes in sex hormones, such as estrogen, may decrease lung function [10], and health-related behaviors, such as drinking and smoking, are significantly less common in women than in men [18,20,21]. For these reasons, it is important to consider gender differences when preparing an individualized management strategy for patients with COPD and MetS. Until recently, few studies have investigated the relationship between COPD and MetS according to gender in large population-base samples of Korean patients.

The present study used large-scale data on the general population, obtained via the fifth Korean National Health and Nutrition Examination Survey (KNHANES-V), to assess the relationship between COPD and MetS focusing on gender differences. The specific objectives of this study were to 1) identify differences in the general characteristics, including the health behaviors, of men and women according to the presence or absence of COPD, 2) assess gender differences in the prevalence of MetS and its individual components according to the presence or absence of COPD, and 3) investigate gender differences in the relationships of COPD to MetS and its individual components. The analyses were designed to yield the basic data necessary for establishing individualized intervention strategies and health policies according to the gender of patients with COPD and MetS.

## Methods

### *Study design*

The present study was a secondary analysis of population-based data obtained from the KNHANES-V nationwide cross-sectional health survey.

### *Data source*

The present study used data from the KNHANES-V collected by Korea Centers for Disease Control and Prevention (KCDC) from January 2010 to December 2012. The KNHANES is a nationally representative survey that began in 1998 and collects data using a stratified multistage cluster-sampling design. In total, 3,840 households (192 sampling frames) were surveyed every year in the KNHANES-V (2010-2012).

### *Study sample*

The KNHANES-V included a total of 25,533 respondents [22]: 8,958 (participation rate: 81.9%) in the first year (2010), 8,518 (participation rate: 80.4%) in the second year (2011), and 8,057 (participation rate: 80.0%) in the third year (2012). Of these 25,533 respondents, the present study excluded the data of those younger than 40 years of age and those with missing spirometry data. Of the remaining 9,488 respondents, 207 who had missing weighted values and 202 who had established diagnoses of cancer, tuberculosis, or pregnancy were also excluded. Ultimately, 9,079 eligible respondents (5,128 women and 3,951 men) were included in the present analyses (Figure 1).

### *Measurements*

The KNHANES consists of three main questionnaires: the Health Interview Survey, the Nutrition Survey, and the Health Examination Survey. The variables assessed in this study were collected from the Health Interview Survey and the Health Examination Survey, and are defined in the following [22].

#### *Chronic obstructive pulmonary disease*

Participants in the KNHANES-V older than 40 years of age underwent spirometry (1022 Digital Computed Spirometry®; Sensor Medics, Anaheim, CA, USA) to calculate the forced expiratory volume/forced vital capacity ($FEV_1/FVC$) ratio. For the present study, patients with an $FEV_1/FVC$ ratio < 70% were defined as having COPD [1].

#### *Components of MetS*

MetS was defined according to the new International Diabetes Federation criteria with a modified waist circumference cut-off specific for the Korean population [7]. According to these criteria, MetS is defined as central obesity, a waist circumference $\geq$ 90 cm in men and $\geq$ 80 cm in women, or a body mass index (BMI) $\geq$ 30 kg/$m^2$, and any two of the following four factors: 1) systolic blood

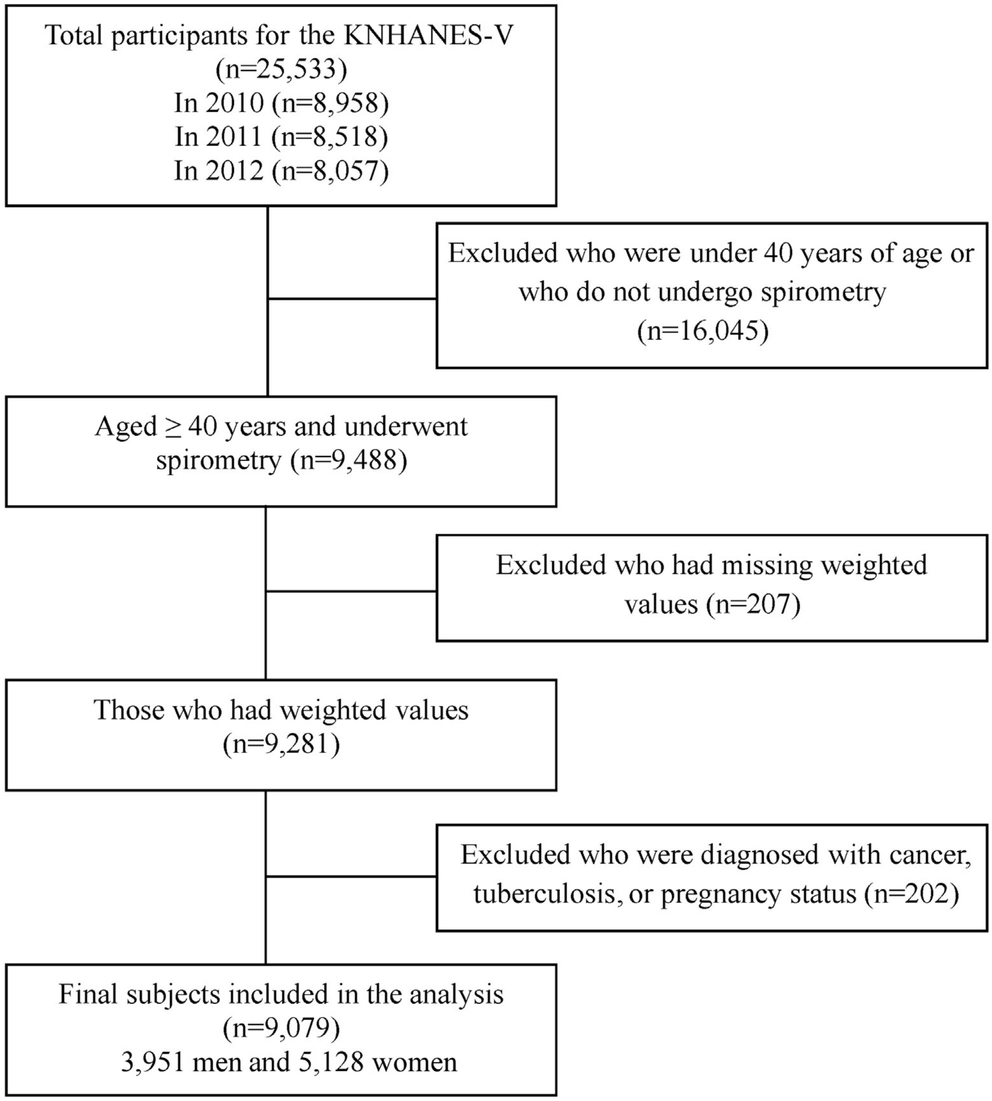


*Figure 1.* Flowchart for study sample. *Note.* KNHANES-V = the fifth Korean National Health and Nutrition Examination Survey.

pressure ≥ 130 mmHg, diastolic blood pressure ≥ 85 mmHg, or use of antihypertensive medications; 2) triglyceride (TG) level ≥ 150 mg/dL or use of antihyperlipidemia medications; 3) high-density lipoprotein cholesterol (HDL-C) level < 40 mg/dL in men and <50 mg/dL in women; and 4) fasting plasma glucose (FPG) level ≥ 100 mg/dL or previous diagnosis of diabetes.

*Covariates*

The covariates assessed in the present analyses included general characteristics, behavioral characteristics, and indicators of obesity (i.e., BMI). The general characteristics included age (40–49, 50–59, 60–69, or ≤ 70 years), marital status (married or unmarried), education level (up to elementary school graduate, middle school graduate, high school graduate, or college graduate or higher), and household income (lower: ≤ 25%; lower-middle: 25–50%; upper-middle: 50–75%; or upper: ≥ 75%). The behavioral characteristics included drinking (never, 1–4 times/month, or ≥ 5 times/month), smoking (never: nonsmoker; light: < 10 pack-years; moderate: ≤ 10 and > 20 pack-years; or heavy: ≥ 20 pack-years), and physical activity (yes or no). For physical activity, if any of the following conditions were met, the answer was “yes”: 1) vigorous physical activity: > 20 min/once on > 3 days/week; 2) moderate physical activity: > 30 min/once on > 5 days/week; and 3) walking for >30 min/once on > 5 days/week. The body weight and height of each participant was measured to determine the BMI, which was calculated as weight divided by height squared (kg/$m^2$). Subsequently, the participants were classified into four groups, as follows: 1) underweight, BMI <18.5 kg/$m^2$; 2) normal ≤18.5 and < 23.0 kg/$m^2$; 3) overweight, ≤ 23.0 and < 25.0 kg/$m^2$; and obese, ≥ 25.0 kg/$m^2$.

*Data analysis*

The KNHANES-V used a stratified multistage cluster-sampling design to provide representative estimates of the Korean population. Sampling weights were used to provide unbiased estimates of the mean, prevalence, and risk ratio values. The statistical analysis was based on individual sample weights provided by the KCDC. Further information on KNHANES-V samples and weighting can be found on the KNHANES website [22]. For the bivariate analysis, chi-square tests were conducted to determine differences in general characteristics, behavioral characteristics, BMI, the prevalence of each MetS component, the prevalence of COPD, and the number of MetS components according to the presence or absence of COPD and gender. Finally, a multiple logistic regression adjusted for variables identified as significant in the bivariate analysis was performed; the odds ratios and 95% confidence intervals were calculated after adjusting for these variables. All analyses were performed using SAS software (ver. 9.1.3; SAS Institute Inc., Cary, NC, USA) with and without weighting, and all data were categorized and separately analyzed by gender, and two-tailed $p$ values < .05 were considered to indicate statistical significance.

### Ethical considerations

The data were obtained from the KNHANES-V conducted by the KCDC [22]. Permission to use the data set was granted by the KCDC after reviewing the proposal for this study, which complied with the regulations of the KCDC raw data disclosure procedure and utilization regulations.

## Results

### Baseline characteristics of study participants with or without COPD by gender

The prevalence rates of COPD were 13.6% in the total sample, 20.9% in men, and 6.9% in women. The prevalence rates of MetS were 26.0% in the total sample, 19.5% in men, and 30.5% in women (Table 1). There were statistically significant differences according to gender ($p < .001$), and details on the general characteristics of the participants are shown in Table 2. Data on the baseline characteristics reflected significant differences between the COPD and non-COPD men in age ($p < .001$), marital status ($p < .001$), education level ($p < .001$), household income ($p < .001$), alcohol intake ($p < .001$), smoking ($p < .001$), and BMI ($p < .001$). Compared with the non-COPD men, the COPD men were older and more likely to be married, had lower education, income and drinking levels, and a higher rate of smoking. In terms of BMI, normal weight status was most common in the COPD men, whereas obesity was most common in the non-COPD men.

**Table 1** *Baseline Characteristics of Study Participants with or without Chronic Obstructive Pulmonary Disease.*

| Variables | All | | | COPD | | | Non-COPD | | | $\chi^2$ | $p$[a] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unweighted | | Weighted | Unweighted | | Weighted | Unweighted | | Weighted | | |
| | (n = 9,079) | | (N = 23,010,574) | (n = 1,237) | | (N = 3,134,588) | (n = 7,842) | | (N = 19,875,986) | | |
| | n | % | W% | n | % | W% | n | % | W% | | |
| Age (yrs) (mean ± SD) | 57.04 ± 10.79 | | | 65.15 ± 9.70 | | | 55.77 ± 10.39 | | | | |
| 40s | 2,579 | 28.4 | 36.3 | 87 | 7.0 | 10.1 | 2,492 | 31.8 | 40.5 | 169.65 | .001 |
| 50s | 2,853 | 31.4 | 30.2 | 259 | 21.0 | 23.8 | 2,594 | 33.1 | 31.2 | | |
| 60s | 2,226 | 24.5 | 17.4 | 442 | 35.7 | 28.3 | 1,784 | 22.7 | 15.6 | | |
| ≥70 | 1,421 | 15.7 | 16.1 | 449 | 36.3 | 37.8 | 972 | 12.4 | 12.7 | | |
| Gender | | | | | | | | | | | |
| Man | 3,951 | 43.5 | 48.3 | 903 | 73.0 | 73.9 | 3,048 | 38.9 | 44.2 | 196.17 | <.001 |
| Woman | 5,128 | 56.5 | 51.7 | 334 | 27.0 | 26.1 | 4,794 | 61.1 | 55.8 | | |
| Marital status | | | | | | | | | | | |
| Married | 8,927 | 98.3 | 97.6 | 1,225 | 99.0 | 99.3 | 7,702 | 98.2 | 97.4 | 16.18 | <.001 |
| Unmarried | 152 | 1.7 | 2.4 | 12 | 1.0 | 0.7 | 140 | 1.8 | 2.6 | | |
| Education | | | | | | | | | | | |
| ≤Elementary | 2,926 | 32.2 | 31.4 | 534 | 43.2 | 46.5 | 2,392 | 30.5 | 29.0 | 47.30 | <.001 |
| Middle school | 1,395 | 15.4 | 15.2 | 206 | 16.7 | 17.4 | 1,189 | 15.2 | 14.9 | | |
| High school | 2,837 | 31.2 | 32.8 | 327 | 26.4 | 25.2 | 2,510 | 32.0 | 34.0 | | |
| ≥College | 1,921 | 21.2 | 20.6 | 170 | 13.7 | 10.9 | 1,751 | 22.3 | 22.1 | | |
| Household income | | | | | | | | | | | |
| Lower | 1,912 | 21.1 | 21.8 | 407 | 32.9 | 35.9 | 1,505 | 19.2 | 19.5 | 38.26 | <.001 |
| Lower-middle | 2,303 | 25.4 | 27.2 | 334 | 27.0 | 25.9 | 1,969 | 25.1 | 27.4 | | |
| Upper-middle | 2,254 | 24.8 | 24.7 | 254 | 20.5 | 20.5 | 2,000 | 25.5 | 25.4 | | |
| Upper | 2,610 | 28.7 | 26.3 | 242 | 19.6 | 17.7 | 2,368 | 30.2 | 27.7 | | |
| Alcohol intake | | | | | | | | | | | |
| Never | 2,896 | 31.9 | 30.0 | 401 | 32.4 | 31.8 | 2,495 | 31.8 | 29.8 | 16.26 | <.001 |
| 1–4 times/month | 4,211 | 46.4 | 45.3 | 458 | 37.0 | 36.3 | 3,753 | 47.9 | 46.7 | | |
| ≥5 times/month | 1,972 | 21.7 | 24.7 | 378 | 30.6 | 31.9 | 1,594 | 20.3 | 23.5 | | |
| Smoking | | | | | | | | | | | |
| Nonsmoker | 5,506 | 60.6 | 55.8 | 395 | 31.9 | 28.9 | 5,111 | 65.2 | 60.1 | 107.11 | <.001 |
| Light | 881 | 9.7 | 10.3 | 131 | 10.6 | 11.3 | 750 | 9.5 | 10.2 | | |
| Moderate | 807 | 8.9 | 10.1 | 150 | 12.1 | 11.9 | 657 | 8.4 | 9.8 | | |
| Heavy | 1,885 | 20.8 | 23.7 | 561 | 45.4 | 47.9 | 1,324 | 16.9 | 19.9 | | |
| Physical activity | | | | | | | | | | | |
| Yes | 4,116 | 45.3 | 45.5 | 571 | 46.2 | 45.5 | 3,545 | 45.2 | 45.5 | 0.01 | .993 |
| No | 4,963 | 54.7 | 54.5 | 666 | 53.8 | 54.5 | 4,297 | 54.8 | 54.5 | | |
| BMI (mean ± SD) | 24.26 ± 2.99 | | | 24.36 ± 3.00 | | | | | | | |
| Underweight | 128 | 1.4 | 1.4 | 33 | 2.7 | 3.4 | 95 | 1.2 | 1.1 | 14.91 | <.001 |
| Normal | 3,062 | 33.7 | 33.3 | 489 | 39.5 | 39.3 | 2,573 | 32.8 | 32.4 | | |
| Overweight | 2,511 | 27.7 | 26.8 | 338 | 27.3 | 27.1 | 2,173 | 27.7 | 26.8 | | |
| Obesity | 3,378 | 37.2 | 38.4 | 377 | 30.5 | 30.2 | 3,001 | 38.3 | 39.7 | | |
| MetS | | | | | | | | | | | |
| With MetS | 2,363 | 26.0 | 25.2 | 285 | 23.0 | 23.7 | 2,078 | 26.5 | 25.4 | 4.66 | .031 |
| Without MetS | 6,716 | 74.0 | 74.8 | 952 | 77.0 | 76.3 | 5,764 | 73.5 | 74.6 | | |

*Note.* BMI = body mass index; COPD = chronic obstructive pulmonary disease; MetS = metabolic syndrome; n = unweighted sample size; N = weighted sample size; SD = standard deviation; W % = weighted percent; yrs = years.

[a] Weighted $p$ value.

**Table 2** *Baseline Characteristics of Study Participants with or without Chronic Obstructive Pulmonary Disease by Gender.*

| Variables | Man | | | | | | $\chi^2$ | p[a] | Woman | | | | | | $\chi^2$ | p[a] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | COPD | | | Non-COPD | | | | | COPD | | | Non-COPD | | | | |
| | Unweighted | | Weighted | Unweighted | | Weighted | | | Unweighted | | Weighted | Unweighted | | Weighted | | |
| | (n = 903) | | (N = 2,316,902) | (n = 3,048) | | (N = 8,792,090) | | | (n = 334) | | (N = 817,686) | (n = 4,794) | | (N = 11,083,896) | | |
| | n | % | W% | n | % | W% | | | n | % | W% | n | % | W% | | |
| Age (yrs) (mean ± SD) | 65.01 ± 9.57 | | | 54.32 ± 10.09 | | | | | 65.60 ± 10.06 | | | | 56.72 ± 10.47 | | | |
| 40s | 64 | 7.1 | 10.3 | 1,133 | 37.2 | 46.0 | 165.20 | <.001 | 23 | 6.9 | 9.6 | 1,359 | 28.3 | 36.1 | 54.64 | <.001 |
| 50s | 190 | 21.0 | 26.0 | 993 | 32.6 | 33.0 | | | 69 | 20.7 | 17.3 | 1,601 | 33.4 | 29.7 | | |
| 60s | 325 | 36.0 | 29.2 | 640 | 21.0 | 14.1 | | | 117 | 35.0 | 25.9 | 1,144 | 23.9 | 16.9 | | |
| ≥70 | 324 | 35.9 | 34.5 | 282 | 9.3 | 6.9 | | | 125 | 37.4 | 47.1 | 690 | 14.4 | 17.3 | | |
| Marital status | | | | | | | | | | | | | | | | |
| Married | 893 | 98.9 | 99.1 | 2,970 | 97.4 | 95.7 | 22.14 | <.001 | 332 | 99.4 | 99.9 | 4,732 | 98.7 | 98.7 | 12.46 | <.001 |
| Unmarried | 10 | 1.1 | 0.9 | 78 | 2.6 | 4.3 | | | 2 | 0.6 | 0.1 | 62 | 1.3 | 1.3 | | |
| Education | | | | | | | | | | | | | | | | |
| ≤Elementary | 314 | 34.8 | 38.7 | 519 | 17.0 | 16.2 | 63.95 | <.001 | 220 | 65.9 | 68.5 | 1,873 | 39.1 | 39.2 | 23.49 | <.001 |
| Middle school | 170 | 18.8 | 19.3 | 444 | 14.6 | 15.1 | | | 36 | 10.8 | 11.9 | 745 | 15.5 | 14.7 | | |
| High school | 273 | 30.2 | 29.3 | 1,052 | 34.5 | 36.9 | | | 54 | 16.2 | 13.8 | 1,458 | 30.4 | 31.7 | | |
| ≥College | 146 | 16.2 | 12.8 | 1,033 | 33.9 | 31.8 | | | 24 | 7.2 | 5.8 | 718 | 15.0 | 14.5 | | |
| Household income | | | | | | | | | | | | | | | | |
| Lower | 268 | 29.7 | 31.4 | 420 | 13.8 | 14.2 | 32.51 | <.001 | 139 | 41.6 | 48.5 | 1,085 | 22.6 | 23.8 | 24.84 | <.001 |
| Lower-middle | 252 | 27.9 | 27.0 | 752 | 24.7 | 27.1 | | | 82 | 24.6 | 22.7 | 1,217 | 25.4 | 27.6 | | |
| Upper-middle | 199 | 22.0 | 22.4 | 847 | 27.8 | 28.0 | | | 55 | 16.5 | 15.3 | 1,153 | 24.1 | 23.3 | | |
| Upper | 184 | 20.4 | 19.3 | 1,029 | 33.8 | 30.7 | | | 58 | 17.4 | 13.5 | 1,339 | 27.9 | 25.3 | | |
| Alcohol intake | | | | | | | | | | | | | | | | |
| Never | 230 | 25.5 | 24.2 | 515 | 16.9 | 16.8 | 8.65 | <.001 | 171 | 51.2 | 53.1 | 1,980 | 41.3 | 40.1 | 7.19 | <.001 |
| 1–4 times | 317 | 35.1 | 34.8 | 1,275 | 41.8 | 39.9 | | | 141 | 42.2 | 40.6 | 2,478 | 51.7 | 52.1 | | |
| ≥5 times | 356 | 39.4 | 41.0 | 1,258 | 41.3 | 43.4 | | | 22 | 6.6 | 6.3 | 336 | 7.0 | 7.8 | | |
| Smoking | | | | | | | | | | | | | | | | |
| Nonsmoker | 107 | 11.8 | 9.7 | 614 | 20.1 | 18.7 | 23.28 | <.001 | 288 | 86.2 | 83.3 | 4,497 | 93.8 | 92.9 | 12.80 | <.001 |
| Light | 102 | 11.3 | 11.9 | 542 | 17.8 | 16.6 | | | 29 | 8.7 | 9.4 | 208 | 4.3 | 5.1 | | |
| Moderate | 144 | 15.9 | 15.0 | 595 | 19.5 | 20.4 | | | 6 | 1.8 | 3.2 | 62 | 1.3 | 1.5 | | |
| Heavy | 550 | 60.9 | 63.4 | 1,297 | 42.6 | 44.4 | | | 11 | 3.3 | 4.1 | 27 | 0.6 | 0.5 | | |
| Physical activity | | | | | | | | | | | | | | | | |
| Yes | 449 | 49.7 | 50.0 | 1,432 | 47.0 | 47.8 | 0.89 | .346 | 122 | 36.5 | 32.8 | 2,113 | 44.1 | 43.6 | 12.25 | <.001 |
| No | 454 | 50.3 | 50.0 | 1,616 | 53.0 | 52.2 | | | 212 | 63.5 | 67.2 | 2,681 | 55.9 | 56.4 | | |
| BMI (mean ± SD) | 23.72 ± 2.70 | | | 24.51 ± 2.69 | | | | | 23.53 ± 3.15 | | | 24.32 ± 3.18 | | | | |
| Underweight | 19 | 2.1 | 2.5 | 27 | 0.9 | 0.9 | 15.28 | <.001 | 14 | 4.2 | 5.9 | 68 | 1.4 | 1.3 | 7.27 | <.001 |
| Normal | 356 | 39.4 | 40.0 | 851 | 27.9 | 27.7 | | | 133 | 39.8 | 37.5 | 1,722 | 35.9 | 36.1 | | |
| Overweight | 245 | 27.1 | 27.2 | 918 | 30.1 | 28.7 | | | 93 | 27.8 | 26.8 | 1,255 | 26.2 | 25.2 | | |
| Obesity | 283 | 31.3 | 30.3 | 1,252 | 41.1 | 42.7 | | | 94 | 28.1 | 29.8 | 1,749 | 36.5 | 37.4 | | |

*Note.* BMI = body mass index; COPD = chronic obstructive pulmonary disease; n = unweighted sample size; N = weighted sample size; SD = standard deviation; W % = weighted percent; yrs = years.
[a] Weighted *p* value.

**Table 3** *Prevalence of Metabolic Syndrome Components and Metabolic Syndrome with or without Chronic Obstructive Pulmonary Disease by Gender.*

| Variables | Man | | | | | | $\chi^2$ | $p$[a] | Woman | | | | | | $\chi^2$ | $p$[a] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | COPD | | | Non-COPD | | | | | COPD | | | Non-COPD | | | | |
| | Unweighted | | Weighted | Unweighted | | Weighted | | | Unweighted | | Weighted | Unweighted | | Weighted | | |
| | (n = 903) | | (N = 2,316,902) | (n = 3,048) | | (N = 8,792,090) | | | (n = 334) | | (N = 817,686) | (n = 4,794) | | (N = 11,083,896) | | |
| | n | % | W% | n | % | W% | | | n | % | W% | n | % | W% | | |
| Obesity | | | | | | | | | | | | | | | | |
| Abnormal | 261 | 28.9 | 29.4 | 944 | 31.0 | 30.9 | 0.61 | .429 | 169 | 50.6 | 52.7 | 2,562 | 53.4 | 53.7 | 0.06 | .803 |
| Normal | 642 | 71.1 | 70.6 | 2,104 | 69.0 | 69.1 | | | 165 | 49.4 | 47.3 | 2,232 | 46.6 | 46.3 | | |
| Blood pressure | | | | | | | | | | | | | | | | |
| Abnormal | 581 | 64.3 | 63.2 | 1,663 | 54.6 | 53.5 | 17.06 | <.001 | 198 | 59.3 | 63.5 | 2,256 | 47.1 | 45.8 | 25.06 | <.001 |
| Normal | 322 | 35.7 | 36.8 | 1,385 | 45.4 | 46.5 | | | 136 | 40.7 | 36.5 | 2,538 | 52.9 | 54.2 | | |
| FPG | | | | | | | | | | | | | | | | |
| Abnormal | 250 | 27.7 | 26.5 | 713 | 23.4 | 21.9 | 5.95 | .015 | 71 | 21.3 | 23.7 | 777 | 16.2 | 15.5 | 9.35 | .002 |
| Normal | 653 | 72.3 | 73.5 | 2,335 | 76.6 | 78.1 | | | 263 | 78.7 | 76.3 | 4,017 | 83.8 | 84.5 | | |
| TG | | | | | | | | | | | | | | | | |
| Abnormal | 376 | 41.6 | 41.8 | 1,410 | 46.3 | 47.8 | 6.73 | .010 | 115 | 34.4 | 33.7 | 1,621 | 33.8 | 33.2 | 5.02 | .025 |
| Normal | 527 | 58.4 | 58.2 | 1,638 | 53.7 | 52.2 | | | 219 | 65.6 | 66.3 | 3,173 | 66.2 | 66.8 | | |
| HDL-C | | | | | | | | | | | | | | | | |
| Abnormal | 304 | 33.7 | 31.2 | 868 | 28.5 | 26.9 | 4.01 | .046 | 179 | 53.6 | 55.2 | 2,297 | 47.9 | 47.6 | 5.32 | .021 |
| Normal | 599 | 66.3 | 68.8 | 2,180 | 71.5 | 73.1 | | | 155 | 46.4 | 44.8 | 2,497 | 52.1 | 52.4 | | |
| MetS | | | | | | | | | | | | | | | | |
| With | 172 | 19.0 | 18.5 | 601 | 19.7 | 19.7 | 0.46 | .496 | 113 | 33.8 | 38.5 | 1,477 | 30.8 | 29.9 | 6.31 | .012 |
| Without | 731 | 81.0 | 81.5 | 2,447 | 80.3 | 80.3 | | | 221 | 66.2 | 61.5 | 3,317 | 69.2 | 70.1 | | |

*Note*. COPD = chronic obstructive pulmonary disease; FPG = fasting plasma glucose; HDL-C = high-density lipoprotein cholesterol; MetS = metabolic syndrome; n = unweighted sample size; N = weighted sample size; TG = triglyceride; W % = weighted percent.

[a] Weighted *p* value.

There were significant differences in age ($p < .001$), marital status ($p < .001$), education level ($p < .001$), household income ($p < .001$), alcohol intake ($p < .001$), smoking ($p < .001$), physical activity ($p < .001$), and BMI ($p < .001$) between the COPD and non-COPD women. Compared with the non-COPD women, the COPD women were older and more likely to be married, and had lower education and income levels, and a higher rate of smoking; these patterns were similar to those of the man group. However, in women, not drinking at all was most common in the COPD group, and drinking 1–4 times/month was most common in the non-COPD group; also, the COPD group exercised less frequently than the non-COPD group. The woman group was similar to the man group in terms of BMI, such that normal weight was most common in the COPD group and obesity was most common in the non-COPD group (Table 2).

*Prevalence of MetS and MetS components in study participants with or without COPD by gender*

The prevalence rate of MetS was 26.0%. Specifically, the prevalence of MetS in the COPD group was 23.0% in the total sample, 18.5% in men, and 38.5% in women. The baseline data revealed significant differences in blood pressure ($p < .001$), FPG levels ($p = .015$), TG levels ($p = .010$), and HDL-C levels ($p = .046$) between the COPD and non-COPD men. Compared with the non-COPD men, the COPD men were more likely to have abnormal blood pressure, FPG, and HDL-C levels, but less likely to have abnormal TG levels.

There were differences in blood pressure ($p < .001$), FPG levels ($p = .002$), TG levels ($p = .025$), HDL-C levels ($p = .021$), and MetS ($p = .012$) between the COPD and non-COPD women. Compared with the non-COPD women, the COPD women were more likely to have abnormal blood pressure, FPG, HDL-C, and TG levels, and to have MetS (Table 3).

*Number of MetS components in study participants with or without COPD by gender*

There were no significant differences in the number of MetS components present between the COPD and non-COPD men ($p = .091$). Among the women with COPD, of the presence of three MetS components was most prevalent, followed by one and two, whereas among the women without COPD group, one MetS component was most prevalent, followed by two and zero ($p < .001$). In other words, the women with COPD were more likely to have three or more MetS components compared with women without COPD (47.4% vs. 34.4%; Table 4).

*Associations of COPD with MetS components and MetS by gender*

In men, one component of MetS (hypertension) had a borderline significant association with COPD development before weighting. In both men and women, the associations of COPD with MetS components and MetS were not statistically significant after weighting (Table 5).

## Discussion

Using a large-scale, nationwide data set, the present population-based study found that the prevalence rates of COPD and MetS in South Korea were 13.6% and 26.0%, respectively. The prevalence of MetS in the COPD group was 23.0% for the total sample, 18.5% in men, and 38.5% in women. The major findings regarding the prevalence of MetS and the individual MetS components in patients with COPD according to gender are as follows.

*Prevalence of MetS in patients with COPD according to gender*

The prevalence rates of COPD and MetS in this study were similar to those observed in previous cross-sectional population-based studies conducted in China [23], the United States [9], and Korea [21]. In this study, 23.0% of the patients had both COPD and MetS compared with 22.5% [23], 57.5% [9], and 36.8% [21], respectively. With respect to gender, the prevalence of MetS in man patients with COPD was 18.5% in this study compared with 37.5% in the United States [9] and 33.0% in a Korean study using KNHANES II data [21]. The prevalence of MetS in woman patients with COPD was 38.5% in this study compared with 51.9% in the United States [9] and 48.5% in Korea [21]. Women with COPD had a significantly higher overall prevalence of MetS than men, presumably because of differences in biological, psychological, and sociological characteristics. One contributing biological factor is that women tend to have smaller lungs and fewer alveoli than men [19]. Given the nature of these structures and their functions, it is plausible that pulmonary dysfunction accompanied by risk factors for metabolic disorders, such as physical inactivity or systemic inflammation, would reduce the $FEV_1/FVC$ ratio of women significantly more than it would reduce that of men, increasing the vulnerability of the former [20,24]. Women are at greater risk of metabolic disorders because they have more body fat, less lean mass, more subcutaneous adipose tissue, and, thus, higher insulin resistance than men because of hormonal changes [24–27]. COPD phenotypes also differ according to gender [28]. Emphysema is more common in men, whereas women are susceptible to several airway diseases characterized by the thickening of the inner wall of the airways [28]. For

**Table 4** *Number of Metabolic Syndrome Components with or without Chronic Obstructive Pulmonary Disease by Gender.*

| Variables | Man | | | | | | $\chi^2$ | $p$[a] | Woman | | | | | | $\chi^2$ | $p$[a] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | COPD | | | Non-COPD | | | | | COPD | | | Non-COPD | | | | |
| | Unweighted (n = 903) | | Weighted (N = 2,316,902) | Unweighted (n = 3,048) | | Weighted (N = 8,792,090) | | | Unweighted (n = 334) | | Weighted (N = 817,686) | Unweighted (n = 4,794) | | Weighted (N = 11,083,896) | | |
| | n | % | W% | n | % | W% | | | n | % | W% | n | % | W% | | |
| 0 | 119 | 13.2 | 13.4 | 543 | 17.8 | 18.4 | 2.01 | .091 | 38 | 11.4 | 11.9 | 865 | 18.0 | 18.7 | 5.53 | <.001 |
| 1 | 250 | 27.7 | 28.5 | 800 | 26.2 | 26.2 | | | 78 | 23.4 | 20.8 | 1,153 | 24.1 | 23.7 | | |
| 2 | 234 | 25.9 | 26.0 | 795 | 26.1 | 26.1 | | | 75 | 22.5 | 19.9 | 1,073 | 22.4 | 23.2 | | |
| 3 | 174 | 19.3 | 19.0 | 527 | 17.3 | 17.4 | | | 85 | 25.4 | 27.8 | 834 | 17.4 | 16.5 | | |
| 4 | 98 | 10.9 | 10.7 | 288 | 9.4 | 9.2 | | | 41 | 12.3 | 13.3 | 633 | 13.2 | 13.3 | | |
| 5 | 28 | 3.1 | 2.4 | 95 | 3.1 | 2.7 | | | 17 | 5.1 | 6.3 | 236 | 4.9 | 4.6 | | |

*Note.* COPD = chronic obstructive pulmonary disease; n = unweighted sample size; N = weighted sample size; W % = weighted percent.
[a] Weighted $p$ value.

**Table 5** *Association of Chronic Obstructive Pulmonary Disease with Components of Metabolic Syndrome and Metabolic Syndrome by Gender.*

| Variables | | SBP≥ 130mmHg/DBP≥ 85mmHg | *p* | FPG ≥ 110mg/dL | *p* | TG ≥ 150mg/dL | *p* | HDL-C < 40mg/dL, man HDL-C < 50mg/dL, woman | *p* | WC ≥90cm, man WC ≥80cm, woman | *p* | Metabolic syndrome | *p* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Adjusted OR (95% CI) | | Adjusted OR (95% CI) | | Adjusted OR (95% CI) | | Adjusted OR (95% CI) | | Adjusted OR (95% CI) | | Adjusted OR (95% CI) | |
| Unweight | Man[a] | | | | | | | | | | | | |
| | Non-COPD | 1 (ref) | | 1 (ref) | | 1 (ref) | | 1 (ref) | | 1 (ref) | | 1 (ref) | |
| | COPD | 1.181 (0.990,1.410) | .065 | 1.004 (0.832,1.212) | .967 | 1.064 (0.894,1.267) | .484 | 1.112 (0.927,1.335) | .252 | 0.921 (0.727,1.166) | .492 | 0.991 (0.780,1.258) | .940 |
| | Woman[b] | | | | | | | | | | | | |
| | Non-COPD | 1 (ref) | | 1 (ref) | | 1 (ref) | | 1 (ref) | | 1 (ref) | | 1 (ref) | |
| | COPD | 0.946 (0.735,1.218) | .669 | 1.050 (0.785,1.405) | .740 | 0.817 (0.637,1.046) | .109 | 0.964 (0.760,1.224) | .766 | 0.788 (0.574,1.082) | .141 | 0.872 (0.654,1.162) | .351 |
| Weight | Man[a] | | | | | | | | | | | | |
| | Non-COPD | 1 (ref) | | 1 (ref) | | 1 (ref) | | 1 (ref) | | 1 (ref) | | 1 (ref) | |
| | COPD | 1.134 (0.910,1.414) | .263 | 1.029 (0.824,1.285) | .802 | 1.037 (0.834,1.288) | .745 | 1.055 (0.849,1.312) | .627 | 1.023 (0.768,1.363) | .877 | 0.961 (0.706,1.309) | .803 |
| | Woman[c] | | | | | | | | | | | | |
| | Non-COPD | 1 (ref) | | 1 (ref) | | 1 (ref) | | 1 (ref) | | 1 (ref) | | 1 (ref) | |
| | COPD | 1.091 (0.813,1.464) | .562 | 1.197 (0.836,1.714) | .327 | 0.758 (0.550,1.045) | .091 | 0.993 (0.761,1.297) | .961 | 0.835 (0.570,1.223) | .354 | 1.092 (0.765,1.559) | .628 |

*Note.* CI = confidence interval; COPD = chronic obstructive pulmonary disease; DBP = diastolic blood pressure; FPG = fasting plasma glucose; HDL-C = high-density lipoprotein cholesterol; OR = odds ratio; SBP = systolic blood pressure; TG = triglyceride; WC = waist circumference.

[a] Adjusted for age, marital status, education, household income, alcohol intake, smoking, and BMI.

[b] Adjusted for age, education, household income, alcohol intake, smoking, physical activity, and BMI.

[c] Adjusted for age, marital status, education, household income, alcohol intake, smoking, physical activity, and BMI.

this reason, despite having similar pulmonary function, women may have greater difficulty breathing and experience more severe anxiety or depression than men [26]. Given these psychological characteristics, woman patients with COPD tend to restrict their physical activity, which contributes to increase systemic inflammations; this starts a vicious cycle leading to the gradual deterioration of pulmonary functioning, insulin resistance, hypertension, and increased dyslipidemia [10]. Moreover, Confucian cultural values encourage women to stay at home rather than engage in social activities [24]. Understanding these gender-specific mechanisms is essential for effective management of MetS in patients with COPD.

Similar to previous studies [9,17,21], this study found that the COPD groups were older, less educated, of lower economic status, more likely to be drinkers and smokers, and both men and women had higher BMIs. Among the women with COPD in this study, 67.2% stated that they did not engage in physical activities, including regular exercise, compared with 56.4% of those without COPD. Physical inactivity has been associated with high levels of systemic inflammation in patients with COPD [10]. More attention needs to be given to providing interventions that promote physical activity to improve insulin resistance and reduce systemic inflammation in COPD patients with MetS. Unlike non-COPD patients, those with COPD should undergo low-grade systemic inflammation profile, cardiovascular health, exercise capacity, and exercise tolerance assessments to provide individualized differentiated pulmonary rehabilitation programs [1]. While comorbid obesity is common in the early stage of COPD, the incidence of comorbid MetS is lower in the most severe stage of the disease because body weight is decreased because of muscle wasting [13,18]. In severe stage of COPD cachexia characterized by unintended weight loss and muscle loss, nutritional support programs and fatigue management should be concurrent with increasing exercise tolerance. Therefore, it is essential that physician and clinical nurses assess the level of airflow obstruction and consider COPD severity and the risk factors for various comorbidities when treating patients with COPD.

In this study, 83.3% of the woman patients with COPD were never-smokers, whereas the rates of woman never-smokers ranged from 88.0 to 93.9% in previous studies [9,18,23]. Furthermore, 53.1% of our COPD group did not drink alcohol, compared with 41.3% of the non-COPD group. Health care professionals should not overlook the fact that patients with COPD are at greater risk of developing MetS and its individual components than non-COPD patients despite being less likely to smoke and drink [26].

### *Relationship between COPD and MetS according to gender*

After weighting the samples and adjusting for covariates, authors found no significant relationships among COPD, MetS, and the MetS components in men or women. This finding differs from those of previous studies. In a study using data from KNHANES II, Park et al. [21] found that abdominal obesity, a component of MetS, was partially correlated with COPD in Korean men (odds ratio: 1.95, 95% confidence interval: 0.93–4.11). A large population study conducted in France [29] and China [23] found that abdominal obesity was associated with the deterioration of lung function. These discrepancies can be explained by differences in the ethnicity, age, and COPD severity of the various study populations. Park et al. [21] included only patients with early-stage COPD. The subjects in the study by Leone et al. [29] were younger (mean age of 45.7 years) than those in our study and excluded underweight subjects (BMI <18.5). In addition, the KNHANES-V data used in this study did not include postbronchodilator spirometry data; it is possible that the number of patients with COPD was overestimated and that asthmatic patients who had temporary airway obstructions were unintentionally included.

Authors found that 32.1% of man patients with COPD and 47.4% of woman patients with COPD had more than three MetS components. Considerably more attention should be paid to the roles that psychological factors play in MetS, particularly in women, because these factors are associated with physical changes, such as menopause, which can affect insulin resistance and systemic inflammation [19]. It is known that MetS is more frequent in women than men after the age of 50 years, and that the symptoms are harder to control in women because multiple symptoms occur simultaneously before and after menopause [30]. The risk levels for each MetS component should be identified during the early stages of a diagnosis to improve the health status of women with COPD. In addition, the pulmonary function, menopausal status, and psychological status of women should be assessed and, if necessary, psychological interventions, such as active counseling, should be provided. The clinical nurses must have the intervention skills to manage systemic and multicomponent diseases, such as COPD and MetS, that require a holistic approach.

The present study had several strengths. First, it analyzed accurate demographic, socioeconomic, and lung function data that were collected as part of a large-scale nationwide survey in Korea, where the quality assurance that these data were subjected to was superior to that in small-scale studies. In addition, sample weighting was performed for more accurate results. Second, comparative analyses were performed according to gender. Few previous studies have investigated gender differences in COPD and MetS. In Asian countries that adhere to Confucian cultural values, including Korea, cultural specificity necessitates separate analyses of men and women.

The present study also had several limitations. Because it used a cross-sectional design, it was not possible to determine a causal relationship between COPD and MetS. Future longitudinal studies should be conducted to assess the causal relationship between COPD and MetS. Second, it was not possible to classify patients based on the latest GOLD guidelines, which recommend the use of combined COPD assessments to reflect lung function, symptoms, and acute exacerbation risk [1]. Future research should analyze the risk of MetS according to the severity of COPD based on the latest GOLD guidelines.

## Conclusion

In the present study, MetS and MetS components were not significantly associated with COPD, but the absence of a relationship between these variables can be partially explained by the higher risk of MetS in those with COPD, particularly the women. The metabolic risk factors of MetS are related to each other and interact to increase the risk of chronic diseases such as CVD and COPD. The prognosis is worse if there are a greater number of risk factors; thus, it is necessary to actively manage these symptoms. However, in most chronic diseases, the focus is on the treatment and management of the disease in isolation rather than considering multimorbidity. Although increasing attention is being paid to the management of various symptoms, the treatment and management of COPD tends to be focused on improving respiratory symptoms through oxygen therapy and medications. The present results will contribute to the development of a comprehensive approach for the management of various diseases, including MetS, and CVD, in terms of preventing and managing chronic comorbidities, such as COPD, to meet the challenges associated with an aging society. Furthermore, the present evidence suggests that it will be necessary to develop clinical guidelines for individualized and tailored patient care, while also taking into account demographic and sociological characteristics, such as gender. These findings also provide a basis for establishing national policies concerned with the early prevention and management of COPD and MetS, to promote better health of the general population.

## Conflicts of interest

No conflict of interest has been declared by the authors.

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