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만성 폐쇄성 폐질환 환자에서 신체활동과 고혈압 이환율 간의 관련성

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Association between Physical Activity and Hypertension in Chronic Obstructive Pulmonary Disease

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Background: Patients with chronic obstructive pulmonary disease (COPD) have increased likelihood of hypertension, which may lead to increased mortality rates. This study investigated the incidence of hypertension in patients with COPD according to the levels of their physical activities.
Methods: This study used data from the fifth Korean National Health and Nutrition Examination Survey, conducted from 2010 to 2012, including 1,243 people aged 40 years or older with COPD who were cross-classified according to their levels of physical activity. The relevance of morbidity associated with high blood pressure was also evaluated through cross and logistic regression analyses.
Results: Among patients with COPD who performed moderate-intensity physical activities, the group without hypertension had 4.3% higher compared to the group with hypertension (P=0.012). Adjusted analysis for patient age, sex, body mass index, smoking, drinking habit, income, diabetes mellitus, hyperlipidemia, and energy intake performed to determine the relationship between physical activity level and hypertension revealed that patients with moderate-intensity physical activity had 53.6% lower (95% confidence interval: 0.288-0.997) incidence of hypertension.
Conclusions: The results of the current study suggest that patients with COPD who perform moderate-intensity physical activity have a lower incidence of hypertension.
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Keywords: Chronic obstructive pulmonary disease, Hypertension, Physical activity

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a respiratory disease characterized by abnormal inflammatory response of the lungs due to inhalation of harmful particles or gases, accompanied by irreversible and gradual airflow limitation.[1)]

The prevalence of COPD and its mortality rates are globally high, resulting in increased social and economic burdens.[2,3)] In addition, owing to the trend of aging society worldwide and increased exposure to risk factors, the number of patients with COPD is also predicted to grow in the future.[3)]

As of 2007, the number of COPD patients around the world is estimated to be approximately 210 million people.[4)] COPD risk factors include old age (65 years or older), male

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gender, low income, past or current smoker, etc.[5]; these factors also increase the risk of cardiovascular diseases in patients with COPD, with high mortality as a consequence.[6]

According to Korean National Health and Nutrition Survey, the prevalence of high blood pressure (HBP) in adults aged 30 years or older, has increased as 26.9%, in 2010.[7] The risk factors of HBP include old age, family history, obesity, lack of exercise, smoking, high salt intake, excessive alcohol intake, and stress. These factors are also associated with previously described COPD risk factors,[8] and HBP is also the main risk factor for cardiovascular diseases.[9]

Domestic and international studies have reported correlation in the degree of morbidity between COPD and HBP. A cohort study from Catholic University in Italy,[10] a domestic research on COPD and comorbidities based on the 2010-2012 National Health and Nutrition Survey,[11] and a cohort research performed in the US[12] all reported high morbidity of HBP in patients with COPD.

Moreover, the association between physical activity and blood pressure (BP) was shown in meta-analysis of the studies in Brazil and Belgium, as well as the studies at Indiana University in the US.[13-15]

Thus, the current study assessed the degree of HBP-associated morbidity according to the level of physical activity in Korean patients with COPD aged 40 years or older, based on data from the fifth (2010-2012) Korean National Health and Nutrition Survey.

METHODS

1. Subjects

The current study included subjects who underwent a pulmonary function test as a part of the fifth Korean National Health and Nutrition Survey (between 2010 and 2012), which consisted of 1,243 people aged 40 years or older.

2. Research survey

1) Definitions of COPD, and HBP

Forced expiratory volume in 1 second (FEV1) and forced vital capacity (FVC) were measured during the pulmonary function test (PFT), and FEV1/FVC<0.7 was considered as positive for COPD. PFT was conducted in all cases except patients who were unable to participate in the lung function test due to past history of operation, disease and medical status within the past three months.

Blood pressure was measured three times for each subjects on their right arm and the average value of the second and third trials was calculated. Individuals with systolic BP (SBP) above 140 mmHg or diastolic BP (DBP) above 90 mmHg or individuals taking HBP drugs were classified as hypertensive.

2) Physical activities

Physical activities were classified based on responses to the physical activity questions of National Health and Nutrition Survey created through International Physical Activity Questionnaire.[16] The subjects were classified into three groups depending on the extent of physical activity for last week: vigorous-intensity, moderate-intensity, and walking. Compared to standard physical activity, subjects performing more challenging, aerobic physical activity, for 20 or more minutes per day, at least three days per week, were categorized into the vigorous-intensity physical activity group. The moderate-intensity physical activity group was defined as subjects performing slightly more difficult, aerobic physical activity than standard for 30 or more minutes a day, five or more days a week. Lastly, subjects who walked for more than 30 minutes or more per day, for five or more days per week, were classified into the mild physical activity group.

3) General characteristics and health habit factors

General characteristics of subjects including gender and age were examined. In addition, factors related to smoking and alcoholic drinking were also examined. Those who ever smoked more than five packs of cigarettes (100 cigarettes) during their lifetime and those who smokes at present were defined as current smokers, while those who drinks alcohol above 30 g were defined as excessive drinkers. Finally, daily energy consumption (kcal/day) was measured through a food intake frequency survey.

4) Socio-economic factors

To assess the economic status of households, we investigated the fraction of households corresponding to the lower 25% based on household income. In addition, educa-

tion level was classified as individuals with elementary school or lower, middle school graduate, high school graduate, and college graduate or higher. For marital status, we only included individuals living with their spouse in the current study.

5) Disease variable factors

Subjects with fasting blood glucose above 126 mg/dL or those who takes diabetes drugs, or insulin injections, or those who had been ever diagnosed with diabetes, were classified as having diabetes. Hyperlipidemia was defined as subjects with a fasting total cholesterol level above 240 mg/dL or those who takes cholesterol medication.

6) Anthropometry

Anthropometric data were also collected. From these data, body mass index (BMI) and waist circumference were used in the current study. BMI was measured by dividing weight (kilograms) by the square of the height (square meters). Waist circumference was measured to the first decimal place (0.1 cm) using a measuring tape without depressing the skin while breathing out, parallel to the floor, at a level midway between the lowest rib and the iliac crest.

3. Data analysis

Among general characteristics, categorical variables were reported as numbers and percentages, while continuous variables were expressed as means (±standard error). Independent *t*-test and chi-square test were performed for continuous and categorical variables, respectively, depending on the research variables. Chi-square tests were used to determine the relationship between the presence or absence of hypertension and the degree of physical activity in patients with COPD. Multiple logistic regression analysis was performed, after adjusting for age, health behaviors, and disease history, to evaluate the risk of hypertension according to the degree of physical activity in patients with COPD.

Using a SAS survey procedure (version 9.3, SAS, Cary, NC, USA), statistical analysis was performed based on a complex sample design, with statistical significance defined as less than 0.05.

RESULTS

1. Analysis of factors related to the presence or absence of hypertension in patients with COPD

The results of the analysis revealed that hypertension was significantly associated with current smoking status, level of education, marital status, combined morbidity of diabetes or hyperlipidemia, age, BMI, waist circumference, SBP, DBP, FVC, FEV1, and daily energy consumption.

Current smokers in hypertensive group was higher by 7.6% than that of the group without HBP (P=0.028). In terms of income, the fraction corresponding to the lower 25% of income levels was higher by 6.6% in hypertensive group (P=0.024). However, the proportion of subjects with a partner in hypertensive group was lower by 11.2% than that in normotensive group (P<0.001). The combined morbidity such as diabetes or hyperlipidemia in hypertensive group was higher than that of normotensive group by 8.4% (P=0.002), 11.4%, respectively (P<0.001).

The group of subjects with hypertension was older by an average of 5.2 years compared to the group without hypertension (P<0.001) and BMI was higher by 0.8 kg/m^2 in hypertensive group, while waist circumference was longer in hypertensive group by 2.9 cm (P<0.001).

SBP and DBP in the group with hypertension were higher than those of the group without by 19.3 (P<0.001), 7.8 mmHg, respectively (P<0.001) in pulmonary function tests, the measured values were lower in the group with HBP, by 0.3 and 0.1 L for FVC and FEV1, respectively (P<0.001 and P<0.001, respectively). Daily energy consumption in hypertensive group was lower than that of normotensive group by 306.9 kcal (P<0.001) (Table 1).

2. Association between the degree of physical activity and the presence of hypertension in patients with COPD

When classifying the subjects according to physical activity and the presence of hypertension, the fraction of those performing moderate-intensity physical activity was significantly higher (about 4.3%) in hypertensive group than in normotensive group (P=0.012). The fraction of subjects who performed vigorous-intensity physical activity in the normotensive group was higher than that in hypertensive

Table 1. General Characteristics of subjects (unweighted n = 1,243)

Variable	Non-hypertension (n = 593)	Hypertension (n = 650)	*P*
Male sex	74.1 (2.4)	75.4 (2.3)	0.673[a]
Current smoking	64.4 (2.6)	72 (2.3)	0.028[a]
Heavy drinker	13.8 (2)	11.7 (1.7)	0.40[a]
Income	25.7 (2.2)	32.3 (2.2)	0.024[a]
Education	57.3 (2.7)	61.6 (2.5)	0.221[a]
Marriage status (yes)	88.7 (1.6)	77.5 (2.2)	<0.001[a]
DM (yes)	12.2 (1.6)	20.6 (2.1)	0.002[a]
Hyperlipidemia (yes)	10 (1.6)	21.4 (2)	<0.001[a]
Chronic bronchitis or emphysema (yes)	2.4 (0.7)	2.5 (0.8)	0.916[a]
Age, y	59.7±0.5	64.9±0.5	<0.001[b]
BMI, kg/m^2	23.3±0.1	24.1±0.2	<0.001[b]
WC, cm	83.2±0.5	86.1±0.4	<0.001[b]
SBP, mmHg	116.9±0.6	136.2±0.9	<0.001[b]
DBP, mmHg	73.9±0.5	81.7±0.6	<0.001[b]
FVC, L	3.8±0.1	3.5±0.1	<0.001[b]
FEV1, L	2.4±0.0	2.3±0.0	<0.001[b]
FEV1/FVC	0.635±0.004	0.634±0.003	0.742[b]
Energy intake, kcal	2235.4±60.2	1928.5±40.4	<0.001[b]

Abbreviations: SE, standard error; DM, diabetes mellitus; BMI, body mass index; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; FVC, forced vital capacity; FEV1, forced expiratory volume in 1 second.
Values are presented as percentage (SE) or mean±SE.
[a]Calculated by chi-square test.
[b]Calculated by *t*-test.

Table 2. Association between physical activity and hypertension in COPD patients

	Physical activity		
	Vigorous (yes) (n = 154)	Moderate (yes) (n = 92)	Mild (yes) (n = 488)
Non-hypertension	13 (1.9)	9.2 (1.5)	38.2 (2.7)
Hypertension	11 (1.5)	4.9 (1)	39.5 (2.3)
P[a]	0.390	0.012	0.709

Abbreviations: COPD, chronic obstructive pulmonary disease.
Values are presented as percentage (SE).
[a]Calculated by chi-square test.

Table 3. Correlations between hypertension and intensity of physical activity in COPD patients[a]

	Physical activity		
	Vigorous (yes) (n = 154)	Moderate (yes) (n = 92)	Mild (yes) (n = 488)
Model 1[b]	0.830[a] (0.542-1.270)	0.511[a] (0.299-0.871)	1.060[a] (0.782-1.435)
Model 2[c]	0.962[a] (0.607-1.526)	0.528[a] (0.298-0.938)	0.992[a] (0.724-1.359)
Model 3[d]	0.789[a] (0.497-1.252)	0.536[a] (0.288-0.997)	0.951[a] (0.668-1.356)

Abbreviations: COPD, chronic obstructive pulmonary disease; BMI, body mass index; DM, diabetes mellitus.
[a]Reference was hypertensive group in COPD patients. Calculated by multiple logistic regression analysis.
[b]Model 1: not adjusted.
[c]Model 2: adjusted for age, sex, BMI, smoking, and drinking.
[d]Model 3: adjusted for age, sex, BMI, smoking, drinking, income, DM, hyperlipidemia, and energy intake.

group by 2%; among subjects who performed mild activity, the fraction with hypertension was higher than that without hypertension by 1.3%, but this difference was not statistically significant (P=0.709) (Table 2).

3. Association between combined morbidity of the degree of physical activity and hypertension in patients with COPD

Multiple logistic regression analysis was performed to examine the association of combined morbidity of hypertension and the degree of physical activity in patients with COPD. The results showed that the rate of accompanying hypertension was lower by 0.511 (95% confidence interval [CI], 0.299 to 0.871) among subjects who performed moderate-intensity physical activity, and was 0.536-fold lower (95% CI from 0.288 to 0.997) after adjusting for age, gender, BMI, smoking, drinking alcohol, income, diabetes mellitus, hyperlipidemia, and energy intake (Table 3).

DISCUSSION

COPD and HBP have common risk factors, including old age, smoking, as well as cardiovascular risk factors.[9] The correlation between BP (especially SBP) and cardiovascular disease is known, and in many studies have demonstrated the relationship between COPD and cardiovascular diseases. Maclay et al[6] reported that chronic systemic inflammatory response due to increased interleukin (IL)-6, IL-8, tumor necrosis factor-alpha, and fibrinogen levels may increase the risk of cardiovascular diseases in patients with COPD. In addition, an American study reported that patients with COPD had higher prevalence of cardiovascular disease compared to those without COPD,[17] and a Canadian cohort study showed higher morbidity of cardiovascular disease and mortality rates in patients with COPD comapred to general population (standardized rate ratios of 1.9 and 2.0, respectively).[18]

A cohort study in Italy showed comorbidity with hypertension was 28% in 270 patients with COPD,[10] and Jo et al[11] analyzed data from the 2010-2012 fifth National Health and Nutrition Survey, reporting comorbidity with hypertension was 418 of 744 (56.18%) adult male patients with COPD, with high comorbidity. In this study, 650 of 1,243 adult men and women aged 40 years or older with COPD had comorbidity with hypertension (52.29%). A cohort study based on data from the Atherosclerosis Risk in Communities study and Cardiovascular Health study in the US also demonstrated the relative risk of hypertension in patients with Global Initiative on Obstructive Lung Disease stage 3 and 4 was 1.6-fold higher.[12] Several previous studies have reported the high comorbidity rate of COPD and HBP in health-related surveys in Korea, with similar results.

Regarding the similarity in risk factors between COPD and HBP, as well as the risk of morbidity to cardiovascular disease, a previous study reported that physical activity influences the prevalence of HBP. A meta-analysis study in Brazil showed significant reduction in SBP and DBP by 10.09 mmHg and 7.47 mmHg, respectively, associated with aerobic and resistance exercise;[13] similarly, a meta-analysis of 44 randomized controlled trials in Belgium showed significant reduction of SBP and DBP both by 2.4mmHg, respectively, associated with dynamic aerobic and resistance exercise.[14] Finally, a study conducted in the US classified the measured BP of subjects into three groups as normal, pre-HBP, and HBP to examine the effect of physical activity in daily life on BP. They reported that various physical activities (cycling fast walking, moving heavy objects, cleaning house, climbing stairs, gardening etc.) resulted in reduced SBP in subjects with pre-HBP and HBP.[15]

In the current study, we examined comorbidity with hypertension according to physical activity (vigorous-intensity, moderate-intensity, and walking) in COPD patients and noted that the incidence of comorbidity with hypertension was significantly lower in the group with moderate-intensity physical activity compared to those with vigorous-intensity or mild physical activities. Based on the results of studies in other countries, moderate-intensity physical activity is recommended for patients with COPD, and these findings may be used as an evidence to prevent HBP-associated morbidity.

This study has several limitations. First, cross-sectional study design does not provide temporal sequencing relationship data; thus the causal relationship between the comorbidity with hypertesnion in patients with COPD was not clearly determined. Second, there might be recall bias for quantifying physical activities due to the self-reported questionnaire rather than direct measurement of physical activity. In addition, this study did not accurately classify

different intensity of simultaneous physical activities; it was categorized only to three groups by recalls of patients who might have performed different degrees of physical activity. Finally COPD was diagnosed only by PFT findings, not with comprehensive clinical correlation.

Despite the limitations, this study has meaningful results, and is valid in that it utilized data obtained from the National Health and Nutrition Examination Survey, which was designed to target a sample population that represented the entire country. The findings of the current study suggested that moderate-intensity physical activity in patients with COPD is associated with low HBP prevalence. However, long-term prospective studies are necessary to confirm the causal relationship based on temporal sequencing data. Therefore, further research should assess the reduced levels of hypertension in patients with COPD who perform physical activity, including follow-up research on patients and more accurate measurement physical activity. Futhermore, in addition to the positive effect of exercise on hypertension in patients with COPD, further research is necessary on the appropriate level of physical activity in patients with COPD, considering their individual physical and physiological characteristics.

요 약

연구배경: 만성 폐쇄성 폐질환(COPD) 환자에서 고혈압의 높은 동반 이환을 보여주는 앞선 연구 및 조사결과들이 보고되고 있으며 그로 인한 심혈관질환의 이환이 높아져 사망률 또한 높아짐이 보고되고 있다. 이에 본 연구에서는 COPD 환자군에 있어 신체활동 정도에 따른 고혈압 이환 정도를 알아보고자 한다.

방법: 2010-2012년에 수행된 제5기 국민건강영양조사 자료를 이용하여 만 40세 이상의 성인 중 1,243명의 COPD 환자를 대상으로 교차분석 및 로지스틱 회귀분석을 실시하였으며, 신체활동의 정도에 따라 대상자를 분류하여 고혈압 동반 이환과의 관련성을 알아보았다.

결과: COPD 환자 중 고혈압이 없는 자에서 중등도 신체활동을 하는 자의 분율이 고혈압이 있는 자에서의 분율보다 4.3% 유의하게 높았다(P=0.012). COPD 환자에서 신체활동 정도와 고혈압 동반 이환의 위험도를 살펴보기 위해 나이, 성별, 소득수준, 비만도, 흡연과 음주 여부, 당뇨, 고지혈증의 동반 이환, 에너지 섭취량 등을 고려하여 보았을 때 중등도 운동을 시행하는 군에서 고혈압의 동반된 위험도가 0.536배(95% 신뢰구간, 0.288-0.997) 낮았다.

결론: COPD 환자군에서 신체활동 중 중등도의 신체활동을 하는 경우 고혈압의 이환 정도가 유의하게 낮음을 알 수 있었다.

중심 단어: 만성 폐쇄성 폐질환, 고혈압, 신체활동

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