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The Impact of Wearing a Mask on Oxygenation and Hemodynamics in Patients with Mild to Moderate Chronic Obstructive Pulmonary Disease

To the Editor:

During the ongoing coronavirus disease (COVID-19) pandemic, wearing face masks has been effective in preventing the transmission of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus and in protecting people from COVID-19 infection (1). Thus, many countries have mandated the use of masks in public; at the same time, there is concern regarding the potential adverse effects of face masks, especially among patients with chronic respiratory diseases (2). There is little evidence to guide mask-wearing in patients with chronic obstructive pulmonary disease (COPD) (3, 4). Moreover, evidence to date is limited and has had conflicting or varying findings, depending on the type of mask and disease severity. In this study, we aimed to evaluate the impact of wearing masks on oxygen saturation and hemodynamic responses during exercise and daily activities in patients with mild to moderate COPD.

Methods

This prospective randomized crossover study was performed at a university hospital in Seoul, Korea. Eligible patients were adults aged 40 years or older with COPD and a postbronchodilator forced expiratory volume in 1 second (FEV_1) to forced vital capacity ratio less than 0.7 who were on regular maintenance treatment and had mild or

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Table 1. Characteristics of the study population ($N = 30$)

Characteristic	Measure
Age (yr), median (IQR)	71 (65–75)
40–49, *n* (%)	4 (13.3)
50–59, *n* (%)	9 (30.0)
60–69, *n* (%)	16 (53.3)
70–79, *n* (%)	1 (3.3)
Males, *n* (%)	29 (96.7)
Body mass index (kg/m^2), mean ± SD	24.2 ± 2.8
Smoking status, *n* (%)	
Never	2 (6.7)
Ex-smoker	21 (70.0)
Current smoker	7 (23.3)
COPD Assessment Test score, median (IQR)	8.5 (5–16)
Postbronchodilator spirometry, mean ± SD	
FVC, L	3.5 ± 0.7
FVC, %predicted	79.8 ± 14.8
FEV_1, L	2.1 ± 0.5
FEV_1, %predicted	68.1 ± 8.7
FEV_1/FVC, %	59.8 ± 8.7
D_{LCO}, %predicted*	73.3 ± 14.1
GOLD grade (FEV_1 %predicted), *n* (%)	
1 (⩾80)	3 (10.0)
2 (50–80)	27 (27.0)
Medications, *n* (%)	
LAMA monotherapy	6 (20.0)
LAMA + LABA	18 (60.0)
ICS + LABA	3 (10.0)
ICS + LABA + LAMA	3 (10.0)
Comorbidities, *n* (%)	
Hypertension	10 (33.3)
Diabetes	6 (20.0)
Chronic rhinitis	4 (13.3)
Ischemic heart disease	2 (6.7)
Connective tissue disease	2 (6.7)
Chronic kidney disease	1 (3.3)

Definition of abbreviations: COPD = chronic obstructive pulmonary disease; D_{LCO} = diffusing capacity for carbon monoxide; FEV_1 = forced expiratory volume in 1 second; FVC = forced vital capacity; GOLD = Global Initiative for Chronic Obstructive Lung Disease; ICS = inhaled corticosteroid; IQR = interquartile range; LABA = long-acting β2 agonist; LAMA = long-acting muscarinic antagonist; SD = standard deviation.
*$n = 13$.

moderate airflow limitations with a percentage predicted FEV_1 greater than 50%. We selected the KF80 mask, which has a 0.6-μm particle filtration rate of at least 80% and is equivalent to a European FFP1 mask (5). The testing was performed in two parts. First, we examined the impact of face masks during a treadmill exercise performed according to the modified Bruce protocol, which employs two initial low-level 3-minute stages at a speed of 1.7 mph and grades 0% and 5%, respectively, and then continues into the full Bruce protocol. The measurement of oxygen saturation was performed before and just after the treadmill exercise using a pulse oximeter. Hemodynamics were monitored, including heart rate, systolic and diastolic blood pressure, and electrocardiogram, at baseline and during treadmill exercise. In addition, echocardiography was performed before and just after the treadmill exercise. The E/e' ratio, which is the ratio of early diastolic mitral inflow velocity to early diastolic mitral annulus velocity, was calculated to assess diastolic dysfunction (6). Immediately after the treadmill test, we also assessed the effects of wearing masks on hemodynamic responses during daily activities for 24 hours in the same patients with the use of 24-hour ambulatory blood pressure and Holter monitoring. In this crossover design, patients were randomly assigned to the on-mask or off-mask phase. When a participant completed the two-part tests in the on-mask (or off-mask) phase, then he/she moved to the off-mask (or on-mask) phase and performed the same two-part tests. The interval between the on- and off-mask phases was 2–3 weeks. This study was approved by the Institutional Review Board of Hanyang University (2020–01–013), and informed consent was obtained from all participants.

Results

A total of 30 people were included in the study. Demographic and clinical characteristics are shown in Table 1. During the treadmill exercise, the oxygen saturation decreased significantly from baseline both in the off-mask (from baseline median 96.0% [interquartile range (IQR), 95.0–97.0] to after exercise 91.0% [IQR, 86.0–94.0]; $P < 0.001$) and on-mask phases (from baseline 96.0% [IQR, 94.0–97.0] to after exercise 91.0% [IQR, 86.0–93.0]; $P < 0.001$) (Figure 1A). However, the lowest oxygen saturation was not different between the off-mask (median, 91%; IQR, 86–94%) and on-mask phases (median, 91%; IQR, 86–93%). To determine if the impact of mask-wearing differed among those who did versus did not have baseline oxygen desaturation with exercise while not wearing a mask, we divided the subjects into two groups on the basis of the changes in oxygen saturation with the treadmill exercise in off-mask phase and compared the impact of wearing masks between groups. No significant differences were observed between the groups: group 1 ($n = 14$) with less than 5% of oxygen saturation changes with exercise, and group 2 ($n = 16$) with 5% or more change. The heart rate increased considerably from baseline both in the off-mask ($P < 0.001$) and on-mask phases ($P < 0.001$) (Figure 1B), whereas the maximum heart rate at peak exercise was similar between the off-mask and on-mask phases. No patient showed a significant drop in blood pressure or electrocardiogram changes at any point during treadmill exercise. In the analysis of echocardiography, the mean E/e' ratio did not change significantly during exercise in the off-mask phase ($P = 0.533$). Although E/e' decreased statistically after exercise in the on-mask phase from 9.3 (IQR, 7.8–13.3) to 8.5 (IQR, 7.4–10.6) ($P = 0.045$) (Figure 1C), this finding does not imply the presence of a relaxation abnormality or a significant hemodynamic compromise (6). In addition, no significant regional wall motion abnormalities were noted in any participant. Next, 24-hour monitoring of the heart rate and blood pressure showed no significant difference in the mean heart rate, mean systolic blood pressure, or mean diastolic blood pressure between the off-mask and on-mask phases (Figures 1D–1F). Furthermore, no patient showed significant arrhythmia, even in the on-mask phase.

Discussion

Patients with COPD are more likely to have worse outcomes with COVID-19 than the general population (7, 8). Thus, special attention should be given to the management of patients with COPD during the COVID-19 pandemic (9). On the basis of the efficacy of masks for protecting patients from COVID-19 in the general population, it is recommended that all patients with COPD wear face masks or facial coverings (10). A previous study reported that patients with COPD who wear N95 masks experience impaired oxygen saturation, exhaled carbon dioxide concentration, heart rate, and respiratory rate after a 6-minute-walk test (3). However, the differences between patients

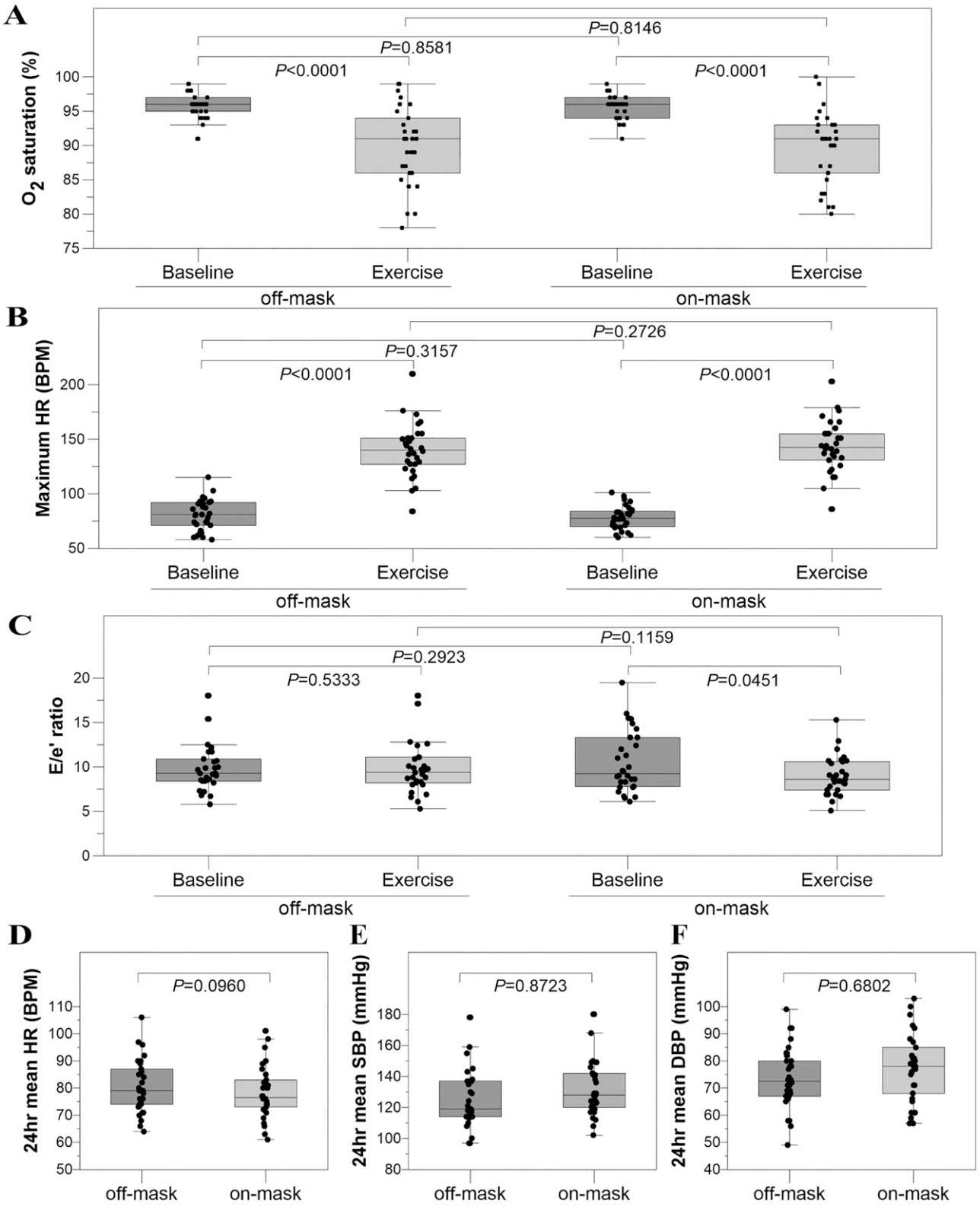

Figure 1. Oxygen saturation and hemodynamic factors according to wearing masks in patients with chronic obstructive pulmonary disease. (*A*) Changes in oxygen saturation during treadmill exercise. (*B*) Changes in the maximum HR during treadmill exercise. (*C*) Changes in the E/e' ratio after treadmill exercise. (*D*) The 24-hour mean HR. (*E*) The 24-hour mean systolic blood pressure. (*F*) The 24-hour mean diastolic blood pressure. DBP = diastolic blood pressure; HR = heart rate; SBP = systolic blood pressure.

with or without N95 masks seemed minimal and without clinical significance, as the difference in oxygen saturation after the 6-minute-walk test between with and without mask wearing was just 0.8%. Furthermore, because the study participants included all severity types of COPD, it is difficult to recommend that all patients with COPD should not wear face masks. Despite their greater protective effects, high-filtration respirators, such as N95, KN95, and KF94 masks, can increase inspiratory resistance and induce cardiopulmonary dysfunction (11, 12). Although surgical masks did not produce a detrimental effect on the gas exchange even in patients with severe COPD (FEV_1 less than 50%) (4), evidence is uncertain regarding the impact of face masks among patients with COPD of mild to moderate severity.

This is the first study to evaluate the effects of mask-wearing on oxygenation and cardiopulmonary hemodynamics during both exercise and daily activities in patients with mild to moderate COPD. We did not observe any impairment in oxygenation or serious changes in hemodynamic parameters while our participants wore KF80 masks. Although we did not measure the end-tidal carbon dioxide or respiratory rate, these findings suggest that wearing masks does not have serious adverse effects on respiratory function and cardiovascular hemodynamics, even during strenuous exercise.

Limitations. A few limitations should be considered in the interpretation of the study results. First, because only one type of face mask was used, we cannot compare the effects of various face masks and respirators. Second, all the patients had mild to moderate COPD, and most participants were male. Therefore, the generalizability of our findings to females is uncertain, and this study has a limited ability to make recommendations for wearing masks for patients with severe COPD, including among those with impaired oxygenation who require supplemental oxygen. Third, because we analyzed only the short-term effects of wearing masks for up to 24 hours, the long-term consequences of wearing masks cannot be determined from this study. Lastly, there was no measurement of patients' perception of dyspnea, which might influence willingness to wear masks, independently of whether there are objective changes in O_2 saturation and hemodynamics.

Conclusions. The findings of this prospective randomized crossover study suggest that wearing a face mask does not have serious effects on oxygenation and cardiovascular hemodynamics in patients with mild to moderate COPD. Thus, the protective benefits of wearing masks with regard to infection prevention appear to outweigh the risks. ■

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