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BRIEF REPORT

Facemasks and Walk Distance in Pulmonary Arterial Hypertension Patients

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Abstract

Little is known about the effect of wearing a facemask on the physiological and perceptual responses to exercise in patients with pulmonary arterial hypertension (PAH). We performed a single-center retrospective study to evaluate whether facemask wearing impacted distanced covered, rating of perceived exertion (RPE), and arterial oxygen saturation (SpO_2) during a 6-minute walk test (6MWT) in PAH patients. Forty-five patients being treated for group 1 PAH and who performed a 6MWT before and after implementation of a facemask mandate were included in the analysis. Each included patient performed a 6MWT without (test 1) and with (test 2) a facemask between October 1, 2019, and October 31, 2020. At both time points, all patients also underwent a submaximal cardiopulmonary exercise test, echocardiogram, and blood laboratory tests, with a Registry to Evaluate Early and Long-Term PAH Disease Management Lite 2.0 score calculated. The two 6MWTs were performed 81±51 days apart, and all patients were clinically stable at both testing timepoints. Six-minute walk test distance was not different between test 1 and test 2 (405±108 m vs 400±103 m, P=.81). Similarly, both end-test RPE and lowest SpO_2 during the 6MWT were not different in test 1 and test 2 (RPE: 2.5±1.7 vs 2.5±2.1, P=.91; SpO_2 nadir: 92.8±3.4% vs 93.3±3.3%, P=.55). Our findings show that wearing a facemask has no discernable impact on the arterial oxygen saturation and perceptual responses to exercise or exercise capacity in patients with moderate-to-severe PAH. This study reinforces the evidence that wearing a facemask is safe in PAH patients, even during exercise.

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Routine facemask wearing is a key control measure to prevent transmission of severe acute respiratory syndrome coronavirus 2. Despite evidence that facemasks provide enhanced protection against severe acute respiratory syndrome coronavirus 2 infection, achievement of widespread face mask use in the general public has proven challenging.[1-3] Frequently asserted reasons for noncompliance with facemask wearing include heightened breathlessness and carbon dioxide retention and/or hypoxemia, especially during exertion.[4,5]

Previous studies have shown that facemask wearing has only a modest or no significant impact the physiological or the perceptual responses to exercise, even in patients with severe lung disease.[6-8] Nonetheless, little is known about the effect of facemask wearing in patients with pulmonary arterial hypertension (PAH) who may be challenged by both gas exchange abnormalities and right heart dysfunction. Our objective was to evaluate whether facemask wearing impacted distanced covered, rating of perceived exertion (RPE), and arterial oxygen saturation (SpO_2) during a 6-minute walk test (6MWT) in PAH.

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PATIENTS AND METHODS

This single-center retrospective study was approved by the Mayo Clinic Institutional Review Board (#20-011268). On April 1, 2020, facemask wearing during 6MWTs was mandated in all patients at Mayo Clinic Jacksonville, FL. Forty-five patients being treated for group 1 PAH and who performed a 6MWT before and after implementation of the facemask mandate were included. Each patient included in this analysis performed a 6MWT without (test 1) and with (test 2) a facemask between October 1, 2019, and October 31, 2020. The 6MWTs were

performed according to standard American Thoracic Society procedures.[9] All patients were provided with, and wore, a new level 2 procedural mask during each 6MWT (Halyard, Alpharetta, GA, USA). Arterial oxygen saturation was measured at rest, throughout the 6MWT, and for up to 5 minutes after the 6MWT using a pulse oximeter instrumented with a finger probe (Nonin PalmSAT 2500, Nonin Medical Inc, Plymouth, MN, USA); presently, we report the lowest SpO_2 value (ie, the nadir) recorded during the 6MWT. The RPE was obtained within 15 seconds of 6MWT termination using the Borg category-ratio 10 scale.

At both timepoints (test 1 and test 2), all patients also underwent a submaximal cardiopulmonary exercise test (CPET),[10,11] echocardiogram, and blood laboratory tests, with a REVEAL Lite 2.0 score calculated.[12] A facemask was not worn during the submaximal CPET at either "Test 1" or "Test 2". The Registry to Evaluate Early and Long-Term PAH Disease Management (REVEAL) Lite 2.0 risk assessment calculator for patients with PAH includes six noninvasive variables: New York Heart Association (NYHA) functional class, vital signs (resting systolic blood pressure, and heart rate), 6MWT distance (6MWTd), brain-type natriuretic peptide (BNP)/N-terminal prohormone of brain natriuretic peptide, and renal insufficiency (by estimated glomerular filtration rate).

Based on visual inspection, data were determined to be normally distributed. Continuous data are displayed as a mean ± SD and categorical data are displayed as number (% patient cohort). Paired samples Student *t*-test was used to compare distance covered (6MWTd), RPE, and lowest SpO_2 recorded during the 6MWT, pulmonary gas exchange responses to the submaximal CPET, echocardiographic-derived measures of right ventricular systolic pressure and right ventricular size and function, BNP concentration, and REVEAL Lite 2.0 score. The acceptable type I error was set at $P<.05$, and all statistical analyses were performed using JMP version 14.1.0 (SAS Institute Inc., Cary, NC, USA).

RESULTS

Patient demographics are shown in Table 1; clinical data and submaximal CPET data are shown in Table 2. Test 1 and test 2 were performed consecutively and were separated by 81±51 days. Between test 1 and test 2, the patients were stable with no change in PAH disease severity as evidenced by no change in NYHA functional class, REVEAL Lite 2.0 score, BNP concentration, right ventricular systolic pressure, right ventricular function, and pulmonary gas exchange responses to the submaximal CPET (Table 2). The 6MWTd was not different between test 1 (without facemask) and test 2 (with facemasks) (405±108 m vs 400±103 m, $P=.81$). Similarly, both end-test RPE and lowest SpO_2 during the 6MWT were not different in test 1 versus test 2 (RPE: 2.5±1.7 vs 2.5±2.1, respectively, $P=.91$; SpO_2: 92.8±3.4% vs 93.3±3.3%, $P=.55$). In the patients who required the same amount of supplemental oxygen at both timepoints (n= 8; 17.8%), 6MWTd was not different between test 1 and test 2 (332±112 m vs 348±104 m, $P=.77$). Only three patients (6.7%) had a medication addition between the two time points.

TABLE 1. Demographics[a]

Characteristics	Values[b]
Age, years	60±11
Sex	
Male	9 (20.0)
Female	36 (80.0)
Race	
White	39 (86.7)
Black	4 (8.9)
Asian	2 (4.4)
Ethnicity	
Not Hispanic	41 (91.1)
Hispanic	4 (8.9)
BMI, kg/m^2	26.8±4.9
PAH subgroup	
1.1; Idiopathic	18 (40.0)
1.2; Heritable	2 (4.4)
1.4.1; Connective tissue disease	24 (53.3)
1.4.4; Congenital heart disease	1 (2.2)

[a]BMI, body mass index; PAH, pulmonary arterial hypertension.
[b]Values are number of patients (%) or group mean ± SD for 45 patients.

DISCUSSION

The main finding of the present study was that in clinically stable PAH patients with

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TABLE 2. Clinical Data[a,b]

Clinical data	Test 1	Test 2	*P*
NYHA/WHO FC			.93
I	4 (8.9)	5 (11.1)	
II	17 (37.8)	16 (35.6)	
III	24 (53.3)	24 (53.3)	
6MWTd, m	405±108	400±103	.81
6MWT SpO_2, %	92.8±3.4	93.3±3.3	.55
RPE, Borg CR10	2.5±1.7	2.5±2.1	.91
REVEAL Lite 2 score	8.2±2.9	8.4±2.8	.80
BNP, pg.mL	175±342	188±342	.86
RVSP, mm Hg	55.7±15.8	54.8±16.0	.80
TAPSE, cm	2.0±0.4	2.0±0.5	.74
RV enlargement			.82
None	14 (31.8)	17 (37.8)	
Mild	18 (40.9)	15 (33.3)	
Moderate	7 (15.9)	9 (20.0)	
Severe	5 (11.4)	4 (8.9)	
RV dysfunction			.97
None	25 (55.6)	25 (55.6)	
Mild	11 (24.4)	11 (24.4)	
Moderate	5 (11.1)	6 (13.3)	
Severe	4 (8.9)	4 (8.9)	
Submaximal CPET			
Resting SpO_2, %	96±3	96±3	.48
$\dot{V}_E/\dot{V}CO_2$ slope	38.0±9.7	38.7±11.1	.74
$\Delta P_{ET}CO_2$, mm Hg	2.2±2.1	2.1±2.0	.88

[a]6MWT, 6-minute walk test; 6MWTd, 6-minute walk test distance; BNP, brain-type natriuretic peptide; CPET, cardiopulmonary exercise test; CR, category-ratio; NYHA/WHO FC, New York Heart Association/World Health Organization functional class; $\Delta P_{ET}CO_2$, change in partial pressure of end-tidal CO_2 from start to end of submaximal CPET; SpO_2, arterial oxygen saturation; REVEAL, Registry to Evaluate Early and Long-Term Pulmonary Arterial Hypertension Disease Management; RPE, rating of perceived exertion at the point of 6MWT termination; RV, right ventricular; RVSP, right ventricular systolic pressure; TAPSE, tricuspid annular plane systolic excursion; $\dot{V}_E/\dot{V}CO_2$, ventilatory equivalent for carbon dioxide.

[b]Values are number of patients (%) or group mean ± SD for 45 patients. Test 1 and test 2 were performed 81±51 days apart. Six-minute walk test (6MWT) at test 1 was performed without a facemask, whereas 6MWT at test 2 was performed with a facemask. A facemask was not worn during the submaximal cardiopulmonary exercise test (CPET) during either test 1 or test 2.

moderate-to-severe disease, wearing a facemask had no effect on distance covered, rating of perceived exertion, or oxygen saturation during a 6MWT. This is important because 6MWTd and SpO_2 during the test provides adjunctive clinical information regarding functional status, disease severity and/or progression, and efficacy of therapeutic intervention.

Facemask function is, in part, determined by the resistance to airflow provided. Effective facemasks likely lower the risk of virus transmission between people in close proximity to each other secondary to a reduction in forward particle velocity in exhaled breath.[13] This functionality has, however, led to concerns regarding facemask use during physical activity. It has been considered possible that such resistance to airflow could negatively impact pulmonary gas exchange and heighten breathlessness and breathing discomfort, especially during exercise; such reasoning is often cited when justifying facemask noncompliance.[4,5] Despite these concerns, there is growing evidence that any negative effects of wearing a facemask during physical activity are negligible, and unlikely impact the thermal, cardiopulmonary (including heart rate, respiratory frequency, and pulmonary gas exchange), and perceptual responses to exercise.[6-8,14]

Importantly, our data suggest that the distance covered (ie, exercise capacity), the perceptual response, and SpO_2 during a 6MWT are not negatively affected by the wearing of a facemask in clinically stable PAH patients with moderate-to-severe disease. Ventilatory inefficiency coupled with impaired pulmonary gas exchange and breathlessness during exercise is a hallmark of PAH. A number of signature breathing and gas exchange derangements, including a greater ventilatory equivalent for carbon dioxide, a blunted increase or even a decrease in the partial pressure of end-tidal CO_2 early in exercise, and exercise-related arterial hypoxemia become apparent during exercise in PAH patients.[10,11] The etiology of these derangements in PAH is complex, but is likely related to ventilation-perfusion imbalances, physiological shunts, and an exaggerated ventilatory drive secondary to greater sensitivity of muscle ergoreceptors and/or central and peripheral chemoreceptors.[10,15] As such, the present findings suggest that wearing a facemask is safe and has no deleterious impact on exercise capacity, even in a high-risk population who are predisposed to impaired exercise

pulmonary gas exchange, heightened breathlessness, and exertional intolerance.

Two important questions remain: (1) Does wearing a facemask negatively impact exercise capacity when exercise is performed at a higher intensity? and (2) Does the type of facemask used affect the physiological and perceptual responses to exercise? First, achieving a 6MWTd of ~400 m is approximately equivalent to 3.0 metabolic equivalents.[16] That is, although patients are instructed to "walk as far as possible for 6 minutes," the exercise intensity associated with a 6MWTd of ~400 m is possibly only moderate. Higher intensity exercise naturally requires higher minute ventilations. Whether the resistance to airflow provided by facemasks at such higher ventilatory rates negatively impacts exercise capacity requires further investigation. Second, N95 respirators provide greater airflow resistance compared to surgical and/or cloth facemasks. However, even at a relatively high minute ventilation (100 $L \cdot min^{-1}$), it has been shown that the airflow resistance provided by N95s is modest, and similar to the facemask and tubing used during standard cardiopulmonary exercise tests. Thus, it is perhaps unlikely that the physiological and perceptual responses to exercise with versus without a facemask are substantially altered by the type of facemask worn.

CONCLUSION

Our findings demonstrate that wearing a facemask has no discernable impact on the arterial oxygen saturation and perceptual responses to exercise or exercise capacity in patients with moderate-to-severe PAH. This study reinforces the evidence that facemasks are safe in PAH patients, even during exercise.

Abbreviations and Acronyms: **6MWT**, 6-minute walk test; **6MWTd**, 6-minute walk test distance; **BNP**, brain-type natriuretic peptide; **CPET**, cardiopulmonary exercise test; **NYHA**, New York Hear Association; **PAH**, pulmonary arterial hypertension; **RPE**, rating of perceived exertion; **SpO_2**, arterial oxygen saturation

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