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The effect of body mass index on pulmonary rehabilitation outcomes in patients with chronic obstructive pulmonary disease

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Abstract

CONTEXT: Although pulmonary rehabilitation (PR) is increasingly used in patients with chronic obstructive pulmonary disease (COPD), the factors affecting the gains obtained from PR are still not clear.

AIMS: We aimed to investigate the effect of body mass index (BMI) on PR outcomes in COPD.

SETTINGS AND DESIGN: The study was a retrospective–descriptive study.

SUBJECTS AND METHODS: Patients with BMI of 18.5–25 kg/m^2 were referred to as Group 1 (n = 15) and patients with BMI ≥25 kg/m^2 as Group 2 (n = 17). All patients received PR for 8 weeks. Six-min walking distance (6MWD), forced expiratory volume in 1-s, forced vital capacity (FVC), carbon monoxide diffusing capacity (DLCO), maximal inspiratory pressure (MIP), modified Medical Research Council dyspnea scale (mMRC), and COPD assessment test (CAT) scores were compared.

STATISTICAL ANALYSIS USED: Paired *t*-test, Wilcoxon rank, and Mann–Whitney-U test were used for statistical analysis.

RESULTS: Thirty-two patients were included in the study. Baseline parameters were similar except 6MWD. Following PR, 6MWD, mMRC, and CAT scores were significantly improved in both the groups ($P < 0.05$). A significant difference was found in favor of Group 1 for FVC ($P = 0.039$) and MIP ($P = 0.018$), while no difference was detected in DLCO.

CONCLUSIONS: In this study, PR yielded similar gains between COPD patients with high BMI and those with normal BMI in terms of exercise capacity, dyspnea, and disease symptom severity. The only additional gains were achieved in the respiratory functions of patients with normal weight. All COPD patients should be referred to PR, regardless of the BMI, taking into account the resulting PR gains.

Keywords:

Body mass index, chronic obstructive pulmonary disease, obesity, pulmonary rehabilitation

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Introduction

Pulmonary rehabilitation (PR) is a valid and reliable treatment modality for many patients with respiratory conditions, especially chronic obstructive pulmonary disease (COPD).[1] The effect of obesity on exercise tolerance and dyspnea in COPD patients is still unclear.[2] Although there are some views that clinical and functional findings will not affect PR outcomes,[3] it is suggested that PR may be more effective in obese patients, especially weight loss reduces airway obstruction in COPD patients and increases static lung volumes.[4] In our study, we aimed to investigate the effect of body mass index (BMI) on PR gains in COPD patients.

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Subjects and Methods

The records of 32 COPD patients enrolled in the exercise program of PR center between 2014 and 2017 were retrospectively reviewed. The study was approved by the Local Ethics Committee (Protocol no: 10840098-604.01.01-E.4229). Signed informed consent was obtained from each patient before commencing the PR program for routine clinical procedure. Data from fifty patients were retrospectively analyzed. Sixteen with missing data and two cachectic patients were excluded from the study. The remaining patients were divided into two groups by BMI. Patients with BMI of 18.5–25 kg/m^2 were referred to as Group 1 (n = 15) and patients with BMI ≥25 kg/m^2 (25.3–38.4) as Group 2 (n = 17) [Figure 1].

Outcome measurements

Six-min walking test

The test was conducted in a 30-m corridor in line with the American Thoracic Society (ATS) guidelines. Patients were informed that they should walk as fast as they can walk. Before and after the test, oxygen saturation, heart rate, Borg fatigue rating, and walking distance were recorded.[5,6]

Pulmonary function test

It was conducted using the SensorMedics model 2400 (Yorba Linda, CA, USA), according to the ATS guidelines.[7]

Carbon monoxide diffusion test

It was performed in the pulmonary function test laboratory using Cosmed Quark PFT (USA) with single-breath technique.[8]

Maximum inspiratory pressure-maximum expiratory pressure

The mouth pressure measurement was performed with the Micro-RPM® instrument from SensorMedic. Patient placed a rubber mouthpiece with flanges, on the device, sealed their lips firmly around the mouthpiece, exhaled/inhaled slowly and completely, and then tried to breath in as hard as possible.[9] The patient was allowed to rest for about a minute and the maneuver was repeated five times. Verbal or visual feedback was provided after each maneuver. The aim is that the variability between measurements is <10 cmH_2O. The maximum value was obtained.[10]

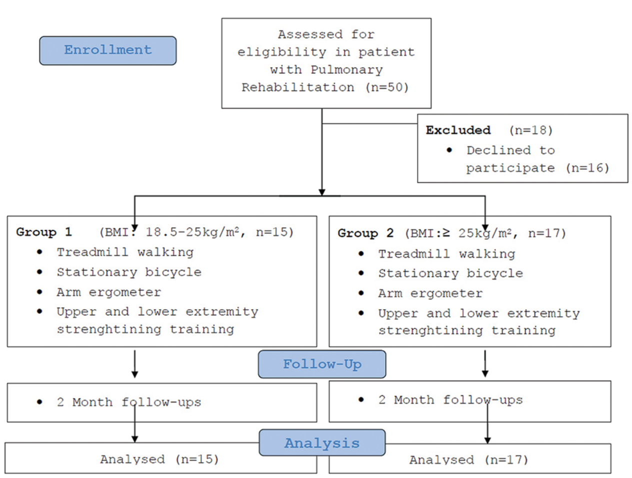

Figure 1: Study flow chart

Modified medical research council dyspnea scale

Dyspnea perceptions during the activities of daily living were assessed with the modified Medical Research Council (mMRC) scale.[11]

Chronic obstructive pulmonary disease sment assessment test

COPD Assessment Test (CAT) scale was employed to determine the severity of COPD.[12]

Exercise program

All patients received an 8-week PR for a total of 5 days consisting of 2 days a week at hospital setting and 3 days a week at home setting without supervision. The exercise program included breathing exercises, aerobic exercises, and upper and lower extremity strengthening exercises. Chest breathing, diaphragmatic breathing, and lateral basal breathing exercises were taught as a part of respiratory exercises. Methods of breath control and coping with dyspnea were explained. Treadmill (15 min/day), cycling (15 min/day), and arm ergometer workouts (15 min/day) were used for aerobic exercises, while free-weight lifting was used for strengthening exercises. The aerobic exercise workload was calculated by target heart rate method with the maximum heart rate being at least 60%. One-repetation maximum which was calculated in the strengthening exercises started at 20% of the weight which was progressively increased depending on the tolerance.

Statistical analysis

Normalities of the test data were examined using "Shapiro–Wilk" test. With regard to normally distributed data, intragroup variances were compared using "paired t-test," while intergroup comparisons were made using "Independent student's t-test." With regard to nonnormally distributed data, intragroup comparisons were made using "Wilcoxon rank test," while intergroup variances were compared using "Mann–Whitney U-test." Statistical significance level was accepted at $P < 0.05$. We estimated that a sample size of 15 patients for each group to have 80% power with 5% Type 1 error level to detect a minimum clinically significant difference of 54 m[13] of the 6-min walking distance (6MWD)[14] with the highest standard deviation of the study parameters.

Results

The records of 32 COPD patients with a mean age of

58.81 ± 11.58 years, of whom 24 (75%) were male and 8 (25%) were female, and who were included in the PR program, while they were in stable period, were retrospectively reviewed. The patients' disease severity stages according to The Global Initiative for Chronic Obstructive Lung Disease were 12.5% (*n* = 4) Stage 1; 21.9% (*n* = 7) Stage 2; 13% (*n* = 40.6) Stage 3; and 25% (*n* = 8) Stage 4, respectively. Patients with BMI of 18.5–25 kg/m² were referred to as Group 1 (*n* = 15) and patients with BMI >25 kg/m² (25.3–38.4) as Group 2 (*n* = 17). When additional disease profiles were examined, two hypertensive patients and one patient with ischemic heart disease in Group 1 and three hypertensive patients and one diabetic patient in Group 2 were detected. Baseline parameters were similar in groups except for 6MWD. In Group 2 patients, baseline 6MWDs were lower than in Group 1 patients (*P* = 0.039). Patients' baseline clinical and demographic characteristics are presented in Table 1.

Table 1: Comparison of prepulmonary rehabilitation clinical and functional parameters by groups

	Group 1, (*n*=15)	Group 2, (*n*=17)	*P*
Demographic characteristics			
Male/female	10/5	14/3	0.314
Age (year)	57 (34-75)	60 (30-75)	0.438
BMI (kg/m²)	22.53 (20-24)	29.16 (25-38)	0.0001
Smoking (pack/year)	37 (7-60)	44 (7-80)	0.612
Lung functions			
FEV_1, L	1.08 (0.5-2.40)	1.35 (0.6-2.50)	0.088
FEV_1 (%)	38.33 (21-83)	51.52 (20-8)	0.117
FVC, L	2.01 (1.2-4.60)	2.26 (1.20-3.80)	0.185
FVC (%)	53 (5-102)	67.23 (29-126)	0.126
FEV_1/FVC	55.06 (39-91)	61.05 (34-85)	0.140
Exercise capacity			
6MWD (m)	436 (279-594)	375.47 (195-489)	0.039
CAT	18 (7-30)	14.23 (2-27)	0.151
mMRC	3 (1-4)	2 (1-4)	0.597

Group 1: Patients with BMI 18.5–25 kg/m², Group 2: Patients with BMI >25 kg/m², BMI: Body mass index, FEV_1: Expiratory volume in 1 s, FVC: Forced vital capacity, 6MWD: 6-min walking distance, COPD: Chronic obstructive pulmonary disease, CAT: COPD assessment questionnaire, mMRC: modified Medical Research Council dyspnea score

Statistically significant improvement was observed in both the groups for 6MWD (m), CAT, and mMRC scores at the end of the PR exercise program. However, there was no difference between the groups; the gains were similar. When the changes in the parameters of respiratory function test were examined, there were positive but nonstatistical improvements in Group 1, while there were nonstatistically significant decreases in Group 2. Intergroup comparisons showed a significant

Table 2: Pre- and post-pulmonary rehabilitation clinical and functional parameters of Group 1 vs. Group 2

	Group 1 (*n*=15)			Group 2 (*n*=17)			Differences between groups	
	Pre-PR	Post-PR	*P*	Pre-PR	Post-PR	*P*	*Z*	*P*
Lung functions								
FEV_1, L	1.08 (0.5-2.40)	1.07 (0.43-2)	0.722	1.35 (0.6-2.50)	1.26 (0.6-2.10)	0.176	−1.128	0.259
FEV_1 (%)	38.33 (21-83)	39.48 (17.60-83)	0.609	51.52 (20-98)	47.17 (18-95)	0.065	−1.400	0.162
FVC, L	2.01 (1.2-4.60)	2.13 (1.20-4)	0.220	2.26 (1.20-3.80)	2.12 (1.2-4)	0.081	−1.875	0.061
FVC (%)	53 (5-102)	61.56 (41-89)	0.088	67.23 (29-126)	61.52 (28-126)	0.209	−2.060	0.039
FEV_1/FVC	55.06 (39-91)	51.59 (40-77)	0.245	61.05 (34-85)	61.48 (34-86)	0.733	−1.286	0.199
Exercise capacity								
6MWD (m)	436 (279-594)	480.46 (297-598)	0.002	375.47 (195-489)	454.23 (332-550)	0.001	−1.813	0.070
CAT	18 (7-30)	12.93 (2-22)	0.001	14.23 (2-27)	10 (1-25)	0.005	−0.588	0.557
mMRC	3 (1-4)	2 (0-4)	0.002	2 (1-4)	1 (0-4)	0.002	−0.289	0.773
	Group 1 (*n*=7)			Group 2 (*n*=5)			Differences between groups	
	Pre-PR	Post-PR	*P*	Pre-PR	Post-PR	*P*	*Z*	*P*
MIP	62.28 (42-88)	78.71 (53-94)	0.018	70.40 (44-101)	83.40 (72-92)	0.176	0.000	1.000
MEP	108.14 (65-138)	118.28 (61-168)	0.237	134.80 (99-194)	128.80 (79-157)	0.893	−0.244	0.808
	Group 1 (*n*=12)			Group 2 (*n*=16)			Differences between groups	
	Pre-PR	Post-PR	*P*	Pre-PR	Post-PR	*P*	*Z*	*P*
DLCO	16.15 (5-37)	15.69 (9-28)	0.598	16 (10-25)	16.25 (7-42)	0.585	−0.155	0.877
DLCO (% predicted)	60 (27-117)	60.76 (35-114)	0.972	63.93 (42-86)	62.75 (35-143)	0.460	−0.592	0.554
DLCO/VA	3.58 (2.20-5.30)	3.43 (2.10-5.30)	0.057	4.18 (2.20-7.20)	6.60 (1.50-44)	0.409	−1.696	0.090
DLCO/VA (% predicted)	82.69 (46-120)	79.61 (44-120)	0.053	97.50 (50-171)	97.75 (40-126)	0.313	−1.802	0.072

Group 1: Patients with BMI 18.5–25 kg/m², Group 2: Patients with BMI >25 kg/m², PR: Pulmonary rehabilitation, FEV_1: Expiratory volume in 1 s, FVC: Forced vital capacity, 6MWD: 6-min walking distance, COPD: Chronic obstructive pulmonary disease, CAT: COPD assessment questionnaire, mMRC: modified Medical Research Council dyspnea score, MIP: Maximal inspiratory pressure, MEP: Maximal expiratory pressure, DLCO: Carbon monoxide diffusing capacity, BMI: Body mass index DLCO/VA: alveolar volume ratio of carbonmonoxide diffusion capacity

difference in forced vital capacity (FVC) (% predicted) value in favor of Group 1 ($P = 0.039$). The changes in the pre- and post-PR clinical and functional parameters of the groups were presented in Table 2.

Maximal inspiratory pressure (MIP) and ME*P* values of the subgroup with available mouth pressure measurements (Group 1, $n = 7$; Group 2, $n = 5$) showed increased MI*P* value in Group 1 ($P = 0.018$), whereas no difference in Group 2 ($P = 0,176$). There was no statistically significant difference between the groups for delta MIP versus ME*P* values [Table 2]. In the subgroup (Group 1, $n = 12$; Group 2, $n = 16$) consisting of patients who were eligible for testing and compatible with the measurement of carbon monoxide diffusing capacity (DLCO), no statistically significant difference was found between the groups in terms of diffusion capacity [Table 2].

Discussion

The study results showed that PR yielded similar gains between COPD patients with high BMI and those with normal BMI in terms of exercise capacity, dyspnea, and disease symptom severity. The only additional gains were achieved in respiratory functions of patients with normal weight. After rehabilitation, no statistically significant difference was found between the groups in terms of respiratory muscle strength and diffusion capacity.

Excess weight and obesity is a health problem seen worldwide. Based on the Global Burden of Disease Study, as per 2013 data, 2.1 million people were reported to be overweight or obese, whereas as per 2016 data, 120.1 million people were reported to be overweight or obese and the prevalence of obesity in COPD was known to be 18%.[15]

In obese patients with COPD, dyspnea increases, quality of life impairs, and depression, sleep disturbances, and cardiac and metabolic comorbidity risks are also increased.[16] On the other hand, physical inactivity and obesity are interchangeable risk factors of chronic diseases and PR is the most important nonpharmacological treatment approach that can reverse this.[17] A study examining the effect of body composition on PR gains in COPD setting demonstrated that gains increased exercise tolerance, irrespective of muscle mass or obesity.[18] A similar study including 155 patients achieved similar gains of exercise capacity and self-report disease impact of individuals regardless of BMI.[19] In parallel with our literature, it was also found that the PR program is effective in controlling exercise capacity, dyspnea, and disease symptom severity both in overweight and obese COPD patients and COPD patients with normal weight.

Obese patients often experience the vicious cycle of low exercise capacity, physical disability, and breathlessness leading to physical inactivity.[20] Excess weight is associated with low exercise capacity.[21] Exercise capacity of obese and nonobese COPD patients is affected by many factors both pulmonary and nonpulmonary.[22] A study reported that obese individuals had similar features in terms of many parameters such as oxygen consumption and minute ventilation while having a lower 6MWD.[23] In our study, the 6MWD of high BMI group was shorter. Moreover, we showed that although the COPD patients with high BMI had a shorter initial 6MWD, similar exercise capacity improvement was observed in both the groups.

PR protocols applied in obese patients are similar to those applied in patients with other chronic respiratory diseases. In a study,[24] obese patients on CPAP with sleep apnea syndrome were randomly allocated to exercise training on a cycle ergometer, either alone or with respiratory muscle training or noninvasive ventilation (NIV). It was emphasized that NIV may be preferred for its ability to reduce cardiometabolic risk, while no additional benefit was observed in groups whose program was supplemented with respiratory muscle training and NIV. Another approach in the literature is land-based and water-based exercise programs. Water-based exercise programs have long been on the agenda in obese patients.[25] In a study examining water-based exercise in COPD setting, water-based exercise training was found to increase endurance exercise capacity more than land-based exercise.[26] Same investigators reported that water-based training in obese patients with COPD improved exercise capacity and health-related quality of life more than a similar land-based exercise training program.[27] In our study, a standard PR program boosted with aerobic and strengthening exercises applied to all chronic respiratory patients was used. There is a need for studies designed with different exercise modalities.

In a parallel design study, compared obese and nonobese COPD patients, researchers reported that obese patients had higher static recoils and intraabdominal pressures, while there was no difference in resting respiratory muscle strength.[28] In our study, an increase in postrehabilitation inspiratory muscle strength was found only in individuals with a low BMI. Obesity may be a clinical parameter that prevents the positive effect of PR on respiratory muscle strength.

A study where dietary energy restriction coupled with resistance exercise training is applied together in obese patients with COPD showed improved BMI, increased exercise capacity, and improved health status.[29] In another study on obese women, dyspnea on exertion was reduced by only aerobic exercise with no weight loss.[30] All of our patients have consulted to a dietician for our routine clinic operation. One of the weaknesses of our study is that the reflections of dietary programs applied to the patients on PR gains have not been documented. Given the literature, we believe that the combination of healthy nutrition and exercise is the ideal approach.

Dyspnea is one of the most important symptoms affecting the quality of life in patients with COPD and moderate or severe dyspnea is defined in more than 40% of the COPD patients.[31] In a population-based study, it was reported that obese patients with COPD had more dyspnea complaints and poorer quality of life compared to patients with normal weight.[32] Compared with COPD patients with different weights and similar forced expiratory volume in 1-s values, obese patients with COPD have been shown to have less hyperinflation and greater inspiratory capacity.[33] One study showed that the post-PR dyspnea score decreased in patients with a mMRC dyspnea score of 3 and higher.[34] In another study, PR was shown to improve dyspnea score in all patients having different mMRC dyspnea scores.[35] In our study, baseline dyspnea scores were similar among groups and similarly to the literature; a significant improvement in the dyspnea score was observed in both groups following PR. However, there was no difference in the level of improvement among groups.

In a study[36] on a patient population consisting of obese asthma and COPD patients, it was found that weight loss decreased airway obstruction and increased expiratory reserve volume (ERV), RV, functional residual capacity, and DLCO parameters. Another study[3] showed that exercise capacity is low even in obese patients with COPD with early-stage spirometric changes. The same study emphasized that obesity had no effect on PR outcomes. In our study, we found that baseline respiratory function parameters were similar in both groups and that the spirometric values of COPD patients with normal weight were either maintained or had a tendency to increase after the exercise program, and that the spirometric parameters of the obese group tended to decrease in a nonstatistically significant manner. We also found that there was a significant difference in FVC values in favor of patients with normal weight. This can be interpreted as reduced positive effect on respiratory functions in obese patients with COPD, resulting from PR.

The CAT is an easy-to-use questionnaire that has become increasingly common in clinical practice to determine the control status and quality of life of the disease.[37] It correlates strongly with dyspnea and exercise tolerance.[38] It has also been reported that CAT test can be used to follow the changing health situation and determine the PR gains.[39] A study involving 544 patients with severe COPD found significant improvement in CAT and mMRC scores after PR applied at home setting.[40] Another study conducted on obese patients with COPD reported that PR significantly improved CAT scores, irrespective of BMI.[19] Similarly, in our study, we observed a significant post-PR improvement in CAT score in both groups, with no difference in terms of improvement level.

A study investigating what clinical predictors might be in predicting PR activity in COPD, it has been reported that baseline clinical and functional findings may not be predictive of PR gains. However, it has been suggested that overweight and obese hypoxemic patients with BMI >25 kg/m^2 may benefit more from exercises due to their low conditions.[41] Although, in our study, there were groups that were not similar in terms of 6MWD among groups that were formed by their BMI, PR gains for exercise capacity, dyspnea score, and self-report disease impact of individuals were similar at the end of the program. The results were not affected by basal exercise capacity. In addition, PR gains for respiratory muscle strength and spirometric values were lower in the group with higher BMI.

Study limitations

The study design was retrospective and the number of cases was relatively small.

Conclusions

PR yielded similar benefits between COPD patients with high and normal BMI in terms of exercise capacity, dyspnea, and disease control status in this study. Additional gains were achieved in respiratory functions of COPD patients with normal BMI. In the literature, although different effects of obesity on PR outcomes are reported, we can say that PR improves exercise capacity, dyspnea, and disease severity control independently of BMI and that every COPD patient should be referred to PR. However, the future studies are warranted on the development of new exercise programs and dietary recommendations to increase the gains of obese patients with COPD from PR.

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Conflicts of interest

There are no conflicts of interest.

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