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Does Increased Body Mass Index Effect the Gains of Pulmonary Rehabilitation in Chronic Obstructive Pulmonary Disease Patients?

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Abstract

Objective: We aimed to compare the gain of pulmonary rehabilitation (PR) in obese, pre-obese, and normal-weight patients with chronic obstructive pulmonary disease (COPD) who underwent a PR program.

Methods: COPD patients (n=137) underwent pulmonary and cardiac system examination and pulmonary function tests (PFTs) before PR. Chest X-rays, arterial blood gases, body mass index, quality of life (QOL) questionnaires, anxiety and depression scores, and Modified Medical Research Council dyspnea scale (MMRC) scores were evaluated in all patients. A 6-min walk test was performed to determine the exercise capacity of the patients. All patients underwent an 8-week outpatient PR program. The patients were reevaluated at the end of 8th week in terms of all parameters.

Results: The study group consisted of 44 normal-weight, 52 pre-obese, and 41 obese COPD patients. Before PR, there was no significant difference in terms of 6-min walk distance (6MWD), PFT, MMRC, or QOL scores between the groups ($p>0.05$ for all). After PR, partial arterial oxygen pressure and arterial saturation, MMRC, and QOL scores improved significantly in all three groups ($p<0.05$ for all). 6MWD and walkwork significantly increased after PR in all three groups ($p<0.001$ for all), but the gain in 6MWD was significantly lower in obese patients compared to pre-obese and normal-weight patients ($p=0.049$).

Conclusion: Pre-obese and obese patients benefit from PR similarly to the normal-weight patients in terms of gas exchange, dyspnea perception, and QOL. But it seems to be that exercise capacity improves less in obese COPD patients compared to pre-obese and normal-weight patients.

Keywords: COPD, exercise capacity, obesity, pulmonary rehabilitation

INTRODUCTION

Obesity is one of the most important public health problems, and it is increasing in prevalence worldwide (1, 2). Obesity is an inflammatory disease that involves many systems in the body, especially the respiratory system, causing changes in pulmonary functions (2). Chronic obstructive pulmonary disease (COPD) is also an important public health problem usually accompanied by nutritional abnormalities (3, 4). The majority of COPD patients are overweight or obese rather than normal or low-weight (4). Obesity and COPD cause mortality and morbidity all over the world, and this global outbreak is predicted to be much higher in the future (5). Obesity might be the reason for respiratory symptoms alone due to decreased pulmonary compliance, increased work in breathing, and increased need for oxygen, even without airway obstruction. However, obesity might also increase the numbers of obstructed peripheral airways (6). It was determined that dyspnea perception is enhanced, health status is impaired, and quality of life (QOL) is reduced in obese COPD patients compared to non-obese COPD patients (7, 8). It has been shown that pulmonary rehabilitation (PR) reduces dyspnea, enhances exercise performance, improves QOL, and decreases psychological symptoms in COPD patients (9). The present study aimed to compare the gains of PR in obese, pre-obese, and normal-weight COPD patients who completed an 8-week outpatient PR program.

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METHODS

Chronic obstructive pulmonary disease patients (n=265) referred to the Pulmonary Rehabilitation Unit between January 2013 and May 2016 were retrospectively reviewed from the hospital's database. This retrospective cohort study was approved by our hospital's ethics committee. The flowchart of the study is shown in Figure 1. After acceptance of the PR program, data from 208 patients with COPD who started the program were studied. Patients were excluded because of lack of PR coherence (lack of motivation, transportation problems, and symptom exacerbations). Also, patients were excluded if they had a BMI <21 or >40 kg/m^2. Finally, a total of 137 COPD patients (122 males) who completed the PR program were enrolled in the study. Demographic characteristics and clinical features of the patients as well as smoking history were obtained from the database. All study participants were called by phone and informed about the aim of study and analysis methods, and their consent for participation was obtained. The patients were questioned in detail about comorbidities. Diabetes mellitus, hypertension, and coronary artery disease were evaluated from medical records. All patients routinely underwent pulmonary and cardiac system examination and pulmonary function tests (PFT) before and after PR. Chest X-rays and arterial blood gases were evaluated. According to the World Health Organization criteria for body mass index (BMI), the patients were classified as normal-weight (BMI=18.5–24.9 kg/m^2), pre-obese (BMI=25–29.9 kg/m^2), or obese (BMI=30–39.9 kg/m^2) (10). COPD patients with BMI <21 had undergone a supportive nutrition program, so these patients were excluded from the study. COPD severity was classified according to The Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria as mild, moderate, severe, or very severe (11).

Respiratory Functions: Body plethysmography (Zan 500, Germany) and carbon monoxide diffusion capacity (TLCO) (Zan 300, Germany) were measured and recorded before and after PR.

Assessment of Dyspnea: The Modified Medical Research Council (MMRC) dyspnea scale, which consists of five items ranging between 1 and 5, was used to determine the severity of patients' shortness of breath (12). The score "1" represents the best level, and the score "5" indicates the poorest.

Exercise Capacity: The patients underwent a 6-min walk test, and the 6-min walk distance (6MWD) was obtained from the database recorded before and after PR (13). The walkwork value was obtained by multiplying the patient's walking distance by their body weight according to the formula in (14).

Psychological Symptoms: The Hospital Anxiety and Depression (HAD) scale, which consists of 14 questions, was used to determine the patients' psychological status (15). A HAD score of 0–7 indicates normal, 8–11 indicates borderline disease, and >11 indicates the presence of anxiety or depression.

Quality of Life: St. George's Respiratory Questionnaire was used to determine disease-specific QOL (16). High scores define worsened disease and increased symptoms. Overall QOL was assessed by the SF-36 QOL Questionnaire (17). Increased scores were considered in favor of improved QOL.

PR and physiotherapy sessions, lasting 2 h, were performed twice a week for eight weeks to all patients that joined the program. The exercise program included breathing exercises, relaxation and stretching exercises, peripheral muscle strength training, and aerobic exercises. Breathing exercises consisted of pursed-lip breathing, diaphragmatic breathing, and thoracic expansion exercises. In addition, bronchial hygiene techniques and dyspnea-reducing positions were taught. Aerobic exercises were performed on a treadmill or bicycle for 30 min. An arm ergometer was used for the patients with joint disorders or anatomical lower extremity disability. Exercise intensity was predetermined to be 60–90% of the maximum heart rate. Exercise intensity was gradually increased taking the severity of dyspnea as the basis. An intermittent exercise program with oxygen support was performed in the hypoxic or hypercapnic patients with severe COPD. All patients were informed about the importance of continuing exer-

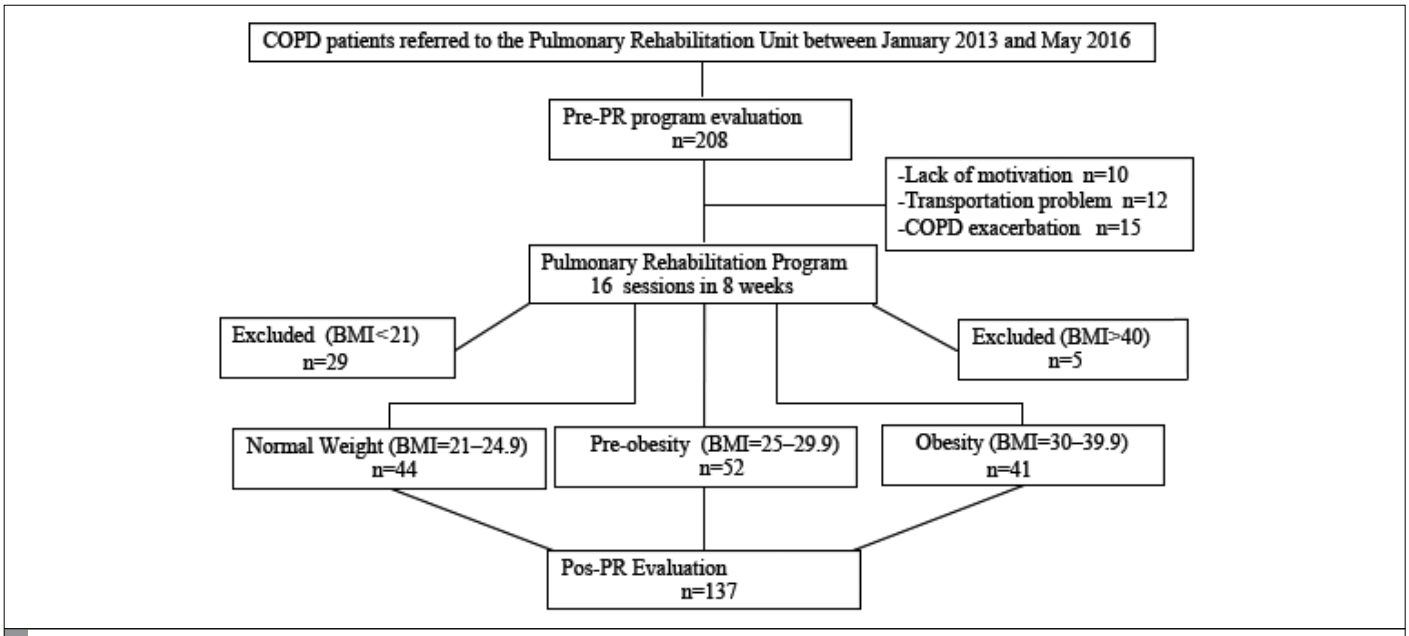

Figure 1. Flowchart of the study

cising at home. Patients were reevaluated at the end of 8th week in terms of all parameters.

Statistical Analysis

Statistical analyses were performed with the SPSS 17.0 program (Statistical Package for the Social Sciences Inc.; Chicago, Illinois, USA). The normality of the data was evaluated by the Kolmogorov–Smirnov test. Results are shown as the change between post-treatment and baseline values (Δ values). The Kruskal–Wallis H-test followed by the Mann–Whitney U-test with Bonferroni correction was used for intergroup comparisons. The variables before and after PR were compared in each group with the Wilcoxon Signed Rank Test. A p-value < 0.05 is considered significant.

RESULTS

The study group consisted of 44 normal-weight, 52 pre-obese, and 41 obese COPD patients. Demographic features and differences between three groups before PR are shown in Table 1. Each group was similar in terms of gender distribution (p=0.958). Age, gender, GOLD stage, smoking consumption, exacerbation history, arterial blood gas, 6MWD, and QOL scores did not differ between the three groups (p>0.05, Table 1). The prevalence of hypertension was significantly higher in pre-obese and obese patients as compared to the normal-weight patients (p=0.008, Table 1). Also, as expected, diabetes mellitus was significantly more prevalent in obese patients compared to normal-weight and pre-obese patients (p<0.001, Table 1). TLCO was significantly lower in normal-weight patients as compared to pre-obese and obese patients (p<0.001, Table 1), but there was no significant difference between the groups in terms of 6MWD (p=0.761, Table 1). The walkwork value was significantly higher in obese patients as compared to both pre-obese and normal-weight patients (p=0.003 and p<0.001, respectively, Table 1). When comparing post-PR outcomes with the baseline values, we found that forced expiratory volume in the first second (FEV_1) was significantly increased in normal-weight and pre-obese patients, whereas the increase in obese patients was not considered significant. None of the groups had a significant change in PFT results after PR (p>0.05, Table 2). Partial arterial oxygen pressure (PaO_2) and arterial oxygen saturation (SaO_2) were significantly increased in all groups, but the change in partial carbon dioxide pressure ($PaCO_2$) was not significant in any of the groups (p>0.05, Table 2). The 6MWD and walkwork values were significantly increased and dyspnea scores were significantly decreased in all groups after PR (p<0.001, Table 2). Each group showed significant improvement in all scores of disease-related QOL and in most of health-related QOL scores after PR (p<0.05, Table 2). In the normal-weight patients, both anxiety and depression scores were significantly decreased after PR (p<0.001 and p=0.003, respectively, Table 2); however, a significant decrease was determined only in the anxiety scores in pre-obese patients (p=0.054, Table 2). There was no significant decrease in depression scores in obese patients (p>0.05, Table 2).

When comparing the three groups in terms of post-PR benefits, it was observed that the increase in 6MWD was significantly lower in obese patients than normal-weight and pre-obese patients (p=0.049, Table 3, Figure 2). Other improvements were similar in each group (p>0.05, Table 3, Figure 3).

DISCUSSION

In the present study, although 6MWD was similar in each group before PR, the walkwork value was higher in the obese patients. After PR there were similar benefits in all groups with the exception of the increase in 6MWD. The gain in 6MWD was significantly lower in obese patients as compared to pre-obese and normal-weight patients.

In obese subjects, fat tissue accumulates in the chest wall, diaphragm, and abdomen and alters respiratory mechanics. Accumulated fat reduces lung volume and decreases airflow by mechanically compressing the chest wall, diaphragm, and lungs (2). In addition, cytokines such as IL-6, which are released from visceral adipose tissue, cause systemic inflammation involving many systems, primarily the respiratory system (2). There is conflicting data regarding PFTs in obese patients. One study found no difference between normal-weight and obese patients in terms of FEV_1 and FEV_1/Forced vital capacity (FVC) values (18), whereas another study found FEV_1 values to be significantly lower in normal-weight patients as compared to the overweight and obese patients (19). Moreover, in another study both FEV_1 and FEV_1/FVC values were found to be significantly higher in obese versus non-obese patients (20). In our study, there was no significant difference between the groups in terms of FEV_1 values, but the FEV_1/FVC value was significantly higher in the obese patients. This finding might be due to the decreased FVC levels in obese patients. Similar to the literature (18), we found that the TLCO value was significantly higher in the obese patients. This might have resulted from increased pulmonary blood volume in the obese patients (21).

In our study, we observed significantly higher $PaCO_2$ in the obese patients, but there was no significant difference between the groups in terms of PaO_2 or SaO_2. The ventilation-perfusion ratio in obese patients is impaired due to micro-atelectasis in the basal segments of the lungs, and gas exchange is unfavorably influenced leading to impaired oxygenation. Partial oxygen pressure might mildly decrease, while $PaCO_2$ is mildly increased (22). In obese patients, dyspnea might be due to increased respiratory load and decreased static lung volume (23).

In the majority of previous studies, dyspnea scores were found to be higher in obese subjects compared to normal-weight subjects (7, 8). However, there are studies demonstrating no difference between obese and normal-weight patients in terms of dyspnea (21). In the present study, dyspnea scores were similar in each group.

Not all of the above studies take the COPD severity into account, and in our study the MMRC scores might reflect the COPD severity, which was similar in all three groups. Exercise intolerance might increase in obese subjects due to increased metabolic need and mass load (5). Owing to the different body weights, the walkwork value shows differences among individuals. In one study, it was determined that the walkwork value reflects the patients' functional capacity better than the other tests. (14). In two studies, which examined the patients in three groups as normal-weight, overweight, and obese, the 6MWD was found to be significantly lower in the obese patients with significantly higher walkwork values (3, 20). In one study that investigated the patients in two groups as obese and non-obese, there was no significant difference between the walkwork values, while the 6MWD was significantly lower in the obese patients (20). Another study show no decrease in the exercise capacity in the obese patients versus normal-weight patients (21). In our study, 6MWD was not significantly different before PR, but the walkwork value was significantly higher in the obese COPD patients as compared to the other two

Table 1. The demographic and clinical parameters of the patients before pulmonary rehabilitation

	Normal n=44	Pre-obese n=52	Obese n=41	p*
Age (years)	63 (56,68)	63 (58,69)	63 (57,69)	0,818
Male gender (n)	39	46	37	0,958
GOLD Stage				
Stage 1	1/44	-	1/41	0.765
Stage 2	12/44	18/52	15/41	
Stage 3	18/44	21/52	18/41	
Stage 4	13/44	13/52	7/41	
Comorbidities				
Hypertension n (%)	4 (9)	18 (35)	14 (34)	0.008
Diabetes mellitus n (%)	0 (0)	2 (4)	10 (24)	0.000
Chronic Heart Diseases n (%)	1 (2)	4 (8)	2 (5)	0.483
Other n (%)	13 (30)	11 (22)	16 (39)	0.189
Body Mass Index (kg/m^2)	23 (22,24)	27 (25,21)	33 (31,34)	<0.001
Smoking (pack years)	60 (40,80)	50 (37,85)	50 (40,70)	0.579
Emergency visits in the last year	0 (0,1)	0 (0,0)	0 (0,0)	0.113
Hospitalization in the last year	0 (0,0)	0 (0,0)	0 (0,0)	0.531
Pulmonary Function Tests				
FEV_1%	40 (29,53)	41 (29,62)	41 (32,58)	0.775
FEV_1/FVC	51 (45,65)	58 (52,69)	64 (53,71)	0.033
IC (%)	57 (34,86)	65 (49,85)	50 (38,70)	0.125
VC (%)	68 (58,81)	65 (52,81)	62 (49,72)	0.318
RV (%)	174 (120,215)	172 (129,206)	155 (124,186)	0.423
TLCO (%)	25 (15,42)	40 (30,81)	44 (31,57)	0.001
Arterial Blood Gas				
ΔPaO_2 mmHg	72 (67,79)	71 (64,82)	71 (63,78)	0.844
$\Delta PaCO_2$ mmHg	39 (35,44)	40 (38,44)	42 (39,51)	0.010
ΔSaO_2 (%)	93 (94,96)	94 (93,96)	95 (92,96)	0.907
6MWD (meters)	340 (272,410)	355 (250,430)	360 (315,402)	0.761
Walkwork	22 (18,28)	25(16,33)	33 (26,38)	0.000
MMRC	3 (2,4)	3 (2,4)	3 (3,4)	0.835
SGRQ Scores				
Symptoms	62 (45,81)	58 (40,85)	50 (40,68)	0.256
Activity	67 (53,80)	61 (48,86)	66 (54,86)	0.889
Impact	50 (36,62)	42 (29,60)	49 (32,65)	0.369
Total	49 (41,67)	48 (40,73)	56 (41,71)	0.667
SF-36 Scores				
Physical Functioning	50 (20,75)	45 (20,77)	45 (25,70)	0.953
Social Functioning	62 (37,87)	62 (50,94)	62 (60,87)	0.683
Role Physical	0 (0,50)	25 (0,75)	12 (0,75)	0.376
Role Emotional	0 (0,67)	33 (0,100)	33 (0,100)	0.087
General Health	40 (24,55)	35 (20,58)	45 (30,57)	0.627
Mental Health	64 (40,76)	64 (42,80)	72 (56,80)	0.158
Bodily Pain	54 (41,90)	62 (32,87)	62 (41,90)	0.727
Vitality	45 (25,65)	55 (25,67)	55 (40,75)	0.430
HAD Scores				
Anxiety	8 (5,11)	7 (3,10)	6 (3,10)	0.426
Depression	7 (4,10)	6 (2,10)	5 (4,8)	0.799

Data are expressed as median (interquartile range) or n (%), FEV_1: Forced expiratory volume in the first second; FVC: Forced vital capacity; HAD: Hospital Anxiety and Depression Scale; IC: Inspiratory capacity; MMRC: Modified Medical Research Council; $PaCO_2$: Partial arterial carbon dioxide pressure; PaO_2: Partial arterial oxygen pressure; RV: Residual volume; SaO_2: Arterial oxygen saturation; SF-36: Short-Form Health Survey; SGRQ: St. George Respiratory Questionnaire; TLCO: Carbon monoxide diffusion capacity; VC: Vital capacity; 6MWD: 6-min walk distance; * Kruskal–Wallis H-test

Table 2. The difference in clinical parameters before and after pulmonary rehabilitation

	Normal Group n=44			Pre-obese Group n=52			Obese Group n=41		
	BPR	APR	p_1*	BPR	A PR	p_2*	BPR	APR	p_3*
BMI (kg/m²)	23 (22,24)	23 (22,24)	0.82	27 (25,28)	27 (25,27)	0.74	33 (31,34)	32 (31,34)	0,88
PFT									
FEV_1%	40 (29,53)	47 (31,53)	**0.003**	41 (29,62)	44 (34,61)	**0.005**	41 (32,58)	46 (32,56)	0.225
FEV_1/FVC	51 (45,65)	54 (43,68)	0.844	58 (52,69)	60 (48,68)	0.877	64 (53,71)	63 (53,74)	0.968
IC (%)	57 (34,86)	67 (44,90)	0.416	65 (49,85)	66 (43,82)	0.566	50 (38,70)	61 (43,82)	0.083
VC (%)	68 (58,81)	76 (66,81)	0.086	65 (52,81)	64 (54,75)	0.758	62 (49,72)	68 (53,76)	0.064
RV (%)	174 (120,215)	161 (125,195)	0.238	172 (129,206)	170 (133,188)	0.845	155 (124,186)	146 (112,186)	0.688
TLCO (%)	25 (15,42)	31 (18,40)	0.087	40 (30,81)	40 (34,56)	0.111	44 (31,57)	46 (40,59)	0.666
Arterial Blood Gas									
PaO_2 mmHg	72 (67,79)	80 (73,86)	**<0.001**	71 (64,82)	77 (75,82)	**<0.001**	71 (63,78)	74 (63,87)	**0.001**
$PaCO_2$ mmHg	39 (35,44)	39 (35,42)	0.304	40 (38,44)	39 (37,43)	0.068	42 (39,51)	43 (40,46)	0.521
SaO_2 (%)	95 (94,96)	96 (95,97)	**<0.001**	94 (93,96)	96 (94,97)	**<0.001**	95 (92,96)	95 (92,97)	**0.016**
6MWD (meters)	340 (272,410)	440 (355,490)	**<0.001**	355 (250,430)	405 (317,487)	**<0.001**	360 (315,402)	410 (355,450)	**<0.001**
Walkwork (kg·m)	22 (18,28)	28 (23,33)	**<0.001**	25 (16,33)	30 (23,36)	**<0.001**	33 (26,38)	36 (29,43)	**<0.001**
MMRC	3 (2,4)	2 (1,3)	**<0.001**	3 (2,4)	2 (1,3)	**<0.001**	3 (3,4)	3 (1,3)	**<0.001**
SGRQ Scores									
Symptom	62 (45,81)	44 (32,59)	**<0.001**	58 (40,85)	47 (38,66)	**0.015**	50 (40,68)	44 (31,59)	**0.007**
Activity	67 (53,80)	54 (42,79)	**<0.001**	61 (48,86)	48 (36,79)	**<0.001**	66 (54,86)	54 (42,73)	**<0.001**
Impact	50 (36,62)	32 (20,49)	**<0.001**	42 (29,60)	31 (18,55)	**<0.001**	49 (32,65)	32 (19,50)	**<0.001**
Total	49 (41,67)	41 (30,55)	**<0.001**	48 (40,73)	41 (28,65)	**<0.001**	56 (41,71)	40 (29,59)	**<0.001**
SF-36 Scores									
Physical Functioning	50 (20,75)	60 (40,85)	**<0.001**	45 (20,77)	65 (37,82)	**0.001**	45 (25,70)	62 (49,85)	**0.001**
Social Functioning	62 (37,87)	87 (62,100)	**0.001**	62 (50,94)	75 (50,100)	0.366	62 (60,87)	75 (59,100)	**0.012**
Role Physical	0 (0,50)	50 (25,100)	**0.001**	25 (0,75)	50 (0,100)	0.006	12 (0,75)	50 (0,100)	**0.003**
Role Emotional	0 (0,67)	67 (33,100)	**0.007**	33 (0,100)	67 (33,100)	0.155	33 (0,100)	66 (27,100)	0.095
General Health	40 (24,55)	62 (30,75)	**0.001**	35 (20,58)	52 (30,72)	**0.003**	45 (30,57)	52 (35,71)	**0.002**
Mental Health	64 (40,76)	76 (60,88)	**<0.001**	64 (42,80)	72 (44,84)	0.062	72 (56,80)	76 (60,85)	0.268
Bodily Pain	54 (41,90)	90 (62,100)	**<0.001**	62 (32,87)	72 (42,90)	**0.006**	62 (41,90)	79 (52,100)	0.094
Vitality	45 (25,65)	60 (50,80)	**0.002**	55 (25,67)	65 (35,80)	**0.003**	55 (40,75)	75 (50,85)	**0.001**
HAD Scores									
Anxiety	8 (5,11)	6 (3,8)	**<0.001**	7 (3,10)	5 (3,9)	**0.054**	6 (3,10)	4 (1,7)	**0.003**
Depression	7 (4,10)	4 (2,7)	**0.003**	6 (2,10)	6 (2,9)	0.116	5 (4,8)	4 (2,8)	0.091

Data are expressed as median (interquartile range), APR: After pulmonary rehabilitation; BMI: body mass index; BPR: before pulmonary rehabilitation; FEV_1: forced expiratory volume in the first second; FVC: forced vital capacity; HAD: hospital anxiety and depression scale; IC: inspiratory capacity; MMRC: modified medical research council; $PaCO_2$: partial arterial carbon dioxide pressure; PaO_2: partial arterial oxygen pressure; PFT: pulmonary function test; RV: residual volume; SaO_2: arterial oxygen saturation; SF-36: short-form health survey; SGRQ: St. George Respiratory Questionnaire; TLCO: carbon monoxide diffusion capacity; VC: vital capacity; 6MWD: 6-min walk distance

*Wilcoxon Signed Rank Test, p1: Comparison of clinical parameters before and after pulmonary rehabilitation in normal-weight groups, p2: Comparison of clinical parameters before and after pulmonary rehabilitation in pre-obese groups, p3: Comparison of clinical parameters before and after pulmonary rehabilitation in obese groups

groups. Thus we might conclude that obese COPD patients must do more "work" to complete the same 6MWD.

It has been demonstrated that PR programs significantly improve the clinical parameters in COPD patients such as physiological and clinical tolerance and dyspnea as well as health-related QOL (22). For this reason, PR is considered to be one of the most efficient nonpharmacological methods in the treatment of COPD patients (24). Changes in pulmonary functions after PR show variation, however, and there are studies reporting no change in pulmonary functions (25, 26) as well as the studies reporting increased FEV_1 values after PR (27-29). In our study, there was a significant increase in FEV_1 values in the normal-weight and pre-obese patients, whereas the increase in obese patients was not significant. We believe that it can be more difficult to gain in FEV_1 if there is an increased respiratory load on lung volumes in obese COPD patients.

Table 3. The comparison of differences after pulmonary rehabilitation between groups

	Normal n=44	Pre-obese n=52	Obese n=41	p*
Body Mass Index (kg/m^2)	0 (0,1)	-0,7 (-1,0)	-1 (-1,0)	0.732
Pulmonary Function Test				
ΔFEV_1%	3 (-1,7)	2 (-2,9)	1 (-3,4)	0.304
ΔFEV_1/FVC	0 (-7,7)	1 (-5,6)	0 (-7,5)	0.984
ΔIC (%)	2 (-31,46)	-6 (-21,21)	7 (-7,25)	0.270
ΔVC (%)	2 (-2,12)	3 (-22,14)	-3 (-3,11)	0.713
ΔRV (%)	-19 (-37,25)	-11 (-55,54)	6 (-27,31)	0.567
ΔTLCO (%)	3 (-2,12)	4 (-6,12)	1 (-6,9)	0.523
Arterial Blood Gas				
ΔPaO_2 mmHg	9 (3,13)	6 (3,10)	3 (0,10)	0.074
Δ$PaCO_2$ mmHg	0 (-3,2)	-2 (-5,1)	-1 (-4,3)	0.239
ΔSaO_2 (%)	2 (0,3)	1 (0,3)	1 (0,2)	0.078
Δ6MWD	3 (2,7)	50 (30,80)	30 (20,60)	0.049
ΔWalkwork	55 (30,115)	4 (2,6)	3 (2,6)	0.690
ΔMMRC	-1 (-1,0)	-1 (-1,0)	-1 (-1,0)	0.255
SGRQ Scores				
ΔSymptom	-9 (-21,-2)	-5 (-18,5)	-8 (-15,1)	0.184
ΔActivity	-6 (-18,0)	-7 (-18,0)	-6 (-19,0)	0.944
ΔImpact	-16 (-25,-2)	-6 (-15,1)	-8 (-22,-3)	0.062
ΔTotal	-12 (-19,-4)	-5 (-14,-2)	-9 (-16,-2)	0.087
SF-36 Scores				
ΔPhysical Functioning	10 (0,25)	10 (-2,25)	10 (0,30)	0.508
ΔSocial Functioning	12 (0,37)	0 (-12,12)	12 (0,25)	0.126
ΔRole Physical	25 (0,75)	0 (0,50)	0 (0,50)	0.423
ΔRole Emotional	33 (0,67)	0 (-16,33)	0 (0,33)	0.116
ΔGeneral Health	12 (-1,25)	5 (-1,22)	10 (0,21)	0.614
ΔMental Health	8 (0,20)	4 (-6,20)	4 (-8,13)	0.133
ΔBodily Pain	16 (0,43)	10 (0,20)	0 (0,21)	0.183
ΔVitality	10 (0,30)	10 (-2,30)	12 (0,25)	0.936
HAD Scores				
ΔAnxiety	-2 (-4,0)	-1 (-4,1)	-2 (-4,0)	0.180
ΔDepression	-2 (-3,0)	-1 (-2,1)	-1 (-4,1)	0.426

Data are expressed as median (interquartile range). Results are shown as change between post-treatment and baseline levels (Δ values). FEV_1: Forced expiratory volume in the first second; FVC: forced vital capacity, HAD: hospital anxiety and depression scale; IC: inspiratory capacity; MMRC: modified medical research council; $PaCO_2$: partial arterial carbon dioxide pressure; PaO_2: partial arterial oxygen pressure; RV: residual volume; SaO_2: arterial oxygen saturation; SF-36: Short-Form Health Survey; SGRQ: St. George Respiratory Questionnaire; TLCO: carbon monoxide diffusion capacity; VC: Vital capacity; 6MWD: 6-min walk distance; * Kruskal–Wallis H-Test

Decreased exercise tolerance is the main characteristic of COPD patients, and increasing exercise tolerance is the primary goal of PR (30). Earlier studies demonstrated increased exercise capacity after PR (27-29). One study, which evaluated exercise capacity using an incremental shuttle walk test and endurance shuttle walk test by grouping the patients according to BMI found that the baseline ISWT value was significantly lower in obese patients and that there was a significant increase in all groups after PR, but the difference between the groups was not significant (31). According to the study that evaluated the COPD patients in two groups as obese and non-obese, obese patients showed lower but not statistically significant improvement in ISWT after PR, but the walkwork value was found to be significantly higher (20). In our study, the 6MWD and walkwork values were significantly increased in all three groups. Comparing the changes between the groups, the increase in 6MWD was significantly lower in the obese group, but there was no difference between the groups in terms of the increase in walkwork value. So, even obese COPD patients significantly but also clinically improve in exercise capacity

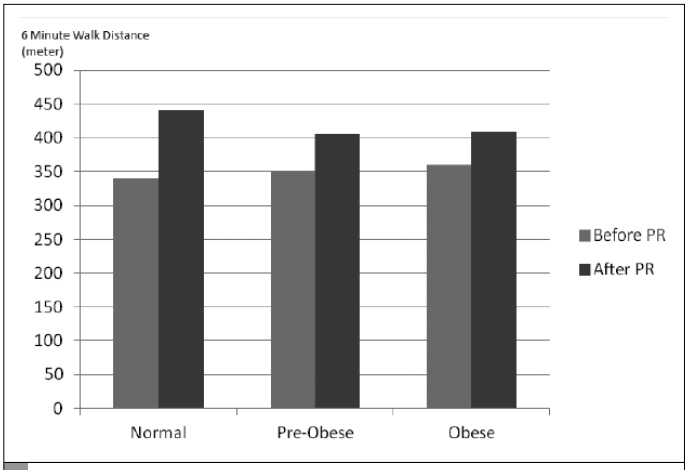

Figure 2. The difference in 6-min walk distance after pulmonary rehabilitation

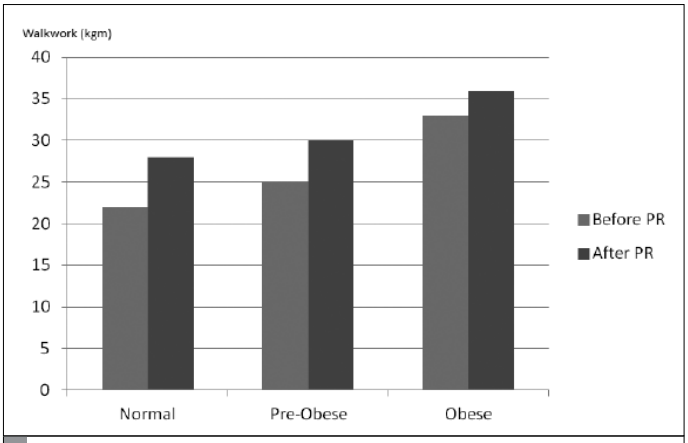

Figure 3. The change in walkwork value after pulmonary rehabilitation

after PR. But this gain, which is smaller than the normal-weight COPD patients' gain, requires nearly the same walkwork.

In light of these findings, we suggest that PR is an essential but not sufficient intervention for obese COPD patients. We believe that weight loss should be consistently encouraged in order to increase the benefit of PR in obese COPD patients. Decreased physical activity in COPD patients brings along psychological problems, which are associated with impaired QOL (32). It is known that PR improves the psychological status of COPD patients and enhances QOL (33). In the present study, all parameters of disease-related QOL were improved in all groups. With regard to the health-related QOL questionnaires, improvement was observed in all parameters in the normal-weight group and in most of the parameters in the pre-obese and obese groups.

There is a two-sided relationship between obesity and depression; while obesity increases the risk of developing depression, depression might be the precursor of obesity (22). Both depression and anxiety scores were significantly decreased in normal-weight patients, whereas only the anxiety scores were decreased in pre-obese and obese patients without a significant change in depression score. This might suggest that depression usually occurs due to excessive weight.

There were some limitations to this study. We could not include COPD patients with BMI below 21 or above 40 kg/m^2 in our study. Thus our study does not give any information about cachexic and morbidly obese patients. Moreover, we could not evaluate the body composition with a comprehensive method such as bioelectrical impedance. Therefore, a number of parameters related to body composition such as lean body mass, body fat ratio, and regional fat distributions could not be evaluated.

CONCLUSION

Pre-obese and obese patients benefit from PR similarly compared to the normal-weight patients in terms of gas exchange, dyspnea scores, and QOL scores. However, FEV_1 % was not improved in the obese patients after PR, and the gain of 6MWD was significantly lower in obese patients as compared to pre-obese and normal-weight patients. Further studies are needed to assess the PR outcomes in obese COPD patients.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of University of Health Sciences Dr. Suat Seren Chest Diseases and Surgery Training and Research Hospital.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - H.D.Ş.; Design - H.D.Ş.; Supervision - H.D.Ş.; Resources - Y.V.; Materials - Y.V.; Data Collection and/or Processing - Y.V.; Analysis and/or Interpretation - İ.N.; Literature Search - İ.N.; Writing Manuscript - H.D.Ş.; Critical Review - B.K.

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