doi • 10.5578/tt.20219602

Tuberk Toraks 2021;69(4):449-457

Received/Geliş Tarihi: 13.07.2021 • Accepted/Kabul Ediliş Tarihi: 23.10.2021

RESEARCH ARTICLE
KLİNİK ÇALIŞMA

Efficacy of pulmonary rehabilitation on patients with non-cystic bronchiectasis according to disease severity

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ABSTRACT

Efficacy of pulmonary rehabilitation on patients with non-cystic bronchiectasis according to disease severity

Introduction: The European Respiratory Society guidelines support pulmonary rehabilitation (PR) in bronchiectasis through high-quality evidence. This study aimed to evaluate the efficacy of PR on bronchiectasis patients according to disease severity assessed by the Bronchiectasis Severity Index (BSI).

Materials and Methods: This prospective study included patients with stable bronchiectasis. Demographic data of all patients were questioned. All patients underwent an 8-week PR program. The patients were grouped into three according to disease severity (mild, moderate and severe) based on their BSI scores. The following parameters were evaluated at baseline (pre-PR) and after PR (post-PR): pulmonary function test results, carbon monoxide diffusion capacity, body mass index, exercise capacity (6-minute walking test), quality of life (QoL; St. George's Respiratory Questionnaire), and Hospital Anxiety and Depression scores.

Results: The study included 69 patients (55 males; mean age, 62.6 ± 9 years). After PR, the patients were observed to have significantly improved QoL and exercise capacity ($p < 0.05$). According to BSI, 16 (23.2%), 29 (42.0%), and 24 (34.8%) patients had mild, moderate, and severe bronchiectasis, respectively. These patient groups significantly differed regarding age, exercise capacity, and QoL ($p < 0.05$). Comparing the change between post-PR and pre-PR values of the study parameters ($\Delta = \text{post-PR value} - \text{pre-PR value}$), no significant differences were observed regarding the exercise capacity and QoL ($p > 0.05$) in the groups.

Cite this article as: Deniz S, Şahin H, Erbaycu AE. Efficacy of pulmonary rehabilitation on patients with non-cystic bronchiectasis according to disease severity. Tuberk Toraks 2021;69(4):449-457.

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Conclusion: PR increases exercise capacity and QoL in bronchiectasis patients, and its efficacy does not differ according to disease severity. Thus, appropriate bronchiectasis patients should be referred to PR program regardless of disease severity.

Key words: Bronchiectasis; pulmonary rehabilitation; bronchiectasis severity index

ÖZ

Non-kistik bronşektazide pulmoner rehabilitasyonun hastalık şiddetine göre etkinliği

Giriş: Avrupa Solunum Derneği kılavuzları bronşektazide pulmoner rehabilitasyonu (PR) yüksek kalitede kanıtla desteklemektedir. Bu çalışma; bronşektazide PR'nin etkinliğini, bronşektazi şiddet indeksi kullanılarak, hastalığın şiddetine göre değerlendirmeyi amaçlamaktadır.

Materyal ve Metod: Bu prospektif çalışma stabil bronşektazili hastaları içermektedir. Tüm hastaların demografik verileri sorgulanmıştır. Tüm hastalar sekiz haftalık PR programına alınmıştır. İndeks kullanılarak hastalığın şiddetine göre hastalar üç gruba ayrılmıştır (hafif, ılımlı ve şiddetli). Başlangıçta (pre-PR) ve PR sonrası (post-PR); pulmoner fonksiyon test sonuçları, karbon monoksit difüzyon kapasitesi, vücut kitle indeksi, egzersiz kapasitesi (6-dakika yürüme testi), yaşam kalitesi (St. George Solunum Ölçeği) ve Hastane Anksiyete Depresyon ölçeği değerlendirilmiştir.

Bulgular: Çalışmaya 69 hasta (55 erkek; ortalama yaş $62,6 \pm 9$ yıl) alındı. Pulmoner rehabilitasyon sonrası hastalarda anlamlı şekilde yaşam kalitesi ve egzersiz kapasitesi artışı gözlemlendi ($p < 0,05$). Bronşektazi şiddet indeksine göre, 16 (%23,2), 29 (%42) ve 24 (%34,8) hasta sırasıyla hafif, ılımlı ve şiddetli bronşektaziye sahip idi. Bu hasta grupları yaş, egzersiz kapasitesi ve yaşam kalitesi açısından farklılık gösterdi ($p < 0,05$). Pre-PR ve post-PR çalışma parametrelerindeki değişiklik karşılaştırıldığında (Δ = post-PR değeri - pre-PR değeri), gruplarda egzersiz kapasitesi ve yaşam kalitesi açısından farklılık saptanmadı ($p > 0,05$).

Sonuç: PR bronşektazili hastalarda egzersiz kapasitesi ve yaşam kalitesini artırmaktadır ve etkinliği hastalığın şiddetine göre farklılık göstermemektedir. Böylece, uygun bronşektazi hastaları hastalığın şiddetinden bağımsız olarak PR programına yönlendirilmelidir.

Anahtar kelimeler: Bronşektazi; pulmoner rehabilitasyon; bronşektazi şiddet indeksi

INTRODUCTION

Bronchiectasis is a chronic respiratory disease characterized by a closed loop of permanent dilatation of the bronchi and frequent bronchial infections, leading to a clinical syndrome of chronic cough and sputum production. Elimination of exacerbations is the key target of therapy (1).

According to the European Respiratory Society (ERS) guidelines, pulmonary rehabilitation (PR) is supported by high-quality evidence. Most therapy recommendations are conditional and based on low to very low quality of evidence (2-4). Patients with bronchiectasis experience reductions in their exercise capacities and quality of life (QoL) (5). The aims of PR in patients with bronchiectasis include improving patients' exercise capacity through certain effects on the patients' aerobic capacity and peripheral muscles, providing disease management, and improving QoL (6).

There are some studies in the literature that investigate the effects of PR on bronchiectasis (5,6). However, to the best of our knowledge, there are no sufficient data comparing the efficacy of PR with regard to the severity of bronchiectasis. Thus, the present study aimed to evaluate the efficacy of PR on

patients with bronchiectasis according to disease severity as assessed by the Bronchiectasis Severity Index (BSI).

MATERIALS and METHODS

Patients

The present prospective study included patients aged ≥ 18 years who were diagnosed with stable non-cystic bronchiectasis through high-resolution computed tomography (HRCT) and referred to the PR unit between 2016-2018 in Health Science University, Dr Suat Seren Chest Disease and Thoracic Surgery Research and Training Hospital. Patients were excluded according to the following criteria: presence of acute infections, history of other lung diseases (such as active or inactive pulmonary tuberculosis, lung cancer, interstitial lung diseases, asthma) or comorbidities, being diagnosed with bronchiectasis due to cystic fibrosis, presence of orthopaedic, neurologic or cardiovascular impairment that would prevent patients from doing exercises, being unable or unwilling to complete the PR program, and being not capable of providing informed consent. The study was approved by the local institutional review board (16-03-2016-2906). An informed consent was obtained from all patients for their participation in the study.

Measurements

All patients were examined by a cardiologist and a physical therapist. Number of hospitalizations and emergency visits in the previous year and demographic and clinical characteristics were questioned for all patients. sputum culture results and, if any, chronic colonization or recurrence of *Pseudomonas aeruginosa* were examined. The frequency of bronchiectasis was investigated through HRCT.

In the PR unit, body mass index (BMI) values were calculated by measuring height and weight of the patients. Arterial blood samples were analysed. Pulmonary function tests (PFT) were performed by a body plethysmography (Zan 500 Bodyplethysmographie, Germany) and by measuring diffusing capacity of the lungs for carbon monoxide (DLCO; Zan 300, Germany). The percent predicted forced expiratory volume in 1 second (FEV₁%), the percent predicted forced vital capacity (FVC%), and FEV₁/FVC were recorded. All measurements were performed both before and after PR.

6-minute walking test (6MWT) was performed according to the American Thoracic Society (ATS) guidelines (7). and the distance walked in 6 minutes [6-minute walk distance (6MWD)] was recorded for each patient before and after PR.

Delta 6MWT was accepted as 30 meters, and higher values were considered significant. All patients were evaluated with the Medical Research Council (MRC) dyspnoea scale for assessment of patients' breathlessness (the scale is scored from 1 [best score] to 5 [worst score]), 6 St. George's Respiratory Questionnaire (SGRQ) for assessment of QoL (high scores indicates worsened disease and increased symptoms) (8) and Hospital Anxiety Depression Scale (HADS) for the assessment of depression and anxiety (the scale consists of 14 questions; lower scores represents lower levels of anxiety and depression) (9,10). The severity of bronchiectasis in all patients was determined using BSI (3).

BSI was calculated using the following criteria: age, BMI, predicted FEV₁%, hospitalization and emergency visits, MRC score, colonisation status, and frequency of bronchiectasis. Based on the calculated index scores, the patients were categorized into three groups as patients with mild bronchiectasis (a score of 0-4), patients with moderate bronchiectasis (a score of 5-8) and patients with severe bronchiectasis (a score of >9) (3).

Interventions

All patients underwent a PR program twice a week during a period of 8 weeks with each session being 2-h long. The exercise program consisted of breathing exercises including pursed lip breathing, diaphragmatic breathing and thoracic expansion exercises, relaxation and stretching exercises, peripheral muscle strength training, upper and lower extremity stretching, and strengthening and aerobic exercises. The patients were trained for nutritional requirements, PR, and the exercise programme. Additionally, bronchial hygiene techniques and dyspnoea-reducing positions were told and the necessary training was given to the patients. All strengthening exercises were started with zero weight exercises and then a half kilogram of weight was added in every four sessions of exercises according to the Borg's scale (4-6). A treadmill and a bicycle/arm ergometer were used for aerobic exercises. The patients were trained at 60-90% of their maximum heart rates. The Borg dyspnoea scores were used to regulate the exercises (6). Exercise intensities were increased depending on the progress of each patient. During the exercises, the patients were monitored and evaluated using pulse oximetry. Accordingly, in case peripheral arterial oxygen saturation (SpO₂) of a patient fell below 90%, the patient was provided with oxygen support. Aerobic exercises were performed for 30 minutes, including 15 minutes of treadmill exercises and 15 minutes of stationary bike exercises. All variables were evaluated at baseline (before PR [pre-PR]) and at the end of PR (post-PR).

Statistical Analysis

Data were analysed using IBM SPSS Statistics for Windows version 22.0 (IBM Corp., Armonk, NY, USA). Nominal variables were expressed as frequencies and percentages and were compared using cross tables. Continuous variables were expressed as mean, standard deviation (SD), median, and minimum and maximum values and normality of continuous variables were examined using the normality tests and graphical analyses in consideration of the sample size. Comparisons of the variables were performed through nonparametric tests. Mann-Whitney U test was used for independent groups, and Wilcoxon signed rank test was used for repeated measurements. Kruskal-Wallis test was used for comparison of three groups. For all statistical comparisons, the level of significance was set at $\alpha=0.05$ (the probability of a type 1 error) and two-sided. A p value of <0.05 was considered statistically significant.

RESULTS

The study included 69 patients (55 males) with stable non-cystic bronchiectasis, and mean age of the patients was 62.6 ± 9 years. The general characteristics of the study patients are presented in Table 1. The comparisons of the pre-PR and post-PR values of the study parameters in all patients (Table 2) revealed that the QoL and exercise capacity of the patients were improved with PR ($p < 0.05$).

According to BSI, 16 (23.2%) patients (10 males) had mild bronchiectasis, 29 (42.0%) patients (25 males) had moderate bronchiectasis, and 24 (34.8%) patients (20 males) had severe bronchiectasis. Significant differences were found between the patients with mild, moderate, and severe bronchiectasis in terms of age, exercise capacity, and QoL at baseline ($p < 0.05$ for all, Table 3).

Comparisons of the patients with mild, moderate, and severe bronchiectasis in terms of change (Δ)

Table 1. General characteristics of the study patients

Variables	Patients with bronchiectasis n= 69
Age, years	62.6 ± 9
Sex	
Male	55 (79.7)
Female	14 (20.3)
BMI, kg/m ²	24.4 ± 4.8
Number of EDVs in the previous year	2.8 ± 3.7
Number of hospitalizations in the previous year	0.83 ± 1.58
BSI	7.9 ± 4.3

Data are presented as mean $\pm$ standard deviation (SD) or number (percentage, %), where appropriate.
SD: Standard deviation, BMI: Body mass index, EDVs: Emergency department visits, BSI: Bronchiectasis severity index.

Table 2. Comparisons of pre-pulmonary rehabilitation and post-pulmonary rehabilitation values of the study parameters in patients with bronchiectasis (n= 69)

Study parameters	Pre-PR Mean $\pm$ SD	Post-PR Mean $\pm$ SD	p
FEV ₁ , %	46 ± 20	47 ± 21	0.126
FEV ₁ /FVC, %	59 ± 11	59 ± 12	0.950
DLCO, %	36.9 ± 21	43 ± 24	0.087
pH	7.39 ± 0.03	7.39 ± 0.03	0.289
pCO ₂ , mmHg	41.8 ± 6.8	42.3 ± 7.8	0.528
SpO ₂ , mmHg	93.2 ± 5.7	94.9 ± 3.3	<0.001
pO ₂ , mmHg	72.1 ± 14.7	76.8 ± 13.2	<0.001
6MWD, m	334 ± 123	387 ± 118	<0.001
SGRQ symptom score	58.1 ± 20	51.7 ± 19	0.002
SGRQ activity score	70.2 ± 21	60.5 ± 23	<0.001
SGRQ impact score	54.57	42.11	<0.001
SGRQ total score	60 ± 19	49.3 ± 20	<0.001
HADS-anxiety score	10.1 ± 12	6.1 ± 3	<0.001
HADS-depression score	8.5 ± 12	6.2 ± 3	0.020
MRC	3.4 ± 1.1	2.4 ± 1.2	<0.001

PR: Pulmonary rehabilitation, FEV₁: Forced expiratory volume, FVC: Forced vital capacity; DLCO: Diffusing capacity of the lungs for carbon monoxide (carbon monoxide transfer factor), pCO₂: Partial arterial carbon dioxide pressure, SpO₂: Peripheral arterial oxygen saturation, pO₂: Partial oxygen pressure, 6MWD: 6-minute walk distance, SGRQ: St. George's Respiratory Questionnaire, HADS: Hospital Anxiety and Depression Scale, MRC: Medical Research Council.

Table 3. Comparison of the patients with mild, moderate and severe bronchiectasis in terms of study parameters assessed at baseline (pre-pulmonary rehabilitation)

Parameters	Patients with mild bronchiectasis n= 10	Patients with moderate bronchiectasis n= 29	Patients with severe bronchiectasis n= 24	p
	Mean $\pm$ SD Min-Max	Mean $\pm$ SD Min-Max	Mean $\pm$ SD Min-Max	
Age, years	56.8 $\pm$ 8.6 58 (42-68)	63.4 $\pm$ 7.8 65 (38-74)	65.5 $\pm$ 9.3 68 (36-77)	0.007
BMI, kg/m ²	25.2 $\pm$ 3.7 25 (21-34)	25.2 $\pm$ 5.3 25 (16-41)	23 $\pm$ 4.7 24 (15-31)	0.313
Number of EDVs in the previous year	0.4 $\pm$ 0.6 0	1.5 $\pm$ 1.8 1 (0-2)	5.2 $\pm$ 4.6 4 (0-15)	<0.001
Number of hospitalizations in the previous year	0 0	0.1 $\pm$ 0.3 0	1.9 $\pm$ 2 1 (0-8)	<0.001
FEV ₁ , %	58 $\pm$ 18 58 (27-82)	48 $\pm$ 21 42 (22-80)	31 $\pm$ 12 31 (18-61)	<0.001
FEV ₁ /FVC, %	64 $\pm$ 15 66 (34-80)	60 $\pm$ 13 63 (37-79)	55 $\pm$ 11 54 (34-75)	0.129
DLCO, %	51 $\pm$ 18 53 (26-70)	33 $\pm$ 17 26 (20-68)	27 $\pm$ 24 20 (11-54)	0.003
pO ₂ , mmHg	79 $\pm$ 17 83 (38-95)	74 $\pm$ 11 74 (46-93)	64 $\pm$ 13 65 (36-92)	0.001
pCO ₂ , mmHg	38 $\pm$ 4.6 38 (31-45)	41 $\pm$ 5.7 41 (32-57)	44 $\pm$ 8.2 41 (35-65)	0.077
SpO ₂ , %	94.9 $\pm$ 5.7 96 (75-98)	94.3 $\pm$ 3.7 95 (80-99)	90.8 $\pm$ 7.1 93 (70-98)	0.002
pH	7.39 $\pm$ 0.04 7.41 (7.33-7.43)	7.40 $\pm$ 0.03 7.40 (7.35-7.45)	7.39 $\pm$ 0.04 7.39 (7.35-7.47)	0.962
6MWD, m	394 $\pm$ 93 417 (200-520)	358 $\pm$ 114 390 (80-510)	265 $\pm$ 122 290 (40-460)	0.002
SGRQ symptom score	46.7 $\pm$ 17.4 45.4 (26.4-76)	55.7 $\pm$ 21 59.3 (11.7-92)	70.7 $\pm$ 17.2 73.3 (33.4-95)	0.001
SGRQ activity score	59.2 $\pm$ 17.6 57 (29-87)	66.8 $\pm$ 23 66.3 (29-100)	84.1 $\pm$ 16 92.5 (56-100)	<0.001
SGRQ impact score	42.4 $\pm$ 19.2 44.6 (12.8-76)	51.3 $\pm$ 20.8 49 (16-88.6)	68.9 $\pm$ 20.3 67.4 (34.8-99)	0.002
SGRQ total score	48.2 $\pm$ 16 47.4 (22-75)	57 $\pm$ 18.8 52.6 (28-89)	73.8 $\pm$ 16.8 77.2 (47-96)	<0.001
HADS-Anxiety score	8 $\pm$ 4.5 6 (0-20)	9.1 $\pm$ 4.9 8 (0-20)	10.1 $\pm$ 4.9 9.5 (3-19)	0.065
HADS-Depression score	8.4 $\pm$ 4.8 6 (1-20)	7.4 $\pm$ 4.3 6.5 (0-15)	8 $\pm$ 3.4 8 (2-15)	0.143
MRC dyspnoea scale score	2.3 $\pm$ 0.8 2.5 (1-3)	3.3 $\pm$ 1.1 3 (1-5)	4.1 $\pm$ 0.9 4 (2-5)	<0.001

SD: Standard deviation, Min-Max: Minimum-maximum, BMI: Body mass index, EDVs: Emergency department visits, FEV₁: Forced expiratory volume, FVC: Forced vital capacity, DLCO: Diffusing capacity of the lungs for carbon monoxide (carbon monoxide transfer factor), pCO₂: Partial arterial carbon dioxide pressure, SpO₂: Peripheral arterial oxygen saturation, pO₂: Partial oxygen pressure, 6MWD: 6-minute walk distance, SGRQ: St. George's Respiratory Questionnaire, HADS: Hospital Anxiety and Depression Scale, MRC: Medical Research Council.

between post-PR and pre-PR values of the study parameters (Δ = post-PR value - pre-PR value) revealed no significant differences between the patient groups in terms of exercise capacity and QoL ($p > 0.05$ for all; Table 4).

DISCUSSION

In the present study, in which the efficacy of an 8-week PR program was evaluated in patients with non-cystic bronchiectasis, it was found that the

Table 4. Comparison of the patients with mild, moderate and severe bronchiectasis in terms of the change (Δ) between the study parameters (Δ = post-pulmonary rehabilitation value-pre-pulmonary rehabilitation value)

Parameters	Patients with mild bronchiectasis n= 10	Patients with moderate bronchiectasis n= 29	Patients with severe bronchiectasis n= 24	p
	Mean $\pm$ SD Min-Max	Mean $\pm$ SD Min-Max	Mean $\pm$ SD Min-Max	
Δ FEV ₁ , %	3.3 $\pm$ 14.8 0.5 (-16-53)	2.2 $\pm$ 7.1 1 (-14-24)	2 $\pm$ 5.9 0.5 (-9-17)	0.928
Δ FEV ₁ /FVC, %	3.9 $\pm$ 11.7 3.5 (-18-29)	1.3 $\pm$ 11.6 0 (-18-31)	-1.8 $\pm$ 11.8 -2 (-26-31)	0.118
Δ DLCO, %	3.3 $\pm$ 15.3 -1.5 (-12-36)	8.2 $\pm$ 16.5 4 (-20-67)	-1.2 $\pm$ 13.4 -0.5 (-32-21)	0.177
Δ pO ₂ , mmHg	7.2 $\pm$ 13.8 5 (-11-39)	4 $\pm$ 8.3 5 (-23-16)	4.9 $\pm$ 10.1 2.5 (-13-29)	0.982
Δ pCO ₂ , mmHg	0.4 $\pm$ 3.3 0.4 (-5.8-7)	-0.5 $\pm$ 4.5 -0.4 (-10-16)	0.5 $\pm$ 5.7 2 (-19-8)	0.126
Δ SpO ₂ , mmHg	1.2 $\pm$ 5.2 0.4 (-3.7-19)	1 $\pm$ 1.8 0.6 (-1.8-5)	2.8 $\pm$ 6.1 1.8 (-6.5-25)	0.176
Δ pH	-0.01 $\pm$ 0.03 -0.01 (-0.09-0.04)	-0.01 $\pm$ 0.04 0 (-0.14-0.06)	0 $\pm$ 0.03 0.01 (0.07-0.04)	0.694
Δ 6MWD, m	49 $\pm$ 38 40 (0-140)	48 $\pm$ 90 50 (-320-200)	60 $\pm$ 59 42 (-40-170)	0.926
Δ SGRQ symptom score	-5.5 $\pm$ 15.5 -5.3 (-32-26)	-1.4 $\pm$ 15.4 -1.2 (-28-29)	-14.3 $\pm$ 15 -12.4 (-51-6)	0.028
Δ SGRQ activity score	-14.5 $\pm$ 18.5 -12.3 (-54-11)	-4.3 $\pm$ 21.7 -5.9 (-67-64)	-13.8 $\pm$ 19.1 -6.7 (-48-12)	0.243
Δ SGRQ impact score	-13.8 $\pm$ 20.1 -12.4 (-49-5)	-8.2 $\pm$ 19.2 -10.2 (-45-42)	-17.5 $\pm$ 15.6 -12.2 (-54-2.5)	0.344
Δ SGRQ total score	-12.7 $\pm$ 15 -13 (-42-8.6)	-6 $\pm$ 15.1 -5.4 (-34-46)	-15.9 $\pm$ 14 -10.9 (-49--0.6)	0.075
Δ HADS-Anxiety score	-8.7 $\pm$ 25 -3 (-99-2)	-2.7 $\pm$ 3.5 -2 (-10-2)	-2 $\pm$ 3.9 -1 (-14-2)	0.507
Δ HADS- Depression score	-7.2 $\pm$ 24.7 -2 (-96-4)	-1 $\pm$ 3.1 -0.5 (-10-6)	-0.6 $\pm$ 3.1 0 (-5-4)	0.745
Δ MRC dyspnoea scale score	-0.88 $\pm$ 1 -1 (-3-1)	-1.1 $\pm$ 1.2 -1 (-4-2)	-0.8 $\pm$ 1.1 -1 (-4-1)	0.320

SD: Standard deviation, Min-Max: Minimum-maximum, BMI: Body mass index, EDVs: Emergency department visits, FEV₁: Forced expiratory volume, FVC: Forced vital capacity, DLCO: Diffusing capacity of the lungs for carbon monoxide (carbon monoxide transfer factor), pCO₂: Partial arterial carbon dioxide pressure, SpO₂: Peripheral arterial oxygen saturation, pO₂: Partial oxygen pressure, 6MWD: 6-minute walk distance, SGRQ: St. George's Respiratory Questionnaire, HADS: Hospital Anxiety and Depression Scale, MRC: Medical Research Council.

patients with bronchiectasis had improved levels of QoL and exercise capacity after the PR program and that the patients grouped into 3 according to their disease severity (mild, moderate and severe) using the BSI had similar levels of improvement.

In a previous study by Zanini et al. (11) conducted on 108 bronchiectasis patients, an average change of 35 m in 6MWD and a significant improvement in QoL [EuroQol visual analogue scale (EQ-VAS)] have been observed after PR (11). In the study, 55% of the patients were females and mean age was 71 years (11). In the present study, 20.3% of our patients were females and mean age was 62.6 years, and a significant improvement was observed in both QoL and 6MWD. Both the present study and the study by Zanini et al. (11). included patients with and without airflow obstruction.

In a retrospective study by Ong et al. (12) in which 95 bronchiectasis patients (mean age, 67 years; 53% females) underwent PR, significant improvements have been reported in the results of the Chronic Respiratory Disease Questionnaire (CRQ) and in the 6MWD after PR. In addition, they have compared bronchiectasis patients with a matched chronic obstructive disease (COPD) patient group who completed the same PR program and reported no significant difference between the groups (12). In the present study, the QoL of the patients was assessed using the SGRQ and a significant improvement was detected in the post-PR results as compared with the pre-PR results for all domains of the SGRQ in the whole study group. Similarly, a significant improvement was also observed in the 6MWD of the whole study group after the 8-week PR program.

In a randomized controlled trial (RCT), 30 patients with non-cystic fibrosis bronchiectasis have been randomized either to receive acapella (control group) or to receive PR (intervention group) in addition to acapella for an 8-week period (13). Accordingly, a significant change in the QoL (SGRQ) and exercise capacity (incremental shuttle walk test [ISWT] and endurance walk test [EWT]) has been reported in the intervention group, whereas no change was reported in the control group. Mean ages of the study groups were similar (64.6 years vs. 64.8 years), and baseline evaluation was worse for the control group in terms of exercise capacity (ISWT: 343 m in the control group and 287 m in the intervention group). The

patients in the intervention group have been reported to have significantly improved results despite their lower exercise capacities (13). In the present study, in which the mean age of the patients was similar to those reported in the mentioned RCT, three patient groups were formed based on disease severity, and the differences between the groups in terms of improvements were not found to be significant after the PR program.

Patients with bronchiectasis frequently experience acute exacerbations (14). Since frequent airway infection and inflammation cause airway damage resulting in further infection and thereby airway and lung parenchyma destruction, (15) those are independent predictors of progressive decline in respiratory function (16) and indicators of poor prognosis (17). In an RCT investigating short and long term effects of exercise training in non-cystic fibrosis bronchiectasis, exercise training has been observed to increase the incremental shuttle walk distance (ISWT) and the 6MWD; however, it has been reported that such improvements were not sustained at the 6th and 12th months (18). Nevertheless, fewer exacerbations have been reported in the PR group over 12 months follow-up, with longer time to the first exacerbation (8 months in the PR group and 6 months in the control group, $p=0.047$) (18). In the present study, the patients with bronchiectasis were observed to have improved QoL and 6MWD with the 8-week PR program; however, the effects of PR on the frequency of exacerbations in patients with bronchiectasis were not investigated in this study.

In a systematic review including 4 recent RCTs evaluating PR or exercise training as compared with no treatment in patients with bronchiectasis, it has been reported that supervised outpatient programs in stable patients provided short-term benefits in endurance and functional exercise capacity, cough-related symptoms, and disease-specific health-related QoL with reductions in dyspnoea and fatigue levels but that improvements were not sustained beyond 3 months (19).

Unlike COPD patients, although patients with bronchiectasis are not referred for PR, they could also benefit from PR. Exercise programs improve physical fitness levels of patients with cystic fibrosis and non-cystic fibrosis bronchiectasis (20). According to the newest guidelines, PR is strongly recommended

based on high quality of evidence suggesting that patients with bronchiectasis and impaired exercise capacity should participate in a PR programme and perform regular exercise. All interventions should be arranged according to the patient's symptoms, physical capability, and disease characteristics (1).

In a study conducted by Ong et al. (12), it has been reported that the patients with bronchiectasis had improved exercise capacity and health-related QoL (assessed by the CRQ) following a 6- to 8-week out-patient PR program and that these improvements were also sustained for up to 12 months after PR. The study by Ong et al. (12) differs from other studies in the literature (18,19). In terms of the long-term effects of PR. In the present study, the QoL of the patients were evaluated using the SGRQ; although the observed benefits of PR were similar to those found in other studies, the long-term effects of PR were not evaluated in the present study. In a recently published meta-analysis, patients with impaired exercise capacity have been strongly recommended to participate in PR and take regular exercise based on high quality of evidence (4). In the present study, the patients with severe bronchiectasis were older, had lower exercise capacity, had more frequent daily symptoms, and had lower FEV₁%, DLCO%, and SpO₂ values as compared with the patients with mild and moderate disease severity. However, it was observed that patients with mild, moderate, and severe bronchiectasis were all benefited equally from the PR program regardless of their disease severity. To the best of our knowledge, this study is the first to investigate the effects of PR program in bronchiectasis patients based on disease severity.

Limitations

Some patients in the present study had airflow limitations. PR has been proven to provide benefits in chronic respiratory diseases. In the present study, the patients benefited from PR and the airflow limitation may have contributed to this benefit. As the assessment of disease severity is relatively a new concept in bronchiectasis, it will be debatable if disease severity alone is sufficient to guide clinical care in bronchiectasis patients. Having not measured endurance time was also a limitation.

CONCLUSION

In the present study, PR program was shown to increase exercise capacity and QoL in patients with

bronchiectasis. No difference was determined in the efficacy of PR between the patients with different disease severity (mild, moderate, severe) determined by the BSI. Appropriate patients with bronchiectasis should be referred to PR programs regardless of their disease severity. Although some patients had airway limitations, the benefits of PR cannot be attributed to the COPD component alone as each patient was benefited from the PR program. It was concluded that PR could be beneficial for bronchiectasis, which is a chronic airway disease.

Ethical Committee Approval: The study was approved by the Ethics Committee of Suat Seren Chest Diseases and Thoracic Surgery Research and Training Hospital (Approval number: (16-03-2016-2906), Date: 15.03.2016). All procedures performed in studies involving human participants were in accordance with the ethics standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

CONFLICT of INTEREST

The authors declare that they have no conflict of interest.

AUTHORSHIP CONTRIBUTIONS

Concept/Design: SD, HŞ

Analysis/Interpretation: All of authors

Data acquisition: HŞ

Writing: All of authors

Clinical Revision: All of authors

Final Approval: All of authors

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