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Original Article

The Effect of Pulmonary Rehabilitation on the Physical Activity Level and General Clinical Status of Patients with Bronchiectasis

Esra Pehlivan, Elif Yelda Niksarlıoğlu, Arif Balcı, Lütfiye Kılıç

Clinic of Pulmonary Rehabilitation, Health Sciences University, Yedikule Chest Diseases and Thoracic Surgery Training and Research Hospital, İstanbul, Turkey

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Abstract

OBJECTIVES: We aimed to investigate the effects of pulmonary rehabilitation (PR) on the level of physical activity (PA) and the general clinical status in adult patients with non-cystic fibrosis bronchiectasis.

MATERIALS AND METHODS: The patients were included prospectively in the study and followed a home-based PR program for 2 months comprising breathing exercises, training in chest hygiene techniques, peripheral muscle strengthening training, and self-walking. The outcomes measurements were the following: 6-minute walking distance, pulmonary function test, peripheral and respiratory muscle strength measurements, International Physical Activity Questionnaire (IPAQ), Saint George Respiratory Questionnaire, and modified Medical Research Council dyspnea scores.

RESULTS: Of the total 25 patients included in the study, six were excluded due to follow-up and adherence problems. A comparison of the outcome measures recorded before and after PR showed statistically significant improvements in the IPAQ total (p=0.015) and walking scores (p=0.011). While the proportion of patients in the low PA category was 73% (n=14) prior to PR, this rate decreased to 42% (n=8) post-PR. The proportion of patients in the moderate PA category was 26% (n=5) prior to PR and increased to 52% (n=10) post-PR. While positive improvements were seen in all clinically monitored parameters, aside from spirometric values, these changes did not reach a statistically significant level.

CONCLUSION: The majority of patients with bronchiectasis have a low level of PA. PR ensures positive improvements in the level of PA and general physical clinical status of such patients.

KEYWORDS: Bronchiectasis, dyspnea, exercise, lung function, muscle strength, quality of life

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INTRODUCTION

Bronchiectasis is an abnormal permanent dilatation of the bronchi and bronchioles, and it occurs as a result of recurrent or chronic airway infection and inflammation [1]. The primary symptoms of bronchiectasis include sputum-producing cough, dyspnea, and fatigue [2,3].

While the benefits of pulmonary rehabilitation (PR) in cases of chronic obstructive pulmonary disease (COPD) have been well documented, there have been only a limited number of studies investigating the efficacy of PR in patients with bronchiectasis [4,5]. These studies reported that positive effects of PR was also seen in bronchiectasis patients, but they have underlined the need for additional studies including larger patient groups to define PR indications and to ensure that exercise protocols are specific for this patient group [6].

A significant proportion of patients with bronchiectasis have shown marked decreases in exercise tolerance and physical activity (PA) level [7], although in a literature review, we were able to find only one study investigating the effects of PR on the level of PA in patients with bronchiectasis [8]. This single study assessed the feasibility and acceptability of an internet-based program to monitor and encourage exercise and daily PA. A clinical study performed on patients with cystic fibrosis, as a similar patient group, highlighted the impact of lung function on the level of PA and exercise capacity [9], and another study reported the positive effects of an exercise-based and video-assisted rehabilitation program on exercise capacity in patients with cystic fibrosis [10]. In the study by Elce et al. [11], the authors reported that positive effects were seen with a supervised exercise program on the clinical status and forced expiratory volume in 1 second

Address for Correspondence: Esra Pehlivan, Department of Physiotherapy and Rehabilitation, Health Sciences University, Faculty of Health Sciences, İstanbul, Turkey.
E-mail: fztesrakambur@yahoo.com

percentage (FEV_1) of patients, as well as anthropometric characteristics and such metabolic systems as lipid and glucose metabolism.

As the number of studies on this topic is limited, we aimed to investigate the effects of PR on the level of PA and general clinical status in adult patients with non-cystic fibrosis bronchiectasis in the present study.

MATERIALS AND METHODS

Patients with stable non-cystic fibrosis bronchiectasis and with no comorbidity, who were referred from pulmonology outpatient clinics to PR clinics between February 2017 and October 2017, were included prospectively in study.

The inclusion criteria were as follows: patients aged 18-70 years who had been diagnosed with bronchiectasis based on high-resolution computed tomography and were in a stable phase of the disease, and who signed the informed consent form. A stable phase of the disease was defined as follows: absence of fever or increased sputum or purulence over the last month; absence of an increase in dyspnea; and no history of emergency room admission, hospitalization, or use of antibiotics over the last month. The exclusion criteria were as follows: presence of any comorbidities preventing exercise (cardiovascular, orthopedic, or psychological), any type of cancer diagnosis, and already following a regular exercise program.

The patients were asked to follow an exercise program at home for 4 days in a week over a period of 2 months. A physiotherapist in the PR unit provided patient exercise training. The exercise program consisted of local expansion breathing exercises, training in chest hygiene techniques (postural drainage, percussion, huffing), peripheral muscle strengthening training, and self-walking. The apical, bilateral basal, and diaphragmatic breathing exercises were taught. Patients were asked to perform breathing exercises 4 times in a day, in sitting position, with 10 repetitions, for 5 days in a week. Chest hygiene techniques were taught to the patient and his or her family and applied to patient, and a handout with postural drainage positions was given. Patients were asked to perform upper and lower extremity strengthening exercises with free weights, 3 times a week and with 10 times repetition for the following muscles: quadriceps, hamstrings, deltoids, and biceps brachii. In order for the strengthening exercises to be remembered by the patient, an exercise handout was given. The patients were asked to walk daily in their own homes, taking the calculated distance based on the walking distance obtained from the 6-minute walk test (6MWT). It was taught how safe the heart rate, blood pressure, and oxygen saturation intervals are and how patients should behave when possible. They were told that they could get oxygen support and take a break if necessary. It was requested that the walking time be increased by 15 minutes, increasing tolerance every 30 minutes. The patients were asked to keep an exercise diary to allow their adherence to the exercise program to be followed.

Ethics approval was obtained from Medipol University Ethics Committee (Protocol Number: 10840098-604.01.01-E.4230), and the study was conducted in accordance with the Helsinki Declaration. Written informed consent was obtained from each patient.

Outcome Measurements

The radiological severity of the bronchiectasis was assessed using the modified Reiff score, which assesses the number of lobes involved (the lingula was considered as a separate lobe, tubular bronchiectasis=1, varicose bronchiectasis=2 and cystic bronchiectasis=3 points). The minimum score is 1 and the maximum score is 18 [12].

The bronchiectasis severity index (BSI) was applied to determine disease severity. The eight BSI parameters included age, body mass index (BMI), FEV_1%, predicted, hospital admission in the previous year, and exacerbation frequency in the previous year, Modified Research Council (MRC) dyspnea scale score, sputum colonization status, and radiological severity. Based on the BSI score, patients are classified into low-, moderate-, and high-risk groups, and patients at risk of future mortality, hospitalization, and exacerbation are identified [13].

The level of PA was determined using the International Physical Activity Questionnaire Short Form (IPAQ-SF) [14], which was performed by the physiotherapist in a face-to-face interview with the patient, and the scores were recorded on the patient evaluation form. Following the IPAQ guidelines, the respondents were categorized as engaged in vigorous PA, moderate PA, or low PA [15].

The exercise capacity was determined based on a 6MWT, which was conducted along a 30-meter corridor, in line with the American Thoracic Society (ATS) guidelines. The patients were told to walk as fast as they could, with oxygen saturation, heart rate, Borg fatigue rate, and walking distance recorded before and after the test [16,17].

Dyspnea perceptions during daily life activities were assessed according to the modified Medical Research Council (mMRC) scale [18].

The pulmonary function test was conducted using a Sensor Medics model 2400 device (Yorba Linda, CA, USA), in line with the ATS guidelines [19].

The peripheral muscle srength was measured using a digital dinanometer (J-Tech Medical; Utah, USA), with three measurments made in total of the quadriceps femoris, tibialis anterior, and iliopsoas muscles.

The mouth pressure measurement was performed using a Micro-RPM instrument of SensorMEDIC (MDSpiro; Maine, USA) [20].

The Saint George Respiratory Questionnaire (SGRQ) is a quality-of-life questionnaire that has been designed specifically for respiratory patients [21]. All of the patients answered the questions themselves [22], and scores were calculated using the score calculation algorithm (SGRQ manual version 2).

Statistical Analysis

The statistical analyses of the study were carried out using the Statistical Package for Social Sciences (SPSS) Version IBM

Statistic 15.0 (SPSS Inc.; Chicago, IL, USA). The normality of the test data was examined with a Shapiro-Wilk test, while a Wilcoxon test was used for intra-group comparisons for data with abnormal distribution. Variables were expressed as median, minimum, and maximum, and $p<0.05$ was considered statistically significant.

RESULTS

A total of 25 consecutive patients with stable bronchiectasis were included in the study, although four patients with follow-up problems and two patients with exercises compliance problems were excluded from the study. Of the remaining 19 patients, 12 (63%) were male, and the median age of the sample was 48 years. The mean BSI score of the patients was 6.78, and overall disease severity was in the moderate category. The demographic and baseline clinical characteristics of all the patients are given in Table 1.

A comparison of the values recorded before and after PR showed increases in the 6MWT distance, respiratory muscle strength, as well as in peripheral and respiratory muscle strengths and a decrease in mMRC dyspnea scores, although none of these differences were statistically significant (Table 2).

The results of the pulmonary function tests showed an overall worsening in all parameters and minimal increases in SGRQ quality-of-life scores (Table 2).

Among the sub-categories of the IPAQ PA levels, statistically significant improvements were noted in walking and in the total PA categories (Table 2). In the activity categories, based on the IPAQ scores, 73% (n=14) and 26.3% (n=5) of the patients were in the low and moderate PA categories, respectively, while there were no patients in the high PA category prior to PR. Following PR, the number of patients in the low PA category decreased, while the number of patients in the moderate PA category increased, and one patient surpassed the high PA threshold. The changes in PA categories are shown in Table 3. The changes in the PA levels were not significantly correlated with the Reiff (r=0.044, p=0.858) and BSI index (r=0.168, p=0.493) scores.

Table 1. Demographic and clinical baseline characteristics of the patients

Variables	Median (Min–Max)
Demographic features	
Age, year	48.36 (34–73)
BMI	26.56 (20–35)
Sex, male/female (n/%)	7/12 (37/63)
Smoking, packs x year	2.84 (0–30)
Reiff Score	6.36 (2–15)
BSI	6.78 (1–17)
Exercise capacity	
6MWD (m)	485.39 (114–709)
mMRC (0–4)* **	1 (0–4)
Pulmonary Functions	
FVC (L)	2.30 (0.65–3.71)
FVC (%)	65.19 (24.75–88.20)
FEV_1 (L)	1.63 (0.53–3.05)
FEV_1 (%)	55.50 (23.74–95.30)
FEV_1 /FVC	71.42 (48.54–97.40)
Mouth Pressure	
MIP (cm H_2O)	80.36 (30–129)
MEP (cm H_2O)	112.21 (31–197)
Muscle Strength	
Knee extension (N)	48.50 (26–77)
Dorsi flexion (N)	57.10 (31–88)
Hand grip (N)	63.78 (38–109)
IPAQ	
Vigorous PA, kcal/d	25.26 (0–480)
Moderate PA, kcal/d	132 (0–840)
Walking, kcal/d	146 (0–693)
Total PA, kcal/d	304 (0–1533)
SGRQ	
Symptom**	60.01 (25–87)
Activity	53.28 (0–100)
Impact	37.88 (1–73)
Total	46.39 (10–84)

BMI: body mass index; BSI: bronchiectasis severity index; 6MWD: 6-minute walking distance; mMRC: modified medical research council dyspnea score; FVC: forced vital capacity; FEV_1: first forced expiration volume; FEV_1/FVC: ratio of forced expiratory volume to forced vital capacity at first second; MIP: maximum inspiratory pressure; MEP: maximum expiratory pressure; IPAQ: international physical activity questionnaire; PA: physical activity; SGRQ: Saint George Respiratory Questionnaire

DISCUSSION

In the present study, we investigated the effects of PR on PA and the overall clinical status of patients with bronchiectasis. After finding that the majority of patients were at an inactive PA level, PR was seen to improve their level of PA and to have positive effects on their overall clinical status.

In the literature, this group of patients focuses more on secretion clearance [23] and exercise capacity [4]. A review of previously implemented PR applications in patients with bronchiectasis demonstrated that they mostly included personal maintenance methods [24]. The number of studies investigating the effect of PR on different clinical features in patients with bronchiectasis is limited.

There have been a limited number of studies investigating the effects of PR on the PA levels. In a cross-sectional study, an increase in the rate of regular exercise habit was measured by program access, and interview and sustained life changes were observed after an internet-based PR application involving a mixed group of patients with COPD and bronchiectasis. [8] In our study, we applied a home-based PR program only in patients with bronchiectasis and used exercise diaries to encourage the adherence to the exercise schedule.

Different devices and scoring systems were used to determine the level of PA in patients with respiratory disorders. In a

Table 2. The effect of pulmonary rehabilitation on exercise capacity, dyspnea, respiratory functions and muscle strength, and QOL and PA levels

	Before PR Median (Min–Max)	After PR Median (Min–Max)	Inter Group Δ Median (Min–Max)	z	p*
Exercise capacity					
6MWD (m)	485.39 (114-709)	515.39 (294-869)	30 (-158-218)	-1.786	0.074
mMRC (0–4)**	1 (0-4)	1 (0-3)	0 (-1-1)	-1.414	0.157
Pulmonary functions					
FVC (L)	2.30 (0.65-3.71)	2.24 (0.67-3.43)	-0.05 (-0.79-0.77)	-0.745	0.456
FVC (%)	65.19 (24.75-88.20)	62.78 (3.03-94.42)	-2.41 (-84.67-31.26)	-0.161	0.872
FEV_1 (L)	1.63 (0.53-3.05)	1.67 (0.48-3.46)	0.04 (-0.35-0.76)	-0.040	0.968
FEV_1 (%)	55.50 (23.74-95.30)	54.51 (2.68-91.07)	-0.99 (-85.42-38.35)	-0.201	0.841
FEV_1 /FVC	71.42 (48.54-97.40)	69.24 (52.59-92.92)	-2.18 (-17.69-14.40)	-0.966	0.334
Mouth pressure					
MIP (cm H_2O)	80.36 (30-129)	85.84 (30-135)	5.47 (-15-62)	-1.114	0.265
MEP (cm H_2O)	112.21 (31-197)	118.36 (31-196)	6.15 (-38-65)	-1.046	0.296
Muscle strength					
Knee extension (N)	48.50 (26-77)	49.57 (34-81)	1.07 (-13-15)	-0.440	0.660
Dorsi flexion (N)	57.10 (31-88)	51.50 (34-96)	-5.60 (-40-17)	-1.397	0.163
Hand grip (N)	63.78 (38-109)	66.05 (38-110)	2.26 (-10-16)	-1.128	0.259
IPAQ					
Vigorous PA, kcal/d	25.26 (0-480)	252.63 (0-4320)	227.36 (0-4320)	-1.000	0.317
Moderate PA, kcal/d	132 (0-840)	255.78 (0-840)	123.15 (-520-840)	-1.479	0.139
Walking, kcal/d	146 (0-693)	362.13 (0-990)	215.36 (-429-990)	-2.442	0.011
Total PA, kcal/d	304 (0-1533)	870.68 (0-4568)	566.00 (-949-4568)	-1.807	0.015
SGRQ					
Symptom**	60.01 (25-87)	59.28 (20-88)	-1.26 (-23-26)	-0.596	0.551
Activity	53.28 (0-100)	58.87 (0-100)	5.79 (-37-60)	-0.706	0.480
Impact	37.88 (1-73)	39.73 (4-75)	1.63 (-28-30)	-0.345	0.730
Total	46.39 (10-84)	50.81 (5-83)	3.03 (-28-29)	-0.734	0.463

6MWD: 6-minute walking distance; mMRC: modified medical research council dyspnea score; FVC: forced vital capacity; FEV_1: first forced expiration volume; FEV_1/FVC: ratio of forced expiratory volume to forced vital capacity at first second; MIP: maximum inspiratory pressure, MEP: maximum expiratory pressure; IPAQ: International Physical Activity Questionnaire; PA: physical activity; SGRQ: Saint George Respiratory Questionnaire; *Wilcoxan rank test, significance level $p<0.05$; ** The decrease in mMRC and SGRQ symptom scores are better results

Table 3. The changes in the level of physical activity based on IPAQ scores after PR

	Before PR	After PR
	n,%	n,%
Low PA	14 (73.7)	8 (42.1)
Moderate PA	5 (26.3)	10 (52.6)
Vigorous PA	0	1 (5.3)

IPAQ: International Physical Activity Questionnaire; PR: pulmonary rehabilitation; PA: physical activity

cross-sectional study using an accelerometer, pedometer, and questionnaire to measure the PA (IPAQ) in bronchiectasis indicated that an accelerometer most accurately reflected the level of PA [25], and in the same study, it was reported that the IPAQ score was unable to provide accurate results in the determination of the PA levels. In our study, we used the IPAQ score to determine the patients' level of PA and observed an increased level of PA after PR. We believe that this survey is sufficient to determine the PA levels of patients. Unfortunately, we cannot compare the efficacy of the two methods since there is no digital measuring device in our unit.

The absence of a correlation between the radiological and clinical disease severity scores detected by Reiff and BSI and the total IPAQ scores of the patients indicates that all patients with bronchiectasis can benefit from PR, irrespective of their disease severity. In the literature, we did not find any research study that included comparison of PR responses with bronchiectasis disease severity.

Previous PR programs involving patients with bronchiectasis were observed to have different durations, such as 6 weeks [10], 8 weeks [5], and 3 months [26]. In our study, PR was implemented 4 days a week for a period of 2 months. Some

reports in literature suggest that a higher level of benefit can be obtained from long-term programs in patients with COPD [27, 28], and increasing the duration of the program can also contribute to the benefits of PR in patients with bronchiectasis. It should be kept in mind; however, that longer durations could lead to adherence problems. We observed sufficient benefit from the 2-month home-based PR program applied to patients with COPD in our PR clinics, although there is currently no accurate data on this.

The main goals in the PR management are to reduce exacerbations and to improve the quality of life in patients with bronchiectasis [29]. The SGRQ is a quality-of-life questionnaire that has seen frequent use in all patients with respiratory disorder. The Cochrane Database of Systematic Reviews [30] reported that the level of quality of life, as measured by SGRQ, did not significantly increase after PR, and we also noted no significant differences in the SGRQ scores of the patients after PR in the present study. While this finding may highlight the need for the development and implementation of different quality-of-life measurement tools for patients with bronchiectasis, it may also be associated with the low number of cases in this study.

In this study, there was an increase in exercise capacity, dyspnea perception, and respiratory muscle strength, which did not reach statistical level. On the other hand, there was a decrease in the parameters of pulmonary function test. Despite PR, it is not surprising that there is no improvement in respiratory function. Many studies emphasize that there is no gain in pulmonary function test parameters [27,31] or not consider lung functions [5]. In this patient population, gains obtained from exercise programs are largely based on functional parameters and quality of life from respiratory functions with advanced lung diseases.

In this study, we aimed to underline the importance of home-based PR in patients with bronchiectasis. Supervised PR may not be available to a sufficient number of patients with bronchiectasis due to limited number of PR centers and physiotherapists specialized in these programs, as well as the high patient load. However, even a 2-month home-based PR program can have positive contributions to PA in this patient group, and so we believe that it would be appropriate to suggest that adult patients with non-CF bronchiectasis who refer to pulmonology outpatient clinics should take part in home-based PR programs.

There are some limitations to this study. To begin with, the number of patients was low, in part due to the exclusion of patients with other respiratory comorbidities, such as concomitant COPD, asthma, and cancer. Furthermore, only a limited number of bronchiectasis cases were referred to the PR center, which may be due to the lack of knowledge and experience of pulmonologists in the benefits of PR. In addition, the study was performed in a single center, although the patients were trained by physiotherapists who were experienced in PR in the reference center. As a further limitation, there was no control group in the study.

Pulmonary rehabilitation is a comprehensive and effective treatment approach that improves overall clinical status and increases the level of PA in patients with bronchiectasis. It is essential that patients with bronchiectasis could be included in comprehensive PR programs that are planned based on the patients' current clinical status and individual needs. In centers lacking the ability to provide supervised PR programs, home-based PR programs may be initiated for patients with bronchiectasis. We believe that awareness of PR should be increased in all physicians dealing with bronchiectasis patients, particularly in pulmonologists.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Medipol University.

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

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