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Effect of low-intensity pulmonary rehabilitation program on quality of life and pulmonary functions in patients with stable chronic obstructive pulmonary disease

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Abstract:

OBJECTİVES: The effectiveness of low-intensity pulmonary rehabilitation program applied patients with chronic obstructive pulmonary disease (COPD) in terms of exercise capacity, dyspnea scale, life quality and respiratory muscle strength.

METHODS: The study included 30 patients with COPD. The program was 3 days in a week, for a 6 weeks period between December 1st 2012 and August 31st 2013. Arterial blood gas (ABG), 6 minute walking test (SMWT), respiratory function tests and respiratory muscle strength were evaluated before and after treatment. St George's breathing questionnaire (SGRQ) was used to assess quality of life. The dyspnea scores were assessed by the Modified Medical Research Council (mMRC) and the COPD Assessment Test (CAT). Patient approvals were obtained for the study. For analysis of results kolmogorov smirnov test, shapiro – wilk test, wilcoxon test and sample ttest were used.

RESULTS: Of 30 patients participated in our study, 26 completed the treatment program. There were increases in SMWT distance ($P = 0.049$), forced expiratory volume in one second , and forced expiratory flow (FEF 25-75) value ($P < 0.05$); and decreases in mMRC dyspnea scale score ($P = 0.001$), CAT score (p=0.003) and SGRQ score ($P <= 0.001$). Maximum inspiratory pressure and maximum expiratory pressure values and ABG parameters did not show significant change.

CONCLUSION: Low intensity pulmonary rehabilitation therapy has positive effects on exercise capacity, dyspnea scale, walking distance, and quality of life. Patient compliance was high in this treatment modality so according to our study results, low intensity pulmonary rehabilitation treatment can be prefer to high intensity pulmonary rehabilitation treatment in COPD.

Keywords:

Chronic obstructive pulmonary disease, exercise capacity, pulmonary rehabilitation

Introduction

Chronic obstructive pulmonary disease (COPD) is a preventable and treatable disease characterized by progressive airway restriction.[1,2] One of the most common problems in patients with COPD is reduced exercise tolerance. Reduced physical activity in COPD during stable and exacerbation periods increases mortality and hospitalization frequency. As reduced exercise capacity is associated with the respiratory function, it is also associated with peripheral and respiratory muscle weakness.[3]

There is a consensus on the subject that the prevalence of COPD has increased over

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the past 30 years. As reported by the World Health Organization in 2004, COPD was the fourth-most common cause of death among all the ages. With the rate of 5.1%, it comes after ischemic heart disease, cerebrovascular disease, and lower respiratory tract infections.[4]

In chronic diseases such as COPD, a slow loss of muscle mass occurs due to the breakdown of muscle proteins and atrophy develops in skeletal muscles. Over time, these changes cause a decrease in the respiratory functions as well as exercise tolerance of patients, a deterioration in the quality of life and an increase in mortality.[5]

The treatment of COPD is a costly treatment. Since pulmonary rehabilitation therapy reduces hospital admissions and the amount and length of hospital stay, the cost is reduced as well. Combined modality therapy along with drug therapy is required. There is a need for generalization of the applications other than drug therapy.[6] Many cases cannot be adequately treated with pharmacological agents. Patients' experience reduced exercise capacity, social isolation, and mood changes (especially depression). International guidelines propose to include pulmonary rehabilitation as a treatment approach independent of the disease stage in Stage II, III, and IV COPD patients with muscle and weight loss.[7,8] Pulmonary rehabilitation allows patients to socialize. The exercise capacity as well as self-perceptions of dyspnea threshold of patients increase.[9] Pulmonary rehabilitation therapy can be applied at different intensity. The maximum exercise capacity that patients can make is determined by various methods. High-intensity pulmonary rehabilitation therapy is defined when the patient is exercising at a rate of 60%–80% of the maximum exercise capacity on the other and low-intensity pulmonary rehabilitation therapy is defined when the patient is exercising at a rate of 50% of the maximum exercise capacity. One of the ideal methods for calculating the maximum exercise capacity is the cardiopulmonary exercise test. The advantage of the cardiopulmonary exercise test is the patient's ability to comply with the program, and the tolerability of the exercise. The cardiopulmonary exercise test may give an idea about the safety of the pulmonary rehabilitation program.[10]

In the literature, there are little studies evaluating the efficacy of low-intensity pulmonary rehabilitation treatment on the quality of life and respiratory functions. In the present study, we aimed to investigate the efficacy of low-intensity exercise-based pulmonary rehabilitation therapy applied to stable COPD patients in an outpatient setting on parameters such as exercise capacity, dyspnea scale, walking distance, and quality of life.

Methods

Participants

Thirty patients who were followed up with the diagnosis of COPD between December 1, 2012, and August 31, 2013, and who received pulmonary rehabilitation in the Physical Therapy and Rehabilitation Clinic were included in the study. Ethics Committee Approval was obtained for the study and patient approvals were obtained for the study.

The inclusion and exclusion criteria's

Patients were selected among those who were diagnosed with COPD according to the definition of Global Initiative for Chronic Obstructive Lung Disease (GOLD), who did not have any exacerbation for the last 2 months, who had not received pulmonary rehabilitation before, whose general condition was stable and who were in the age range of 50–75 years. The patients who had orthopedic problems which could prevent them from participating in the pulmonary rehabilitation program, who had neurological diseases, who received oxygen therapy at home, who had pneumoconiosis, primary pulmonary hypertension, pulmonary embolism, interstitial lung disease, malignancy, cardiac disease, morbid obesity, exercise-induced asthma, neuromuscular disease, in whom quality of life cannot be questioned due to dementia and Alzheimer, who had central hemiplegia, in whom drug treatment was initiated recently, or whose drugs were modified during clinical follow-up were not included in the study.

Study design

Detailed anamnesis, information on cigarette use, number of exacerbations per year, additional diseases, physical examination findings, chest X-rays of the patients were evaluated. Various tests are available in the form of questions and answers to assess the symptoms of patients with COPD. The most valid inquiry tests include the British Medical Research Council (mMRC) and COPD assessment test (CAT) recommended according to the GOLD guideline. We also evaluated the effect of shortness of breath on the daily activities of patients with the mMRC and CAT inquiry tests.

There are numerous questionnaires and inquiry systems questioning the quality of life in COPD patients. The Saint George Respiratory Questionnaire (SGRQ) is one of these tests and it has many validated translations available worldwide. It is used commonly in our country. Four different parameters as symptom, activity, impact, and sum of all are examined. In terms of symptom, the shortness of breath, cough, sputum, wheezing, and exacerbations were questioned. In terms of activity, the physical activities that cannot be performed due to the shortness of breast were questioned. In the section

of impact, the impact of the disease on the life of case was evaluated. The score range of questionnaire varies between 0 and 100 the most severe disease and a minimum clinically significant change was considered to be four units. The quality of life of the patients was assessed with the SGRQ in our study. The patients were ensured to evaluate the questionnaire alone and in a silent environment. The total score of each three section marked by the patient was proportioned to the maximum score that could be obtained. By this way, the total test score was determined.[11]

Arterial blood gas (ABG) was taken to obtain direct and clear information about gas diffusion in the lungs. ABG was obtained 1 day before the start of rehabilitation therapy. Patients control blood gases was obtained 1 day after the last pulmonary rehabilitation therapy by calling for control. At least 0.2cc of ABG sample was taken from the radial artery of all patients while resting through an injector washed with heparin. Thereby, the patients in need of oxygen during exercise were determined. The pH (partial hydrogen pressure), pO_2 (partial oxygen pressure), pCO2 (partial carbon dioxide pressure), O_2 saturation were measured in the blood samples of the patients using ABG. It is possible to measure only oxygen saturation noninvasively, but with the pulse oximeter alone, we would not be able to get any information about all parameters, pCO2 in particular. The ABG blood gas parameters were analyzed with GASTAT-604 ox Blood Gas System (Techno Medica®, Yokohama, Kanagawa, Japan) device. Pulmonary function tests were assessed with the V max® branded device (Viasys-Healthcare®-2007 GmbH, Hoechberg, Germany). The respiratory muscle strength of the patients was measured with the Micro RPM® branded spirometry device (micro Medical Ltd., Kent, UK). Maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) were measured with the micro-RPM device. This is a simple measurement obtained from the maximum inspiration and expiration performed into a blocked mouthpiece. The mouthpiece consists of a small circle and this circle is connected to a manometer. Patients breathe into the circle using their cheeks or they inhale from the circle, this action of breathing in and out is performed with their maximal strengths. The result of MIP and MEP gives information about the neuromuscular function pathology of the diaphragm, intercostal, and accessory muscles.[12] Acceptable reference values for MIP and MEP were created according to the 2002 American Thoracic Society guideline.[13] The patients were tested at least three times and the best score was recorded. The 6-min walking test (6MWT) was administered to the cases. The purpose of this test is to make the patient walk as brisk as possible within 6 min. The patient was indicated that she/he may slow down or stop when necessary. The 6MWT was demonstrated to the patient by walking one tour. The distance walked for 6 min was recorded in terms of meter. The O_2 saturation was measured with pulse oximeter probe before the patient started to walk and O_2 saturation was measured and recorded again after walking was over.[14]

Pulmonary rehabilitation program

Pulmonary rehabilitation was accompanied by a nurse and a physician. First, the patients were trained, COPD was explained in a way that the patient can understand, and the methods of coping with disease according to the dyspnea severity were described. The patients were trained for the bronchodilator drugs used as pharmacological treatment and their usage errors were corrected by ensuring that they used their drugs in our company at least one time. The cases for whom new drugs were initiated or drug modifications were made (drugs were added or discontinued) were excluded. No change was made in the dose and daily use amounts of the currently used drugs.

The patients were trained for exercise, respiratory muscle strengthening exercise, bronchial drainage techniques, daily life activities, and energy conservation techniques.[15]

Pulmonary rehabilitation was applied to the patients for 6 weeks. Aerobic exercise was applied on the bike ergometer. Oxygen inhalation was applied during exercise to the cases whose oxygen saturation fell <90% during the walking test and to the cases with hypoxemia. The exercise test was carried out in the company of cardiologist through the Cambridge Heart, Inc., Exercise System CH 2000 device with Bruce Protocol. The target heart rate was determined to be 50% of the patient's maximum heart rate. Twelve-lead electrocardiography was obtained at the beginning, end of the test, and during the test. The test was terminated in the patients whose ECG was pathologic, whose blood pressure dropped or increased >10%, who had tachycardia or bradycardia, in whom angina developed, in whom serious arrhythmia developed. The test was also terminated in the patients who reached the target heart rate and who were not able to continue the test. The patients were included in the aerobic exercise program for 18 sessions for 6 weeks and three times a week and as a single session lasting 60 min/day in the cardiopulmonary exercise room under the supervision of physiotherapist and nurse. The aerobic exercise was conducted with a computer controlled bicycle ergometer (Ergoline, ergoselect II 100/200/Reha, Germany) which was developed specifically for this aim and which monitors the ECG, heart rhythm, blood oxygen level, and blood pressure of the patient. To achieve and maintain the heart rate determined in the study at constant heart rate, the system tests the heart rate of the patient and continuously increases or decreases

the load automatically. The exercise program consisted of a warm-up, training, and cool-down phases. The first session of the patients was performed for 20 min including 5 min of warm-up, 10 min of training, and 5 min of cool-down phase so that the target heart rate would be 50% of the maximal heart rate reserve. The training phase was increased for 5 min in each session. Starting from the 3rd week on, patients were engaged in an anaerobic exercise with a total duration of 60 min (5 min of warm-up + 50 min of training + 5 min of cool-down phase) with a target heart rate which would be 50% of the maximal heart rate reserve.

Statistical analysis

While assessing the results obtained from the study, the Statistical Package for the Social Sciences for Windows v20.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analyses. While the data were evaluated, the characteristic and demographic features of our patients were determined with descriptive statistical methods. The results were expressed as mean ± standard deviation. The suitability of the variables to normal distribution was examined with the Kolmogorov–Smirnov test and Shapiro–Wilk tests. Normally distributed parameters were examined with paired samples *t*-test and nonnormally distributed parameters were examined with the Wilcoxon tests.

A value of $P < 0.05$ was considered significant in all statistical analyses.

Results

Of 30 patients participated in the study, 26 completed the exercise program. Twenty-six patients to whom pulmonary rehabilitation was administered were included in the study. Four patients were observed to quit pulmonary rehabilitation voluntarily and to leave the treatment unfinished. Thus, the compliance of pulmonary rehabilitation therapy was observed to be 87%. The demographic and clinical features of the patients completing the study are presented in Table 1.

All respiratory parameters were found to increase after pulmonary rehabilitation treatment. However, only the increases in the parameters of forced expiratory volume in the first second (FEV_1), the ratio of forced expiratory volume in the first second to forced vital capacity (FEV_1/FVC) and functional expiratory flow (FEF 25–75) were statistically significant ($P < 0.05$). The FVC value was detected to increase from 85.4 to 86.1, this elevation was not statistically significant ($P = 0.345$). After 6 weeks of pulmonary rehabilitation treatment, the respiratory muscle strengths of the patients were observed to increase, but these changes were not statistically significant ($P > 0.05$). No statistically significant change was observed in the ABG values after pulmonary rehabilitation treatment of the patients. After pulmonary rehabilitation, a statistically significant elevation was observed in the 6MWT distance and O_2 saturations of the patients at the end of the test ($P < 0.05$) [Table 2].

Table 1: The demographic and clinical characteristics of the patients (*n*=26)

	n (%)
Age (years), mean±SD	62±7
Smokers (pack-years)	
20-39	8 (30)
≥40	18 (70)
Active smokers	7 (27)
Ex-smokers	19 (73)
Co-morbidities	
Diabetes mellitus	2 (8)
Hypertension	7 (27)
Diabetes mellitus with hypertension	2 (7)
Pharmacological therapy	
LABA + ICS	12 (46)
LABA + ICS+tiotropium	14 (54)
Exacerbation history (events/year), mean±SD	1.2±0.6
1/year	23 (89)
≥2/year	3 (11)

LABA: Long-acting beta agonists, ICS: Inhalatory corticosteroids, SD: Standard deviation

Table 2: The comparison of respiratuvar function tests, arterial blood gas, maximum inspiratory pressure, maximal expiratory pressure, 6 min walking tests pre- and post-treatment of the patients

	Mean±SD		*P*
	Pretreatment	Posttreatment	
Pulmonary function tests			
FVC (%)	85.43±9.6	86.1±20.3	0.345
FEV_1 (%)	60.4±13.9	70.6±18.8	<0.001*
FEV_1/FVC ratio (%)	56.2±8.8	62.5±10.1	0.001*
FEF 25-75 (%)	29.4±11.5	35.5±18.7	0.002*
MIP (cmH_2O)	75.3±24.1	78.0±25.2	0.739
MEP (cmH_2O)	94.0±20.2	95.5±20.5	0.246
ABG			
pH (mmHg)	7.41±0.03	7.41±0.02	0.577
pO_2 (mmHg)	64.1±13.6	61.7±8.7	0.444
SO_2 (mmHg)	93.0±9.8	91.2±15.2	0.886
HCO_3 (mmHg)	22.4±2.1	22.2±2.3	0.403
pCO_2 (mmHg)	34.5±4.1	34.4±3.3	0.484
Exercise capacity			
6MWD baseline SO_2 (%)	94.6±2.8	95.3±2.4	0.185
6MWD ending SO_2 (%)	90.77±6.112	92.7±5.7	0.019*
Walking distance (m)	520.8±92.1	542.3±80.5	0.049*

*P<0.05. FVC: Forced vital capacity, FEV_1: Forced expiratory volume in 1 s, FEF 25%-75%: Forced expiratory flow, MIP: Maximal inspiratory pressure, MEP: Maximal expiratory pressure, 6MWD: 6-min walking distance, ABG: Arterial blood gas, SD: Standard deviation

After the pulmonary rehabilitation treatment administered for 6 weeks, the mean mMRC value fell from 1.5 to 0.5, whereas the CAT value fell from 18.1 to 12.6. The means of the changes detected were statistically significant ($P < 0.001$). There was a statistically significant decrease in the values obtained for the parameters of symptom, activity, and effect in the SGRQ evaluation criterion ($P < 0.05$). Furthermore, the total SGRQ assessment score, which was 48 before treatment, decreased to 37 and this drop was statistically significant ($P < 0.05$) [Table 3].

Discussion

When the preexercise and postexercise values were compared, the results of our study demonstrated that positive changes were detected in COPD patients treated with a low-intensity exercise program. The pulmonary rehabilitation program strengthens the peripheral muscles, increases O_2 use in the muscles, increases the exercise performance of the patients and reduces the dyspnea.[14] Croitoru *et al*. observed a significant elevation in the 6MWT (58.3 m) after the pulmonary rehabilitation treatment administered to 60 patients for 7 weeks (3 days a week).[16] Eqan *et al*. investigated the short-term treatment results of 47 patients and long-term treatment results of 17 patients after the pulmonary rehabilitation program. An increase in 6MWT was observed in the patients evaluated after 3 months and 1 year. After a 7-week program, an elevation from 391 to 444 m (55 m) was observed and this value was observed to be preserved for a long time.[17] In the current studies, there was an increase of 45.3 m in the 6MWT of the patients, whereas a statistically significant increase (22.3 m) was observed in our study, although it was lower than most of the other studies. Since there was an elevation of 0.049 in the 6MWT value in our study, the statistical significance was at borderline. The reason for the significance value at borderline may be because the program was only for 6 weeks. The limitation of our study was not to follow-up patients for long-term after treatment. In some of the studies mentioned above, the 6MWT was performed after a long period and a prospective effect of pulmonary rehabilitation was noted.

Table 3: The comparison of chronic obstructive pulmonary disease Assessment Test, Saint George Respiratory Questionnaire of the cases pre- and post-treatment

	Mean±SD		*P*
	Pretreatment	Posttreatment	
CAT	18.1±7.9	12.6±6.1	0.003*
mMRC	1.57±0.236	0.577±0702	0.001*
SGRQ			
Symptoms	51.9±14.2	47.5±13.9	0.029*
Activity	59.6±14.8	49.4±25.4	0.013*
Impacts	39.7±17.7	26.6±18.1	0.000*
Total	47.8±14.2	36.7±15.88	<0.01*

*$P<0.05$. COPD: Chronic obstructive pulmonary disease, CAT: COPD Assessment Test, SGRQ: Saint George's Respiratory Questionnaire, mMRC: Modified Medical Research Council, SD: Standard deviation

In the study by Croitoru *et al*. investigated the benefits of pulmonary rehabilitation, they found statistically significant changes in the mMRC examination of the patients.[16] We also observed a significant change in the mMRC in our study.

de Souto *et al*. divided the patients into three groups, namely, the control group, exercise in water group, and exercise on the land group and a significant improvement was observed in four sub-parameters of the SGRQ inquiry test in the exercise on the land group.[18] Kon *et al*. observed a significant decrease in the SGRQ tests after 6 weeks of pulmonary rehabilitation therapy applied to 261 patients.[19] When current studies were compared with our study, a total of 11 points decrease was observed in the SGRQ values and a mean of 6-point regression was observed in other studies.

There was no statistically significant increase in the FVC after multidisciplinary pulmonary rehabilitation program was performed by Güell *et al*. while there was no change in the FEV_1 value. This result was contributed to the increase in respiratory muscle strength but a lack of change in respiratory functions.[20] Whereas in this study, although there was no significant change in the ABG values of the patients, a statistically significant elevation was observed in the respiratory functions of the FEV_1 value (from 60.4 to 70.6), FEV_1/FVC ratio (from 56.2 to 62.5), and FEF 25–75 value (from 29.4 to 35.5). In addition to the improvement in the musculoskeletal system occurring at the end of exercise studies, also an improvement was detected in the pulmonary functions. In the study by Hsieh *et al*., pulmonary rehabilitation was applied to 34 patients for 6 weeks for three days a week. No significant change was detected in the MIP and ME*P* values of 16 patients who could complete the program, but an averagely significant increase was detected in the 6MWT.[21] In this study, the increase in the MIP and ME*P* values of the patients after pulmonary rehabilitation was not statistically significant. May this condition show that pulmonary rehabilitation provides strengthening in respiratory functions but does cause a change in respiratory muscles? We suggest that significant results may be obtained after a long pulmonary rehabilitation application if MIP and MEP assessments were performed again.

Of 30 patients participated in our study, 26 completed the exercise program. Thus, the rate of compliance with treatment was found to be approximately 87%. In the study by Canavan *et al*. in which a 6-week

multidisciplinary pulmonary rehabilitation was applied and 12 of 17 patients completed the treatment, the compliance rate was found to be 70.58%.[22] The compliance rate was found to be 47.05% in the study by Hsieh *et al*. in which pulmonary rehabilitation was applied for 6 weeks and 16 of 34 patients completed the treatment.[21] The compliance rate of our patients to whom pulmonary rehabilitation was recommended was observed to be high. We consider that the reason increasing the participation rate was that the exercise treatment program had low-intensity exercise. In the study by Donaire-Gonzalez *et al*., low- and high-intensity exercise treatment programs were applied to 177 patients with COPD. The exercise intensity of the patients was determined by measuring with a pedometer attached to their arms. The exercise intensity of the patients was determined by recording for how many days and hours the patients exercised per week, by calculating their steps and by measuring their exercise. In this study, low-intensity exercise was determined to decrease hospitalization rate and mortality. High-intensity exercise treatment was found not to reduce mortality.[23]

All exercise programs such as swimming, walking, running, cycling, and sports are useful for patients, but low-intensity exercise treatment programs at regular intervals provide controlled treatment for patients. As in this study, patients can be closely monitored in these rehabilitation programs while they exercise. Since vital signs such as blood pressure, heart rate, and oxygen saturation are monitored during exercise, it gives us the comfort to intervene if necessary while treating the patient. This monitoring does not seem to be possible in other pulmonary rehabilitation treatment programs. The low-intensity pulmonary rehabilitation treatment program was observed to provide significant contributions to the Pulmonary Functional Test (PFT), sixminutes walking test (6MWT) distance and quality-of-life values. What makes our study strong was that we applied a personalized, low-intensity pulmonary rehabilitation treatment program to which patients could adapt. The participation rate and most importantly, the compliance rate of low-intensity pulmonary rehabilitation treatment can be higher and it can be more effective than high-intensity pulmonary rehabilitation treatment.

The major limitations of our study were the limited number of included patients and the shorter rehabilitation time. The other limitation is that we could not re-evaluated the benefits of our rehabilitation at longer period. Moreover, one of the other limitations is that all of our patients were male.

Conclusion

Low-intensity pulmonary rehabilitation therapy has positive effects on exercise capacity, dyspnea scale, walking distance, and quality of life. Patient compliance was high in this treatment modality so according to the study results, low-intensity pulmonary rehabilitation treatment can be preferred to high-intensity pulmonary rehabilitation treatment in COPD.

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Conflicts of interest
There are no conflicts of interest.

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