ID Design Press, Skopje, Republic of Macedonia
Open Access Macedonian Journal of Medical Sciences.
https://doi.org/10.3889/oamjms.2018.381
eISSN: 1857-9655
Clinical Science

Impact of Lower-Limb Endurance Training on Dyspnea and Lung Functions in Patients with COPD

Amira Permatasari Tarigan[1*], Pandiaman Pandia[1], Erna Mutiara[2], Andika Pradana[1], Ella Rhinsilva[1], Efriyandi Efriyandi[1]

[1]Department of Pulmonology and Respiratory Medicine, Faculty of Medicine, Universitas Sumatera Utara, Jalan Bunga Lau 17, Adam Malik General Hospital, Sumatera Utara, Indonesia; [2]Department of Biostatistics, Faculty of Public Health, Universitas Sumatera Utara, Medan, Indonesia

Citation: Tarigan AP, Pandia P, Mutiara E, Pradana A, Rhinsilva E, Efriyandi E. Impact of Lower-Limb Endurance Training on Dyspnea and Lung Functions in Patients with COPD. Open Access Maced J Med Sci. https://doi.org/10.3889/oamjms.2018.381

Keywords: COPD; Dyspnea; Pulmonary function; Lower-limb endurance training

***Correspondence:** Amira Permatasari Tarigan. Department Pulmonology and Respiratory Medicine, Faculty of Medicine, Universitas Sumatera Utara, Jalan Bunga Lau 17, Adam Malik General Hospital, Sumatera Utara, Indonesia. E-mail: amira@usu.ac.id

Received: 10-Oct-2018; **Revised:** 08-Nov-2018; **Accepted:** 09-Nov-2018; **Online first:** 17-Dec-2018

Funding: This study was funded by the Directorate General of Higher Education, Ministry of Education and Culture, Republic of Indonesia (No.70/UN5.2.3.1/PPM/KP-DRPM/2017)

Competing Interests: The authors have declared that no competing interests exist

Abstract

BACKGROUND: Patients with chronic obstructive pulmonary disease (COPD) exhibit persistent dyspnea in daily activities and irreversible airflow obstruction. These will finally lead to an inability to carry on daily activities and markedly decrease their quality of life. Endurance training was considered as therapy modality to alleviate several symptoms experienced by COPD patients.

AIM: This study aims to identify the impact of lower-limb exercise on dyspnea and spirometry test results in COPD patients.

METHODS: We performed a quasi-experimental study in July 2017 on 20 stable COPD patients divided both in group C and D according to GOLD 2017 criteria. Patients were given an individualised dose of stationary cycling twice a week for one month in which every session lasted 5-20 minutes gradually. Before and after rehabilitation program, pulmonary function tests were measured by spirometry to obtain per cent predicted of Forced Expiratory Volume in 1 second (FEV1), Forced Volume Capacity (FVC), Peak Expiratory Flow (PEF) and Forced Expiratory Flow at 25-75% of the pulmonary volume (FEF25-75), and dyspnea was measured by the mMRC index. Statistical analysis was performed by Wilcoxon and T-dependent test.

RESULTS: Baseline value of FVC (49.6 ± 21.6%) increased significantly to 59.65 ± 16.53% after one month of endurance training program ($p = 0.01$). Surprisingly, there was also a significant increase in FEV1 value from 46.9 ± 21.7 to 52.9 ± 20.7% ($p < 0.005$). The increase of FVC and FEV1 in group C was slightly higher than in group D although not statistically significant ($p = 0.29$; $p = 0.25$ respectively). However, no difference was observed in PEF and FEF25-75 value ($p > 0.05$). Patients' dyspnea scale also showed significant improvement ($p < 0.001$) from mMRC median scale 2 (range 1-3) to 1 (range 0-2) in both groups C and D. There was no exacerbation found during rehabilitation program.

CONCLUSION: Twice a week lower-limb endurance training for one-month improved dyspnea and pulmonary function test results in COPD patients safely and effectively.

Introduction

Chronic obstructive pulmonary disease (COPD) is a major cause of mortality worldwide. COPD is projected to be the 3rd leading cause of death by 2020. More than 3 million people died of COPD in 2012 accounting for 6% of all deaths globally. The COPD burden is projected to increase in coming decades because of continued exposure to COPD risk factors and ageing of the population [1].

Patients with COPD exhibit persistent dyspnea in daily activities and irreversible airflow obstruction. These will finally lead to an inability to carry on daily activities and markedly decrease their quality of life.

The mechanisms contributing to dyspnea must be approached in an integrative manner. Respiratory muscle function and its relationship to metabolic and cardiopulmonary variables during exercise identify some of the factors that limit exercise performance in patients with COPD. The identification of other factors that contribute to variability in dyspnea during exercise could result in improvement in a patient's exercise capacity [2]. In 2016, Hodonska et al., [3] found a decreased level of exercise tolerance in patients with severe COPD. The study also concluded that exercise, assessed by the average of the 6 minutes walk distance (6MWD), could cause greater desaturation in patients with COPD compared with the healthy person [3].

Total daily activities in patients with COPD are largely related to legs activity which is reduced compared with controls of similar age [4]. Muscle dysfunction is especially relevant in COPD because it is related to important clinical outcomes such as mortality, quality of life and exercise intolerance, independently of lung function impairment. Thus, improving muscle function is considered an important therapeutic goal in COPD management [5].

Management strategies should not only be limited to pharmacologic approach but also complemented by appropriate non-pharmacologic interventions. Built around exercise training, the rehabilitation program is a multidisciplinary, evidence-based comprehensive approach to address the patient comprehensively, not only the pulmonary component of the disease [6]. A rehabilitation program is indicated to all patients with relevant symptoms and/or high risk for exacerbation. The rehabilitation program on COPD aims to reduce symptoms, increase exercise tolerance and improve the quality of life of patients with COPD. The rehabilitation program consists of 3 components; physical exercise, psychosocial and breathing exercises. Physical exercises including cardiovascular training and muscle training are the main pillars of pulmonary rehabilitation and are considered as the best strategies for improving exercise tolerance and muscle function in patients with COPD [5].

Studies of skeletal muscle function in COPD have demonstrated that upper limb muscles were less affected than lower limb muscles. Thus, the reduction in quadriceps strength averaged 30% when compared with healthy subjects [7]. Endurance training was considered as therapy modality to alleviate several symptoms experienced by patients with COPD [1].

This study aims to identify the impact of lower-limb exercise on dyspnea and spirometry test results in patients with COPD.

Methods

This was a quasi-experimental study in stable COPD patients from COPD daily clinic at Adam Malik General Hospital. The diagnosis of COPD was established from the history and physical examination and then confirmed by spirometry examination. We performed this study in July 2017 on 20 stable COPD patients divided both in group C and D according to GOLD 2017 criteria. The inclusion criteria were patients with smoking history, aged from 40-80 years old and had not been involved in any exercise program one-month prior intervention. Subjects were excluded if having exacerbation history within the last one month. Patients received optimal medical therapy and were clinically stable at the time they came to the rehabilitation program. Patients were given an individualised dose of stationary cycling, counted based on Metabolic Equivalents (METs) with the formula METs = VO_2 max/3.5. The VO_2 max was calculated using Formula Nury® specifically designed for Indonesian population by converting the 6-minute walking distance, heart rate, and anthropometry value 10 [8]. Twenty patients were referred for endurance training two times a week for four weeks. The subjects underwent lower limb exercise with stationary cycling in which every session lasted 5-20 minutes gradually increased. The heart rate was monitored, and there was a physiotherapist during exercise for safety reasons. No other form of training was provided during the study period. Chest physiotherapy was performed every time before exercising (infrared, stretching, clapping).

Before and after endurance training, pulmonary function tests were measured by spirometry (Vitalograph, Alpha Model, United Kingdom) to obtain percent predicted of Forced Expiratory Volume in 1 second (FEV1), Forced Volume Capacity (FVC), Peak Expiratory Flow (PEF) and Forced Expiratory Flow at 25-75% of the pulmonary volume (FEF25-75), and dyspnea was measured by mMRC index.

Statistical analysis was performed by Wilcoxon and dependent T-test. Ethics approval and informed consent were obtained.

Result

A total of 20 patients with COPD who met the criteria were involved in this study. The overall subjects of this study were men with a history of smoking (ex-smoker), as described in Table 1.

Table 1: Demographic Characteristics of Research Subjects

Characteristics		n	%
Age			
(years old)	40-49	1	5.0
	50-59	2	10.0
	60-69	12	60.0
	70-79	5	25.0
Occupation			
	Retired government officer	11	55.0
	Entrepreneur	8	40.0
	Farmer	1	5.0
Body Mass Index			
	Underweight	3	15.0
	Normoweight	6	30.0
	Overweight	1	5.0
	Obese	10	50.0
Brinkman Index			
	Mild	3	15.0
	Moderate	2	10.0
	Severe	15	75.0

The majority subject of this study was in the age range 60-69 years (60%). Most of the subjects (55%) were an ex-government officer. From body mass index, majority subject was obese (50%), and based on the level of cigarette consumption, it was found that 75% of subjects were patients with severe consumption of cigarettes. The characteristics of research subjects based on the degree of severity of COPD are listed in Table 2.

Table 2: The degree of severity of COPD

COPD characteristics		n	%
Group COPD			
	Group A	0	0
	Group B	0	0
	Group C	6	30.0
	Group D	14	70.0
GOLD severity			
	GOLD I	3	15.0
	GOLD II	3	15.0
	GOLD III	11	55.0
	GOLD IV	3	15.0
CAT Score			
	CAT < 10	5	25.0
	CAT ≥ 10	15	75.0
mMRC Score			
	mMRC 0 – 1	9	45.0
	mMRC ≥ 2	11	55.0
Comorbid			
	Comorbid	9	45.0
	Cardiovascular	9	45.0
	Endocrine	2	10.0

Characteristics of the subjects based on the severity of COPD group, the degree of expiratory airflow obstruction according to GOLD criteria, CAT questionnaire scores reflecting the impact of COPD disease on daily life, mMRC score reflecting the degree of breathlessness, comorbid disease and Brinkman index reflecting consumption level cigarette.

Of the 20 subjects, most of the subjects were within group D (70%). Based on the degree of airflow obstruction according to the forced-expiratory volume in one second (FEV1) obtained from the spirometry examination, we found that more than half of subjects (55%) were within GOLD III. While according to the CAT questionnaire, it was found that 15 patients (75%) had scored more than or equal to 10, reflecting the magnitude of the negative impact that COPD causes on the patient's daily activities.

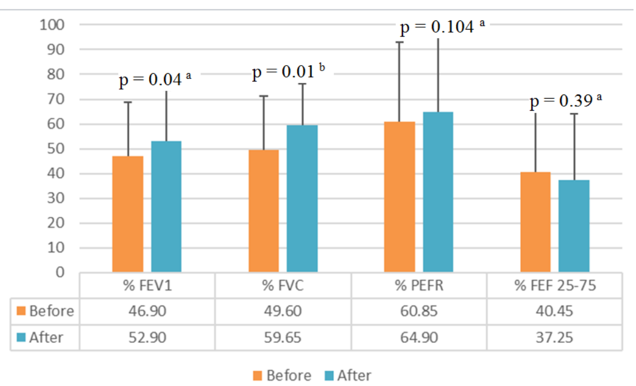

Figure 1: Impact of Lower Limb Endurance Training on Pulmonary Function Test; a) Wilcoxon test; b) Paired T-test

The baseline value of FVC was 49.6 ± 21.6%, and this number increased significantly to 59.65 ± 16.53% after one month of the endurance training program ($p = 0.01$). Surprisingly, there was also a significant increase in FEV1 value from 46.9 ± 21.7 to 52.9 ± 20.7% ($p < 0.005$). However, no difference was observed in PEF and FEF25-75 value ($p > 0.05$) (Figure 1).

Patients dyspnea index also showed significant improvement ($p < 0.001$) from mMRC median scale 2 (range 1-3) to 1 (range 0-2) in both group C and D (Figure 2). There was no exacerbation found during the rehabilitation program.

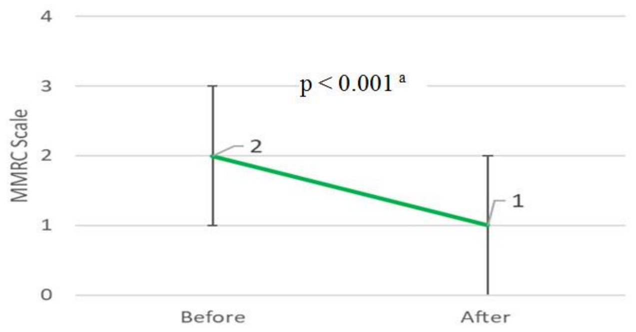

Figure 2: Impact of Lower Limb Endurance Training on mMRC Dyspnea Scale. a) Wilcoxon test

We also evaluated whether the degree of COPD severity affected the increase of pulmonary function test after the rehabilitation program. It was found that the increase of FVC and FEV1 in group C was slightly higher than in group D although not statistically significant ($p = 0.29$; $p = 0.25$ respectively) (Table 3.)

Table 3: Effect of COPD grouping on the increase of Pulmonary function test

Variable	Mean ± Standard Deviation		p-value
	COPD Group C	COPD Group D	
Delta FEV1	8.8 ± 10.9	4.8 ± 6.9	0.32 [a]
Delta FVC	4 ± 7.2	12.6 ± 18.5	0.28 [a]
Delta PEFR	7.8 ± 9.8	2.4 ± 17.8	0.49 [a]
Delta FEF25-75	4.5 ± 16.4	-6.5 ± 16.0	0.18 [a]

Independent T-test.

It was clear now that pulmonary rehabilitation could give some benefits for patients with COPD regardless of their disease severity. Thus, pulmonary rehabilitation can be concluded as a safe and effective program for patients with COPD.

Discussion

All subjects in this study were male. This provides an advantage regarding data analysis because it will be able to reduce the biases that may arise due to gender. This finding is similar to conditions in the field which states that men are the largest number of patients with COPD. The high incidence of COPD in a male is related to the fact that the prevalence rate of smokers is 16 times higher in males (65.9%) than female (4.2%) [9]. Men are more active outdoor, so they will have a higher risk of environmental biomass exposure, such as pollution in the workplace and on the road.

The average age of patients with COPD who were the subject of this study was 64.8 ± 8.21 years. As many as 60% of patients are in the age range 60-69 years. The effects of age on the incidence of COPD can be explained through the concept of pulmonary function decline phenomenon. Pulmonary function will increase from birth and peak at 21 years of age.

Distribution of body mass index found that 50% of patients were classified into obesity. Better measurement for monitoring the nutritional status of patients with COPD is a fat-free mass that reflects muscle mass, rather than fat mass. Obesity in patients with COPD is also influenced by the effects of reduced mobilisation due to deconditioning effect [10].

Characteristics of patients based on the level of cigarette consumption indicate that 75% of patients have a severe Brinkman index. High cigarette consumption will induce TNFα release by alveolar macrophages followed by increased production of metalloproteinase matrices (MMP). This MMP will initiate the destruction of smokers' breathing descent. Thus, the greater the Brinkman index, reflecting the longer and more cigarette consumption levels, the greater the destructive effects that occur. However, not all smokers develop into clinical COPD. This is due to the involvement of genetic polymorphism factors in the pathogenesis of COPD.

The distribution of patients based on grouping system shows that 30% of patients belonging to group C, and 70% sufferers belonging to group D. There are no patients with COPD belonging to group A or B in this study. Spirometry procedure is more widely available in large hospitals, so patients with group A and B COPD in the population are often undiagnosed. In this study, only 15% of patients belonging to GOLD I. This is due to patients with a minimal reduction in FEV1 usually does not experience significant complaints, so they do not look for treatment. Also, there is often a misdiagnosis of the patient while they diagnosed with chronic bronchitis [12].

Pulmonary rehabilitation has been recommended to be a standard of management in patients with stable COPD. The American College of Sports Medicine recommends exercise for 20-60 minutes with the target heart rate is about 40% to 85% of the maximum rate. High-intensity whole-body exercise programmes, which suitable for improving the fitness in normal subjects, are often not tolerated by patients with COPD because of reduced ventilatory reserve and incapacitating breathlessness. Nevertheless, improvements in mobility have been reported following a variety of pulmonary rehabilitation programmes. One explanation of such improvements may be the effects of regular exercise in countering the "vicious cycle" of deconditioning [13], which contribute to exercise intolerance through leg fatigue for example. Endurance training in the form of cycling is the preferred modality for patients with COPD because it gives greater weight to the thigh muscles, and results in less oxygen desaturation [1].

The lower limb survival training program should be integrated with medical therapy as a comprehensive management modality and performed regularly for patients with stable COPD to achieve improved quality of life. Endurance training was proved to increase cardiac output in order to meet the increased oxygen demand in muscles. Muscles are trained to work under aerobic circumstances, and along with these, there will be increased ventilation [1]. The effects of a lower-limb endurance training program on variables are reflecting thoracoabdominal motion. The endurance training program influenced the thoracoabdominal motion positively leading to a significant decrease in asynchrony during exercise in patients assessed. In this study, endurance training used a static bicycle with the intensity based on the individual assessment by medical rehabilitation practitioner.

There is strong evidence that either dyspnea or leg effort limit exercise performance. Leg fatigue appears to be more important in those with less COPD. This is consistent that both respiratory and peripheral muscles play an important role in limiting muscular performance. In conditions of moderate intensity of submaximal exercise, when cardiac output is abnormally low and ventilatory work is high, the effect of respiratory muscle load on maximal exercise performance might be due to the associated reduction in leg blood flow which increases both leg effort and intensity. During prolonged submaximal exercise with a constant load, both the perceived effort of breathing and the perceived effort of exercising the skeletal muscles gradually increase with time, eventually reaching the subject’s tolerable limit.

The present study showed a significant increase in lung functions post exercise intervention. Patients with COPD often have an altered breathing pattern and experience shortness of breath, particularly when they act. This exercise changes the breathing pattern, improves muscle strength and endurance the respiratory muscles that contribute increase the ventilation and lung functions in patients with COPD.

Some of the limitations of this study include the number of sessions, and the duration of exercise is shorter when compared with other studies. The endurance training program conducted in this study was 2 sessions per week which lasted for 4 weeks. Longer sessions and duration of exercise are required for patients with COPD, 8-12 weeks and various forms of exercise to assess the long-term effects of endurance training and to formulate training methods that deliver the best outcomes for patients with COPD, particularly those in COPD group D. However, this study emphasizes the value of pulmonary rehabilitation, thus further study with larger number of patients may be required.

In conclusion, twice week lower-limb endurance training for one-month improves dyspnea scale and pulmonary function test results of patients with COPD safely and effectively.

References

1. Vogelmeier CF, Criner GJ, Martinez FJ, Anzueto A, Barnes PJ, Bourbeau J, Celli BR, Chen R, Decramer M, Fabbri LM, Frith P. Global strategy for the diagnosis, management, and prevention of chronic obstructive lung disease 2017 report. GOLD executive summary. American journal of respiratory and critical care medicine. 2017; 195(5):557-82. https://doi.org/10.1164/rccm.201701-0218PP PMid:28128970

2. Stendardi L, Binazzi B, Scano G. Exercise dyspnea in patients with COPD. International journal of chronic obstructive pulmonary disease. 2007; 2(4):429. PMid:18268917 PMCid:PMC2699965

3. Hodonská J, Neumannová K, Svoboda Z, Sedlák V, Zatloukal J, Plutinský M, Koblížek V, Bizovská L. Incremental shuttle walk test as an indicator of decreased exercise tolerance in patients with chronic obstructive pulmonary disease. Acta Gymnica. 2016; 46(3):117-21. https://doi.org/10.5507/ag.2016.012

4. Walker PP, Burnett A, Flavahan PW, Calverley PM. Lower limb activity and its determinants in chronic obstructive pulmonary disease. Thorax. 2008. https://doi.org/10.1136/thx.2007.087130 PMCid:PMC2717793

5. Nyberg A, Carvalho J, Bui KL, Saey D, Maltais F. Adaptations in limb muscle function following pulmonary rehabilitation in patients with COPD–a review. Revista Portuguesa de Pneumologia (English Edition). 2016; 22(6):342-50. https://doi.org/10.1016/j.rppnen.2016.06.007 PMid:27522458

6. Bernard S, Ribeiro F, Maltais F, Saey D. Prescribing exercise training in pulmonary rehabilitation: A clinical experience. Revista Portuguesa de Pneumologia (English Edition). 2014; 20(2):92-100. https://doi.org/10.1016/j.rppnen.2014.03.005

7. Castagna O, Boussuges A, Vallier JM, Prefaut C, Brisswalter J. Is impairment similar between arm and leg cranking exercise in COPD patients?. Respiratory medicine. 2007; 101(3):547-53. https://doi.org/10.1016/j.rmed.2006.06.019 PMid:16890417

8. Nusdwinuringtyas N, Widjajalaksmi W, Bachtiar A. Healthy adults maximum oxygen uptake prediction from a six-minute walking test. Medical Journal of Indonesia. 2011; 20(3):195-200. https://doi.org/10.13181/mji.v20i3.452

9. Riskesdas Riset Kesehatan Dasar. Badan Penelitian Dan Pengembangan Kesehatan RI, 2013.

10. Koniski ML, Salhi H, Lahlou A, Rashid N, El Hasnaoui A. Distribution of body mass index among subjects with COPD in the Middle East and North Africa region: data from the BREATHE study. International journal of chronic obstructive pulmonary disease. 2015; 10:1685. PMid:26346564 PMCid:PMC4554407

11. Tarigan AP. Hubungan Polimorfisme Gen TNFα Pada Posisi -308 Dan -238 Dengan Kejadian Penyakit Paru Obstruktif Kronik. Universitas Sumatera Utara, 2013. Retrieved from http://repository.usu.ac.id/handle/ 123456789/35075

12. PDPI. PPOK: Diagnosis dan Penatalaksanaan. Jakarta: UI Press, 2016.

13. Casaburi R. Exercise training in chronic obstructive lung disease. Principles and practice of pulmonary rehabilitation. 1995:204-24.

14. França DC, Vieira DS, Vieira BD, Britto RR, Parreira VF. Lower-limb endurance training program influences thoracoabdominal motion of patients with COPD?. Fisioterapia em Movimento. 2013; 26(1):141-50. https://doi.org/10.1590/S0103-51502013000100016

15. Stendardi L, Binazzi B, Scano G. Exercise dyspnea in patients with COPD. International journal of chronic obstructive pulmonary disease. 2007; 2(4):429. PMid:18268917 PMCid:PMC2699965