

The Effect of Inspiratory Muscle Training on spirometry parameters of Patients with Chronic Obstructive Pulmonary Disease

Mahdi Khoshkhabar^a, Maryam Mirenayat^{b*}, Mohsen Abedi^c, Saba Karimzade^d, Mahsa Rizehbandi^a, Atefeh Fakharian^d

^a Department of Internal Medicine, Shahid Beheshti University of Medical Sciences; ^b Chronic Respiratory Diseases Research Centre, National Research Institute of Tuberculosis and Lung Diseases (NRITLD), Shahid Beheshti University of Medical Sciences, Tehran, Iran; ^c Physiotherapy Research Center, School of Rehabilitation, Shahid Beheshti University of Medical Sciences; ^d Chronic Respiratory Diseases Research Centre, National Research Institute of Tuberculosis and Lung Diseases (NRITLD), Shahid Beheshti University of Medical Sciences, Tehran, Iran

*Corresponding Author: Maryam Mirenayat, Chronic Respiratory Diseases Research Centre, National Research Institute of Tuberculosis and Lung Diseases (NRITLD), Shahid Beheshti University of Medical Sciences, Tehran, Iran. Tel: +98- 21 77561723; E-mail: maryammirenayat2020@gmail.com

Submitted: 2019-10-28; Accepted: 2019-12-16; DOI: <https://doi.org/10.22037/english.v5i1.26501>

Abstract

Introduction: The present study aimed to investigate the effects of inspiratory muscle training (IMT) on the spirometry parameters of patients with chronic obstructive pulmonary disease (COPD). **Materials and methods.** In this study, 60 men with COPD referring to Masih Daneshvari Hospital of Tehran were selected and randomly assigned to control (normal rehabilitation) and test (normal rehabilitation with IMT) groups. In addition to standard drug therapy, patients in the test group participated in a 4-week exercise therapy program (for sessions per week) consisting of strength training for the proximal muscles of the upper and lower extremities, aerobic exercises with treadmill, and IMT. The spirometry parameters including FEV1 and FVC were measured before and after the training period. The obtained data were statistically analyzed using the dependent t-test and analysis of covariance at the 0.05 level of significance. **Results:** The results revealed that IMT significantly improved the FEV1 and FVC in patients with COPD ($P < 0.05$). In addition, the results showed that IMT was more effective than normal rehabilitation in improving the studied variables ($P < 0.05$). **Conclusion:** It can be generally concluded that respiratory and rehabilitation exercises with an emphasis on inspiratory muscles strengthening can improve the spirometry parameters in patients with COPD. This suggests these patients should benefit from IMT programs.

Keywords: Inspiratory Muscle Training, Spirometry Parameters, Chronic Obstructive Pulmonary Disease

Please cite this paper as: Khoshkhabar M, Mirenayat M, Abedi M, Karimzade S, Rizehbandi M, Fakharian A. The Effect of Inspiratory Muscle Training on spirometry parameters of Patients with Chronic Obstructive Pulmonary Disease. J Clin Physio Res. 2020; 5(1): e2. DOI: <https://doi.org/10.22037/english.v5i1.26501>

Introduction

COPD is the fourth cause of death worldwide. The disease has been growing in recent years in Iran, possibly due to an increase in tobacco use as well as intensification of air pollution in major cities in Iran. Environmental stimuli (air pollution), social harms, and individual maladaptive behaviors can cause a dramatic rise of chronic diseases in the future [1]. Although there is no precise definition of COPD, the American Thoracic Society (ATS) defines COPD as a disease state characterized by chronic and progressive airflow limitation due to chronic bronchitis and emphysema. The airflow limitation in this disease is basically caused by bronchospasm. In addition, reduced airway diameter, airway collapse, and increased mucus in the airway are also involved in this condition. One of the main symptoms in COPD patients is

different degrees of shortness of breath, which reduces the quality of life and causes early fatigue [2].

Despite the great effort to treat these patients and reduce their symptoms, they face many problems and failures such as the increasing number of visits to hospitals, increased length of stay, and readmission. Therefore, the search for new ways to improve symptoms and especially the reduction of shortness of breath in these patients is very important. Nowadays, the efficiency of pulmonary rehabilitation has been proven in patients with pulmonary disease [3]. The term “pulmonary rehabilitation” refers to a wide range of educational, therapeutic, and rehabilitative measures whose core involves training and exercise therapy. Controlled exercise for such patients also includes a range of aerobic and strength activities primarily targeting peripheral muscles and extremities [4]. Meanwhile, great attention has been recently paid to the strengthening of inspiratory muscles, especially diaphragm.

Since one of the major problems of COPD patients is dynamic emphysema during physical activity, the position of diaphragm changes at the onset of inhalation. Indeed, emphysema shortens the diaphragm muscle and changes its dome-shaped position, resulting in the inappropriate position of muscle fibers for contraction. This, in turn, leads to inappropriate diaphragmatic function and the use of minor respiratory muscles [5].

Recent studies on the mechanism of shortness of breath in COPD patients have led to the development of methods to reduce the volume of remaining air and to modify the diaphragm position. Biomechanical correction of diaphragm contraction and increasing its efficiency are among these methods that have received great attention in recent years [6]. IMT is now part of pulmonary rehabilitation, especially in people with weakness in the inhalation phase. IMT is also used to enhance the respiratory capacity of healthy people and athletes. This has been proven to improve the record of aerobic athletes [3]. Pulmonary rehabilitation includes a set of methods for respiratory and psychological care, nutrition management, and energy consumption modulation in daily activities with an emphasis on exercise therapy [4]. Currently, there is a great deal of evidence of the effectiveness of pulmonary rehabilitation in patients with COPD. Pulmonary rehabilitation in these patients increases aerobic potency, causes positive psychological effects, and controls stress. Nowadays, health care organizations provide patients suffering different diseases with several guidelines on pulmonary rehabilitation as well as its components and implementation [4]. Prominent components of pulmonary rehabilitation include training in disease development, importance of rehabilitation, respiratory cycle, phlegm discharge, exercise therapy, oxygen therapy, and non-invasive ventilation. The pivotal role of exercise therapy and patient training has been emphasized in all guidelines of pulmonary rehabilitation [7]. Considering the conversion of secondary muscle fibers into long-term tissue hypoxia and myopathy caused by inactivity, reversing this faulty cycle is part of the pulmonary rehabilitation goals [8].

Previous studies have shown the effect of rehabilitation training on improving the performance of patients with COPD. Tavanaei et al. (2018) compared the effects of pulmonary rehabilitation in the hospital and at home on the improvement of the 6 MWD in patients with COPD and reported that the pulmonary rehabilitation increased the 6 MWD [9]. Shariati et al. (2013) also reported that aerobic exercises of the lower extremities caused greater improvement in FEV1 and VO2 max compared to breathing exercises [11]. Many studies have been conducted on the effects of IMT. In a study conducted by Battagilla et al. (2006), 6 months of IMT significantly improved the quality of life in COPD patients [12]. Zwick (2009) also observed that this method improved the quality of life and reduced the length of stay [13]. On

the other hand, Berry et al. (2009) stated that there was no extra benefit in the addition of IMT to general exercises [14]. In the latest meta-analysis conducted by Gosselink (2011), it was reported that IMT significantly increased the 6 MWD, ameliorated the quality of life, and reduced nocturnal hypoxemia and hypercapnia compared to the control group [15]. According to the points mentioned above, the question to be addressed here is whether IMT affects the quality of life and aerobic potency of patients with COPD.

Materials and Methods

The present study was an applied clinical trial with a pretest-posttest design. The required data were collected through field studies. The statistical population consisted of men with COPD visiting Masih Daneshvari Hospital of Tehran. Affliction with COPD was confirmed by a pulmonologist after which the patients were referred to the pulmonary rehabilitation unit. Out of the study population, 60 patients were randomly selected and assigned to the control group (normal rehabilitation) and the test group (normal rehabilitation with IMT).

The inclusion criteria were COPD diagnosis by a pulmonologist, a PI Max of less 60 Cm H2O, non-use of antioxidant supplements over the last 6 months, no history of chest fracture or surgery, and willingness to participate in the study. The exclusion criteria also included irregular participation in training sessions, history of spontaneous pneumothorax, high risk of rib fracture, and contraindications for exercise therapy. In addition, the patients were excluded from the study if they were not willing to participate in the rehabilitation program. The age of patients was extracted from their birth certificate while their height and weight were measured using a stadiometer (Balas, made in Iran) and a digital scale (Balas, made in Iran), respectively (Table 1).

In addition to standard drug therapy, patients in the control group participated in controlled exercise therapy consisting of strength training for the proximal muscles of the upper and lower extremities as well as aerobic exercises with the treadmill. Initially, the participants were briefed on and trained on exercises and then were asked to practice walking on the treadmill for a few minutes. Each training session, lasting for 50 minutes, consisted of 3 stages: warming up, training, and cooling down. The participants in the test group performed the training program 4 times a week for 4 weeks. The training protocol involved running with 60-80% of the heart rate maximum (220-age). The duration of the main training was 20-30 minutes, which began with less intensity in the early stages (about 60% in the first week) and finished with higher intensity (about 80% in the last week). The heartbeat of participants was measured and controlled using a heart rate

Table 1. General information of participants in the test and control groups

Group	Number	Age (year)	Height (cm)	Weight (kg)	BMI (kg/m ²)
Test	30	47.2±74.21	179.4±18.89	84.5±12.31	26.2±28.10
Control	30	44.2±30.50	177.4±46.39	83.4±30.67	26.2±61.23

Table 2. Normal rehabilitation protocol

Training weeks	Training intensity	Training attempts	Rests
First week	60%	4 attempts of 3 minutes	2 minutes
Second week	65%	5 attempts of 3 minutes	2 minutes
Third week	70%	6 attempts of 3 minutes	3 minutes
Fourth week	80%	7 attempts of 3 minutes	3 minutes

Table 3. The pretest and posttest mean and standard deviation of variables in the test and control groups

Variable	Group	Pretest	Posttest
FEV1	Test	58.24±8.33	41.16±5.51
	Control	66.37±7.59	43.40±6.70
FVC	Test	34.15±4.32	19.71±2.90
	Control	32.26±5.18	24.05±3.31

Table 4. Pretest and posttest scores of the studied variables

Variable	Group	t-value	Degree of freedom	Level of significance
FEV1	Test	-14.56	29	0.00
	Control	-6.32	29	0.02
FVC	Test	-12.29	29	0.00
	Control	-7.06	29	0.01

Table 5. The results of analysis of covariance on the comparison of mean scores

Variable	Source of change	Sum of squares	Degree of freedom	Mean squares	F-value	Level of significance	Test power
FEV1	Pretest	4014.18	1	4014.18	8.54	0.01	0.77
	Group	673.60	1	673.60	14.02	0.00	0.81
FVC	Pretest	2895.21	1	2895.21	7.19	0.02	0.75
	Group	520.44	1	520.44	13.52	0.00	0.83
	Group	1508.18	1	1508.18	13.52	0.00	0.82
	Group	897.52	1	897.52	16.07	0.00	0.85

monitor (Polar, Finland), which was randomly used by two participants. The training program was developed based on the study conducted by Griff *et al.* (2010) [16], which was adjusted to the level of participants in the present study (Table 2).

The resistance training program to determine the 1RM included barbell squat, bench press, barbell shoulder press, seated cable row, arm cable curl, and decline up-sit.

Resistance exercises, which were performed three sessions per week for four weeks, included 10 minutes of warming up (gentle running, stretching, and relaxing), 6 circuit station exercises, and 5 minutes of cooling down and stretching. The participants performed these exercises with 40% of average 1RM at a medium speed. Each exercise lasted 40 seconds (5 attempts with 8 replicates) with no official rest between their attempts. The first training sessions lasted 20 minutes while other sessions lasted 30 minutes with a 3-minute active rest between each attempt. The training sessions were held afternoons from 4 to 5 pm [17]. The patients in the test group, in addition to standard drug therapy and controlled exercise therapy (similar to the control group), performed IMT in a controlled manner. For this purpose, an IMT device connected to a computer with visual feedback was employed and the patients were asked to inhale deeply several

times at the desired threshold (30% of PI Max). The patient was expected to inhale for 2 minutes with 14 replicates and then rest for 1 minute. This cycle was repeated 7 times. The IMT intensity gradually increased to 60% of PI Max over 2 weeks.

The spirometry parameters were collected before and after the intervention. The data were categorized and described based on mean and standard deviation. To assess the normal distribution of data, the Kolmogorov-Smirnov test was used. As the results indicated that the data followed a normal distribution, parametric statistical tests were used for data analysis. The dependent t-test and analysis of covariance were employed to investigate intra-group and inter-group differences, respectively. All statistical analyses were performed in SPSS-23 at the 0.05 level of significance.

Results

Table 3 provides the pretest and posttest mean and standard deviation of variables in the test and control groups.

The dependent t-test was used to determine intra-group differences (Table 4). The results showed that there was a significant difference between the pretest and posttest mean scores of FEV1 and FVC in the test group ($P<0.05$). This was also

true in the control group ($P<0.05$). Therefore, it can be concluded that both normal rehabilitation exercises and IMT were effective in improving the studied variables in patients with COPD.

Inter-group differences were evaluated using analysis of covariance, with the results are reported in Table 5. According to Table 5 and considering F-value and level of significance, it can be stated that pretest scores significantly affected posttest scores ($P<0.05$). In addition, the group effect on posttest scores was statistically significant ($P<0.05$). As a result, it can be concluded that IMT significantly improved the FEV1 and FVC in patients with COPD ($P<0.05$). The results also indicated that the effect of IMT on the studied variables was greater than that of normal rehabilitation exercises ($P<0.05$).

Discussion

Many studies have recommended finding ways to improve the quality of life of patients with COPD. In the present study, respiratory rehabilitation and IMT were employed as two simple and accessible methods. The study findings suggested that IMT significantly improved the spirometry parameters. This is consistent with the results of Shariati *et al.* (2013), Gosselink (2011), Pedersen *et al.* (2015), and Battagilla *et al.* (2006) [10, 12, 15, 21]. However, this result has been incongruent with the results of Guyatt *et al.* (1992) who reported that IMT caused no improvement in any of the physical and spiritual dimensions of patients [22]. It seems that the failure to achieve desirable results in this study is due to not controlling the inhalation speed. In a study conducted by Vogel *et al.* (2001), the effect of IMT on the quality of life was not significant because of its short duration [23]. The existence of different types of IMT with different durations along with confounding variables has led to divergent and contradictory results of this type of rehabilitation. Therefore, IMT cannot be easily added to respiratory rehabilitation programs as a generally accepted method. Nevertheless, the results of the present study indicated that IMT in a short period of 4 weeks can be beneficial for COPD patients; it not only reduces the disease symptoms but also helps the patients to be more active and feel more independent in everyday life activities through improving their shortness of breath. In this way, it improves their social functioning, prevents depression, gives them a better sense of life, and improves their quality of life. In addition, IMT teaches the patients to correct their lifestyle thereby improving their health and well-being. This will ultimately help patients to reduce fatigue and promote their quality of life [24].

IMT can enhance the resistance of inspiratory muscles to fatigue, motor output of inspiratory muscles, and respiratory

effort of patients. Therefore, it can be concluded that the reduction in respiratory muscle fatigue and respiratory failure when performing a progressive test facilitates ventilation and oxygen supply to the body, improves the walking performance, and increases the distance covered [28]. Khoshnevis *et al.* (2008) reported that aerobic exercises of lower extremities caused greater improvement of FEV1 and VO2max in COPD patients compared to respiratory exercises [11], which is consistent with the findings of the present study. Haji-Hassani and Bakhtiari (2006) also found that IMT is a convenient and effective way to increase vital capacity [29]. William *et al.* (2015) studied the effects of respiratory rehabilitation on patients with COPD and concluded that shortness of breath was less prevalent in the intervention group; however, there was no significant change in their pulmonary function. This suggests the positive impact of IMT on the improvement of respiratory capacity which can improve the function of the respiratory system by boosting vital capacity [29].

The findings of this study reaffirmed the fact that self-care through rehabilitation exercises is an individual necessity which can fulfill the patients' needs. Training according to the principles of rehabilitation exercises in proportion with the disease, compliance with prescribed treatments, and problem-solving training can be effective in dealing with new conditions. Patients' unawareness of how to do exercises is one of the main reasons for readmission. If patients and their families are trained to undertake the care responsibilities, the occupancy rate can be reduced and the health status of patients can be improved.

Conclusion

It can be generally concluded that respiratory and rehabilitation exercises with an emphasis on inspiratory muscles strengthening can improve the spirometry parameters and reduce respiratory complications in patients with COPD. This suggests that patients with COPD should benefit from rehabilitation programs. In addition, it is recommended to provide proper facilities and essential training for patients with COPD to perform respiratory exercises.

Acknowledgments

The present paper was extracted from a Ph.D. thesis in Internal Residency supervised by Dr. Maryam Mirenayat. The authors would like to appreciate Shahid Beheshti University of Medical Sciences and Health Services and all who helped us with this research.

Conflict of interest:

None

Funding support:

None

Authors' contributions:

All authors made substantial contributions to conception, design, acquisition, analysis and interpretation of data.

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