Med. J. Cairo Univ., Vol. 88, No. 5, December: 2111-2115, 2020
www.medicaljournalofcairouniversity.net

Ventilatory Function and Exercise Capacity Response to Inspiratory Muscle Training in Interstitial Lung Disease Patients

FATMA M. MAHMOUD, M.Ss.*; SAMIR A. EL GAZAR, Ph.D.*,**; FATMA ABOELMAGD, Ph.D.* and MAHA F.M. SHEHATA, M.D.***

The Department of Physical Therapy for Cardiovascular/Respiratory Disorder and Geriatrics, Faculty of Physical Therapy, Cairo University and Dean Physical Therapy Collage, Heliopolis University** and The Department of Chest Medicine, Faculty of Medicine, Beni-Seuf University****

Abstract

Background: Interstitial lung diseases impair gas exchange resulting in exertional dyspnea and reduced lung function which limit daily activities and impair quality of life. All these changes are related to respiratory muscles dysfunction.

Aim of Study: To investigate the effect of inspiratory muscles training on ventilatory function and functional capacity in patients with Interstitial lung diseases.

Material and Methods: Thirty female patients with interstitial lung diseases with mean of age of ±48.57 were recruited from outpatient clinic of Beni Seuf University Hospital. The study lasted from July 2018 to August 2019. Patients received threshold inspiratory muscles training for 8 successive weeks, 3 sessions/week. The outcome measures were Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV_1), FEV_1/FVC ratio, Maximum Ventilatory Ventilation (MVV) and the distance walked in 2min which were measured before and after the intervention.

Results: A significant increase were found from pre to post intervention in FVC (0.0001), FEV_1 (0.0001), MVV (0.001) and the distance walked in 2min walk test (0.0001) while a non significant difference was found in FEV_1/FVC ratio (0.09).

Conclusion: Based on the results it can be concluded that inspiratory muscles training can be adjunctive to the rehabilitation program for patients with ILD aiming for improving their ventilatory function and functional capacity.

Key Words: *Interstitial lung disease – Threshold inspiratory muscle training – Ventilatory function – Functional capacity.*

Introduction

THE interstitial lung diseases comprised of a group of pulmonary disorders characterized clinically by diffuse infiltrates on the chest radiograph and histologically by distortion of the gas exchanging portion of the lung. The physiologic correlates are restriction of lung volumes and impaired oxygenation. The term "interstitial" when applied to these diseases is actually a misnomer because it implies that the inflammatory process is limited specifically to the area between the alveolar epithelial and capillary endothelial basement membranes. The diseases currently grouped as "interstitial" also frequently involve the alveolar epithelium, alveolar space, pulmonary microvasculature, and less commonly, the respiratory bronchioles, larger airways, and even the pleura **[1]**.

All ILDs have similar pathophysiology and are characterized by progressive fibrotic changes, structural abnormalities, and common physiology. The result of these different disorders is rather similar: Progressive scarring of the lung and gradual loss of function **[2]**.

People with ILD exhibit a rapid, shallow breathing pattern that is present at rest and worsens during exercise. The small tidal volume and rapid respiratory rate seen in people with ILD is thought to occur secondarily to inspiratory elastic loading, in order to reduce the respiratory forces required to maintain ventilation with poorly compliant lung tissue. Rapid, shallow breathing is more pronounced in those with more severe disease. By progressive fibrosis vasoconstriction induced by chronic hypoxia and the destruction of capillary beds **[3]**.

Patients with ILD often experience dyspnoea and fatigue during daily activities. This results in significant physical limitation, often associated with reduced psychological wellbeing and social interaction **[4]**.

There is considerable evidence that respiratory muscle training improves pulmonary function,

Correspondence to: Dr. Fatma M. Mahmoud, E-Mail: fatmamokhtar700@gmail.com

quality of life and exercise performance in healthy athletic populations. As it increases respiratory muscle strength and delays respiratory muscle fatigue and the onset of breathlessness. Respiratory muscle training has proven to be beneficial for respiratory function in patients with chronic diseases [5].

Inspiratory muscle training has been shown to improve respiratory muscle strength and exercise performance in individuals with inspiratory muscle weakness and poor exercise tolerance. IMT can be performed with resistance or pressure threshold devices. Resistance-training devices typically consist of breathing through a series of adjustable orifices providing flow-dependent resistances that decrease as airflow decreases. Pressure threshold devices provide a constant sustained pressure challenge throughout the entire inspiration that is independent of airflow. When inspiring through a pressure-threshold device, the individual must generate a minimum inspiratory muscle force to overcome a threshold load by generating an inspiratory pressure sufficient to open the spring loaded valve and must sustain this pressure level throughout the inspiration [6].

Therefore the purpose of this study was to investigate the effect of inspiratory muscles training on ventilatory function and functional capacity in patients with ILD.

Material and Methods

Thirty female patients with interstitial lung disease were recruited from an outpatient clinic of Beni Seuf University Hospital. The study lasted from July 2018 to August 2019. They were referred by specialist. Patients were selected according to the following inclusion criteria: All types of interstitial lung disease, they were medically stable, age between 45 to 55 years, they have the ability to perform exercises based on 2min walk test, they were diagnosed for at least 5 years ago while patient with any of the following was excluded from the study: Cardiovascular or orthopedic problem, mental disorders, hepatitis, cirrhosis, current treatment for cancer or active infection.

Procedures:

Evaluation procedures:

The weight and height of each patient was measured for calculation of body mass index (kg/m^2) and as entry parameters in ventilatory function.

Ventilatory function assessment:

Electronic spirometer was used to assess ventilatory function (FVC, FEV_1, FEV_1/FVC & MVV) (Smart PFT Co transfer, Mee, INDIA, No. EC0812-00010). The spirometric test was explained to each patient individually in simple terms and was demonstrated for them before applying its steps. All tests were performed in the sitting position in accordance with recommended standards. A nose clip was applied to the patient to prevent air from passing through the nose and the mouth piece is placed into the mouth firmly and the patient was advised to close her lips. The patient was instructed to inspire fully then exhale as rapidly, forcefully, and completely as possible followed by inspiration fully, as rapidly as possible, from the obtained results FVC, FEV_1 and FEV_1/FVC ratio were taken for analysis. For measuring the MVV the patients were instructed to take deep inspiration and expiration for 15 seconds to evaluate the one minute expressed as liters |minute [7]. The best value is obtained from at least three efforts and measured at 3min intervals.

Functional capacity assessment:

2min walk test was performed by asking each patient to cover as much ground as possible over 2 minutes. Continuous walking if possible, and to be concerned if she need to slow down or stop to rest. The distance walked in 2 minutes was recorded in meters without enhancement.

Intervention:

Patients received inspiratory muscle training using threshold device Respironics, (New Jersy, USA, No.8373-0730) 3 times/week for 8 weeks. Before training: The 10 repetition maximum was detected for each patient which is the maximum resistance the patient can sustain for 10 repetitions. The patients were starting breathing at a resistance equal to 30% of their 10 repetition maximum, measured at baseline [8]. Session duration: 15 minutes [9]. The resistance was increased incrementally, based on the Rate of Perceived Exertion (RPE) scored by the patient on the modified Borg Scale. If the RPE is less than 5, the resistance of the inspiratory threshold trainer was increased incrementally by 2cmH_2O. The resistance was not changed if the level of perceived exertion is rated from 6 to 8, and the resistance was decreased by 1 to 2cmH_2O if the level of perceived exertion is rated 9 or 10 [9]. Then the load was increased rapidly over the first 7 sessions up to 60-80% of baseline 10 repetition maximum. Patients were allowed to take breaks during the training session in order to cough or to rest for a while when they feel fatigue. But the duration of these breaks was minimized in order to maintain the training stimulus [10]. The training program lasted for 8 weeks 3 sessions/week.

Statistical analysis:

Descriptive statistics was conducted to present the subjects' demographic data. Paired *t*-test was conducted for comparison between pre and post treatment mean values of FVC, FEV_1, FEV_1/FVC and 2min walk test pre and post-treatment. The level of significance for all statistical tests was set at $p<0.05$, all statistical measures were performed through the statistical package for social studies (SPSS) version 25 for windows.

Results

Thirty female patients with interstitial lung disease participated in this study. Their demographic characteristics are presented in (Table 1).

Table (1): Demographic characteristics of the study group.

	X ± SD	Minimum	Maximum	Range
Age (years)	48.57±4.14	45	55	10
Weight (kg)	76.03±14.23	55	105	50
Height (cm)	163.27±4.09	158	173	15
BMI (kg/m^2)	28.59±5.63	20.2	39.06	18.86

X: Mean. SD: Mean Difference.

A significant increase was noticed in FEV_1 at the post intervention measurements with *p*-value 0,0001, while FVC showed significant increase with *p*-value 0,0001%. There was no significant change with FEV_1/FVC ratio between pre and post intervention with *p*-value 0,09% (Table 2).

While there was a significance increase in MVV post intervention with *p*-value 0.001%. Concerning 2 MWT also there was a significant increase after intervention with *p*-value 0.0001% as shown in (Table 2).

Table (2): Comparison between pre and post intervention mean values of the studied variables.

Variable	Pre intervention $\bar{X}$ ± SD	Post intervention $\bar{X}$ ± SD	MD	% of change	*t*-value	*p*-value	Sig.
FEV_1 (%)	57.03±18.32	67.83±21.06	–10.8	18.94	–7.52	0.0001	S
FVC (%)	64.44±18.48	73.64±19.00	–9.20	14.28	–6.71	0.0001	S
FEV_1/FVC	88.33±9.25	91.35±10.57	–3.02	3.42	–1.75	0.09	NS
MVV	98.67±8.43	103.14±8.96	–4.47	4.53	–3.82	0.001	S
2 MWT	52.6±8.11	84.2±16.6	–31.6	60.08	–9.5	0.0001	S

$\bar{x}$: Mean. SD : Standard Deviation. *t*-value : Paired *t*-value.
MD : Mean Difference. *p*-value : Probability value. S : Significant.

Discussion

This study was conducted to investigate the effect of Inspiratory Muscle Training (IMT) on ventilatory function and functional capacity in ILD patients and the results showed positive effects of threshold IMT on the studied variables of ventilatory function (FEV_1, FVC, MVV) and the functional capacity measured by the 2 MWT whereas there was no change in FEV_1/FVC ratio. The improvement in ventilatory functions may be due to improvement in the patients pattern of breathing due to enhancement in respiratory muscle strength and endurance as IMT applies load to diaphragm and accessory muscle which assist to increase tidal volume and pulmonary function [11]. Increased functional capacity after intervention resulted from improvement of respiratory muscle strength and endurance leading to enhancement of pulmonary O_2 uptake and reductions of dyspnea.

The result of this study came with accordance with a study done by Ozalp et al., (2019) [12] who found that an 8-week high intensity inspiratory muscle training increased exercise capacity in non-cystic fibrosis patients with bronchiectasis with low to intermediate severity. The H-IMT has improved respiratory muscle strength and endurance.

Patients treated with threshold IMT may subsequently be able to reduce their dependence on others, reduce consumption of medical resources and reduce the risk of future exacerbation. In addition the threshold IMT could shorten inspiratory time, giving the patients more time to breathe and relax which, in turn, reduced lung hyperinflation, promoted lung air evacuation and improved maximal inspiratory pressure which can lead to increases in inspiratory muscle strength and endurance, improve outcomes of exercise capacity and to decrease dyspnoea for patients with moderate-to-very severe COPD [13].

Another study done by Duruturk et al., (2018) who found that inspiratory muscle training in patients with asthma can lead to improvement in respiratory muscle performance, exercise capacity, activity of daily living, health related quality of life and a further decline in dyspnea and fatigue. They found in addition to existing pharmacological and non pharmacological treatment modalities IMT can be an additional therapeutic modality offering a tangible benefits to asthmatic patients **[14]**.

A study done by Hoffman et al., (2019) suggests that an 8-week IMT programme in patients with advanced lung disease was able to reduce dyspnea during daily living activities as well as improve inspiratory muscle function and quality of life **[15]**.

The results of this study came in accordance with a study done by Camcıog (2016) who proved that inspiratory muscle training improves functional and maximal exercise capacity and respiratory muscle strength and decreases severe fatigue and dyspnea perception in subjects with early stages of sarcoidosis. As a result, they recommended inspiratory muscle training as a safe and effective modality to be included in rehabilitation programs in these patients **[16]**.

In agreement with the results of the current study done by tout et al., (2013) who found that training and exercise undertaken by COPD patients with IMT brings about significant improvement with regard to dyspnea and quality of life signs. It also allows for significant improvement with regard to the functional capacities and strength of the patients' inspiratory and expiratory muscles. These improvements are associated with positive FEV_1 evolution and significant improvement in measured maximum inspiratory pressure **[17]**.

On the other hand the results of Beaumont et al., (2018) disagree with the result of the current study as they found that IMT did not significantly improve dyspnea or functional parameter in COPD patients. But this difference may be due to different duration of training in both studies as they conducted 3 weeks of training while the training duration in the current study was 8 weeks **[18]**.

Conclusion:

A programme of 8 weeks of IMT in ILD patients using the threshold mode of training 3 times per week induced positive changes in pulmonary function test, oxygen saturation and functional capacity which can be attributed to improvement of inspiratory muscle strength. So IMT should be recommended for ILD patients to be part of their routine care.

References

1- JOHNSON-WARRINGTON, WILLIAMS J., BANKART J., STEINER M., MORGAN M. and SINGH S.: Pulmonary Rehabilitation and Interstitial Lung Diseas: Journal of Cardiopulmonary Rehabilitation and Prevention, 33 (3): 189-95, 2013.

2- LITOW F.K., PETSONK E.L., BOHNKER B.K., BRODKIN C.A., COWL C.T., GUIDOTTI T.L., HARBER P., BIGGS J.J. and HEGMANN K.T.: Occupational Interstitial Lung Diseases. J. Occup. Environ. Med., 57 (11): 1250-4, 2015.

3- RAGHU G., COLLARD H.R., EGAN J.J., et al.: An official ATS/ERS/JRS/ALAT statement: Idiopathic pulmonary fibrosis: Evidence-based guidelines for diagnosis and management. Am. J. Respir. Crit. Care Med., 183: 788-824, 2011.

4- HOLLAND A.E.: Exercise limitation in interstitial lung disease-mechanisms, significance and therapeutic options: Chron. Respir. Dis., 7 (2): 101-11, 2010.

5- FODEN E., PERRET C., DEGENS H., TOLFREY V. and WAY E.: Effects of inspiratory muscle training on respiratory function and repetitive sprint performance in wheelchair basketball players Correspondenceto, 665-9, 2010.

6- TURNER L.A., MICKLEBOROUGH T.D., McCONNELL A.K., STAGER J.M., TECKLENBURG-LUND S. and LINDLEY M.R.: Effect of inspiratory muscle training on exercise tolerance in asthmatic individuals: Med. Sci. Sports Exerc., 43 (11): 2031-8, 2010.

7- PELLEGRINO R.1, VIEGI G., BRUSASCO V., CRAPO R.O., BURGOS F., CASABURI R., COATES A., VAN DER GRINTEN C.P., GUSTAFSSON P, HANKINSON J., JENSEN R., JOHNSON D.C., MacINTYRE N., McKAY R., MILLER M.R., NAVAJAS D., PEDERSEN O.F. and WANGER J.R.: Interpretative Strategies for Lung Function Tests: European Respiratory Journal, 26 (5): 948-68, 2005.

8- KULKARNI S.R., FLETCHER E., McCONNELL A.K., POSKITT K.R. and WHYMAN M.R.: Pre-operative inspiratory muscle training preserves post-operative inspiratory muscle strength following major abdominal surgery: Randomised pilot study: Annals of the Royal College of Surgeons of England, 92: 700-7, 2010.

9- OVEREND T.J., ANDERSON C.M., JACKSON J., LUCY S.D., PRENDERGAST M. and SINCLAIR S.: Physical therapy management for adult patients undergoing cardiac surgery: A Canadian practice survey. Physiother. Can., 62: 215-21, 2010.

10- HULZEBOS E.H.J., HELDERS P.J.M., FAVIE N.J., De BIE R.A., De La RIVIERE A.B. and VANA MEETEREN N.L.U.: Post-operative intensive inspiratory muscle training to prevent post-operative pulmonary complications in high-risk patients undergoing CABG surgery. JAMA, 296: 1851-7, 2006.

11- ELKINS M. and DENTICE R.: Inspiratory muscle training facilitates weaning from mechanical ventilation among patients in the Intensive Care Unit: A systematic review. J. Physiother., 61 (3): 125-34, 2015.

12- OZALP O., INAL-INCE D., CAKMAK A., CALIK-KUTUKCU E., SAGLAM M., SAVCI S., VARDAR-YAGLI N., ARIKAN H., KARAKAYA J. and COPLU L.: High-intensity inspiratory muscle training in bronchiectasis: A randomized controlled trial. Respirology (Carlton, Vic.), 24 (3): 246-53, 2019.

13- CHUANG H.Y., CHANG H.Y., FANG Y.Y. and GUO S.E.: The effects of threshold inspiratory muscle training in patients with chronic obstructive pulmonary disease: A randomised experimental study. J. Clin. Nurs., 26: 23-24: 4830-8, 2017.

14- DURUTURK N., ACAR M. and DOĞRUL M.I.: Effect of Inspiratory Muscle Training in the Management of Patients With Asthma: A RANDOMIZED CONTROLLED TRIAL. Journal of cardiopulmonary rehabilitation and prevention, 38 (3): 198-203, 2018.

15- HOFFMAN M., AUGUSTO V.M., EDUARDO D.S., SILVEIRA B.M.F., LEMOS M.D. and PARREIRA V.F.: Inspiratory muscle training reduces dyspnea during activities of daily living and improves inspiratory muscle function and quality of life in patients with advanced lung disease: Physiother. Theory Pract., 1-11, 2019.

16- CAMCıOG B.: Effects of Inspiratory Muscle Training in Subjects With Sarcoidosis: A Randomized Controlled Clinical Trial, 483-94, 2016.

17- TOUT R., TAYARA L. and HALIMI M.: The effects of respiratory muscle training on improvement of the internal and external thoraco-pulmonary respiratory mechanism in COPD patients. Annals of Physical and Rehabilitation Medicine; 56 (3): 193-211, 2013.

18- BEAUMONT M., FORGET P., COUTURAUD F. and REYCHLER G.: Effects of inspiratory muscle training in COPD patients: A systematic review and meta-analysis. Clin. Respir. J., 12 (7): 2178-88, 2018.

إستجابة وظائف التهوية الرئوية والقدرة التمرنية لتدريب عضلات الشهيق فى مرضى الداء الرئوى الخلالى

الخلفية: آمراض الرئة الخلالية تضعف تبادل غازات التنفس مما يؤدى إلى ضيق التنفس آثناء القيام بمجهود وإنخفاض وظائف الرئة مما يحد من الآنشطة اليومية ويضعف جوده الحياة. ترتبط كل هذه التغييرات بخلل فى وظائف الجهاز التنفسى.

هدف هذه الدراسة: لمعرفة آثر تدريب عضلات الشهيق على الوظائف التنفسية والقدرة الوظيفية لدى مرضى ILD.

الآساليب: ثلاثون مريضة بآمراض الرئة الخلالية بمتوسط عمر ±٤٨.٥٧ . تم إختيارهم من العيادة الخارجية لمستشفى جامعة بنى سويف. تلقى المرضى تدريب عضلاتهم الشهيق لمدة ٨ آسابيع متتالية، ٣ جلسات/إسبوع. تم قياس السعة الحيوية (FVC)، وحجم الزفير القسرى فى ثانية واحدة (FEV_1)، ونسبة FEV_1/FVC، والتهوية القصوى للتهوية (MVV) والمسافة التى قطعت فى دقيقتين والتى تم قياسها قبل وبعد التدخل العلاجى.

النتائج: تم العثور على زيادة كبيرة من التدخل قبل وبعد فى FVC بنسبة (*p* 0.0001)، FEV_1 بنسبة (*p* 0.0001)، MVV بنسبة (*p* 0.001). والمسافة التى مشيت فى إختبار المشى لمدة دقيقتين بنسبة (*p* 0.0001) بينما وجد آنه لا فرق فى النسبة FEV_1/FVC بنسبة (*p* 0.09).

الخلاصة: بناءً على النتائج، يمكن إستنتاج آن تدريب عضلات الشهيق يمكن آن يكون مساعداً لبرنامج إعادة التآهيل للمرضى الذين يعانون من آمراض الرئة الخلالية بهدف تحسين وظائف التهوية والسعة الوظيفية.