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VOLUME 42, NUMBER 1, January 2022

TABLE OF CONTENT

Original Article

Literature Review

The Effect of Inspiratory Breathing Muscle Exercise Using Respirometer on Changes in Lung Function and Dyspnea Severity in Tuberculosis Pleurisy Patients

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Abstract

Background: *Respirometer has been commonly used to improve lung function, prevent atelectasis and respiratory complications after surgery. The effectiveness of respirometer to improve lung re-expansion in pleural effusion has not been well studied. So far there is no such study implemented to examine this association in pleural effusion particularly tuberculosis pleurisy in Aceh.*

Method: *This was an experimental pretest-posttest controlled trial in patients with tuberculosis pleurisy hospitalized in dr. Zainoel Abidin Hospital between July and December 2019. Systematic random sampling was used to gather 40 samples, which then divided into intervention and control group consisted of 20 people in each group. All participants performed spirometry and were assessed for dyspnea severity using Borg scale after thoracocentesis and repeated 6 days later. Only intervention group received exercise using respirometer. Data were examined statistically using paired T-test and Mann Whitney Test.*

Results*: The majority of participants were male (68%) with mean age of 42 years old. Around one-third of samples were smokers with mean Brinkman Index of 273 (moderate). The nutritional status was mostly good with mean BMI of 21 (normal). There were significant improvements of FEV1 and FVC values before and after 6 days in both groups. However, if the improvements were compared between intervention and control groups, only FVC improved significantly in intervention group (*P*= 0.019) whereas FEV1 improved in both groups without significant difference (*P*= 0.456). Similar result was seen in dyspnea severity where both groups experienced improvement after 6 days with or without intervention.*

Conclusion*: Inspiratory muscle exercise using respirometer could improve lung function, particularly FVC value, significantly and could be an option for additional therapy to help lung re-expansion in tuberculosis pleurisy.* ***(J Respirol Indones 2022; 42(1): 43–51)***

Keywords*: respirometer, lung function, tuberculosis pleurisy, dyspnea*

Pengaruh Latihan Otot Pernapasan Inspirasi Menggunakan Respirometer terhadap Perubahan Fungsi Paru dan Derajat Sesak Napas pada Pasien Pleuritis Tuberkulosis

Abstrak

Latar Belakang*: Respirometer sering digunakan untuk memperbaiki fungsi paru, mencegah atelektasis dan mencegah komplikasi respirasi setelah pembedahan. Efektivitas respirometer dalam membantu pengembangan paru pada efusi pleura masih belum banyak diketahui. Hingga saat ini belum ada penelitian terkait yang dilakukan pada pasien efusi pleura khususnya pleuritis tuberkulosis (TB) di Aceh.*

Metode*: Penelitian ini bersifat eksperimental dengan uji* pretest-posttest *terkontrol pada pasien pleuritis TB yang dirawat di RSUD dr. Zainoel Abidin Banda Aceh periode Juli hingga Desember 2019. Sampel diambil secara acak dan sistematik hingga diperoleh 40 sampel terbagi menjadi 20 orang di kelompok intervensi dan 20 orang kontrol. Semua sampel diperiksa spirometri dan dinilai derajat sesak napas menggunakan skala Borg setelah dilakukan torakosentesis dan diulangi 6 hari kemudian. Hanya kelompok intervensi yang menerima latihan respirometer selama 6 hari. Data diuji menggunakan uji T-berpasangan dan uji* Mann-Whitney*.*

Hasil*: Mayoritas sampel adalah laki-laki (68%) dengan rerata usia 42 tahun. Sepertiga sampel masih merokok dengan rerata Indeks Brinkman 273 (sedang). Status gizi umumnya baik dengan rerata IMT 21. Nilai VEP1 dan KVP meningkat secara bermakna pada kedua kelompok setelah 6 hari. Akan tetapi apabila dibandingkan antara kelompok intervensi dan kontrol, hanya peningkatan nilai KVP yang bermakna secara statistik (*P*= 0,019) sementara peningkatan nilai VEP1 pada kedua kelompok hampir sama (*P*= 0,456). Setelah 6 hari, perbaikan sesak napas dijumpai pada kedua kelompok baik dengan atau tanpa latihan respirometer*

Kesimpulan*: Latihan pernapasan otot inspirasi menggunakan respirometer dapat meningkatkan fungsi paru khususnya nilai KVP dan dapat menjadi terapi tambahan untuk membantu pengembangan paru pada pasien pleuritis TB.* ***(J Respirol Indones 2022; 42(1): 43–51)***

Kata kunci: *respirometer, fungsi paru, pleuritis TB, sesak napas*

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INTRODUCTION

Tuberculous pleurisy (TP) is another name for pleural effusion due to tuberculosis infection and is the second most common form of extrapulmonary tuberculosis. Tuberculous pleurisy is the most common cause of pleural effusion in countries with endemic tuberculosis. The prevalence of TP differs in different parts of the world, ranged from about 4% in the United States and Brazil to 20% in North Africa. In Korea, TP is found in 7.3% of TB patients and constitutes of 35% among all extrapulmonary TB.[1] Light stated that 3–25% of TB patients will develop TB pleurisy.[2]

Pleural effusion has a significant influence on the function of the respiratory system. Pleural effusion causes changes in the dynamic balance of lung volumes and chest wall volumes. As a result, there is a ventilation barrier effect, respiratory restriction occurs, the chest wall expands, and the work efficiency of the inspiratory respiratory muscles decreases. Restriction abnormalities in pleural effusion are characterized by decreased vital lung capacity (VLC), functional residual capacity (FRC) and total lung capacity (TLC). Study from Krell and Rodarte showed that lung volume decreased by 1/3 the amount of fluid outflow, and chest volume increased by 2/3 the amount of pleural effusion. Decreased lung volume was primarily due to reduced lower lobe volume with minimal change in upper lobe volume.[3]

Pleural effusion also causes decreased lung compliance and increased chest wall compliance. This dynamic property change can be reversed by deep breathing and lung inflation. Decompression of the lungs and the reopening of several air cavities in the lungs accompanied by a decrease in the surface pressure of the alveoli are important mechanisms which can restore lung function. This situation can be achieved by breathing deeper where more air enters the lungs.[4]

Management of pleural effusion is individualized. The protocol for treating pleural effusions includes administering oxygen therapy and therapy for lung expansion such as thoracentesis and chest physiotherapy.[5,6]

One form of exercise that has been more commonly used is the respirometer, better known as incentive spirometry.[7] Exercise using this respirometer is one of the therapeutic options for pulmonary hyperinflation.[5] This exercise can increase the strength and endurance of the respiratory muscles and improve respiratory complaints such as shortness of breath.[8] The respirometer is designed to improve the performance of the inspiratory muscles, restore or stimulate normal breathing patterns, maintain a patent airway and prevent and correct atelectasis.[9]

Several previous studies had shown the benefits of inspiratory breathing muscle exercises using a respirometer. Valenza, et al. stated that incentive spirometry and mobilization combined with chest drainage and medication in patients with pleural effusion showed significant improvements in vital capacity values, FEV_1 and FVC compared to the control group, they also exhibited better clinical improvement and shorter treatment periods.[7]

Agarwal, et al. in India, also pointed out that incentive spirometry effectively improved lung expansion in patients with pleural effusion.[10] Respirometers were also able to improve lung function and increased exercise capacity when combined with physical exercise. This was asserted by Weiner, et al. as they found a significant increase in lung function in the intervention group, namely an increase in FEV_1 value and an increase in muscle strength in the group that received incentive spirometry after two weeks of exercise.[11]

Although respirometers have been widely used, there has been no study which evaluates how it affects changes in lung function and dyspnea severity in pleural effusion patients treated at RSUD dr. Zainoel Abidin. This study was aimed to examine the correlation of inspiratory muscle exercises using a respirometer and the changes in lung function and also dyspnea severity in patients with TB pleurisy treated at RSUD dr. Zainoel Abidin.

METHOD

This was an experimental study using a pretest-posttest controlled trial design conducted at RSUD dr. Zainoel Abidin Banda Aceh. A systematic random sampling was carried out from July to December 2019. The number of study subjects were 40 patients diagnosed with clinical TB pleurisy by a pulmonary specialist. The sample was divided evenly into 2 groups; 20 subjects in each intervention and control group. Apart from receiving thoracentesis and medication, the intervention group also received inspiratory breathing muscle training using a respirometer for 6 days, while the control group only received thoracentesis and medication.

The inclusion criteria were subjects aged 18 to 65 years old who had a willing to join the study with good general condition, cooperative and able to perform pulmonary function test and exercises using a respirometer. We excluded subjects who hadever received anti-tuberculosis drugs, could not be performed a thoracentesis, had hemoptysis, hydropneumothorax, loculated pleural effusions or recurrent pleural effusions, lung tumours, mediastinal tumours and other lung diseases, cardiomegaly, ascites, history of the eye or thoracoabdominal surgery in the last 6 months and had contraindications for spirometry examination.

The data was obtained in the form of primary data. Data collection and spirometry examination were carried out directly by the researcher. Patients diagnosed with clinical TB pleurisy by a pulmonologist who met the inclusion and exclusion criteria were asked to participate in the study and signed an informed consent. Thoracentesis were performed on the subjects until the pleural fluid production was <100 ml/day.

We did the examination of lung function using a spirometer (Spirolab, all in one Portable Desktop Spirometer for Spirometry test with oximetry option) and measured the dyspnea severity using Borg scale. The data obtained became the baseline data.

Furthermore, the subjects in intervention group were educated about the technique of using a respirometer (Incentive Spirometry Medinet–Italy, a Respiratory Exercise System for Inspiration) 5–6 times daily for 6 days. After six days, a spirometry re-examination and measurements of dyspnea severity were performed in both groups. The data were then tabulated and displayed in mean±standard deviation. The difference between pre- and post-intervention results was analyzed using paired T-test at 95% Confidence Interval and *P* value of 0.05. The Mann-Whitney test was used to compare the mean scores of the two groups at the 95% Confidence Interval and *P*=0.05.

RESULTS

This study divided the study subjects into 2 groups, namely the intervention group and the control group with equal number of subjects in each group. However, the intervention group had a distribution of subjects dominated by men (85%). Meanwhile, in the control group the proportions of both genders were the same. Statistical analysis showed that the gender characteristics of the two groups were significantly different, with a *P*-value of 0.020.

Based on age, these two groups had homogeneous characteristics where the mean age in the intervention group and the control group were 42 years and 43 years, respectively. Based on age groups of 18-45 years and 46-65 years, these two groups showed the same distribution, namely 11 subjects (55%) in the younger age group and 9 subjects (45 %) in the older age group. Statistical analysis showed that the age characteristics between the two groups were not statistically different (*P*= 1.000) and were homogeneous so that the sampling bias factor could be ignored.

Based on smoking status, there were more smokers in the intervention group than in the control group. Five of 13 people in the intervention group and 4 of 9 people in the control group had stopped smoking for more than 1 year. Approximately one third (35%) of the subjects in the intervention group and half (55%) of the subjects in the control group had never smoked at all or had smoked less than 100 cigarettes at the time of this sampling.

Table 1. Demographic Characteristics

Variable		Intervention n (%)	Control n (%)	*P*
Gender				*0.020*
	Male	17 (85)	10 (50)	
	Female	3 (15)	10 (50)	
Age (years old)				*1.000*
	18-45	11 (55)	11 (55)	
	46-65	9 (45)	9 (45)	
	Mean	41±12.6	43±14.2	
	Min	19	19	
	Max	58	60	
Smoking Status				*0.631*
	Former smoker	5 (25)	4 (20)	
	Smoker	8 (40)	5 (25)	
	Non-smoker	7 (35)	11 (55)	
Brinkman Index				*0.925*
	Non-Smoker	7 (35)	11 (55)	
	Mild	2 (10)	1 (5)	
	Moderate	9 (45)	4 (20)	
	Severe	2 (10)	4 (20)	
	Mean	272	275	
Nutritional Status				*0.243*
	Underweight	4 (20)	7 (35)	
	Normal	14 (70)	11 (55)	
	Overweight	2 (10)	2 (10)	
	BMI (mean)	21.6	20.4	

Although there were more smokers in the intervention group than in the control group, the number of cigarettes smoked expressed as the Brinkman Index (BI) was higher in the control group, with a mean of 275. However, this difference was very small and not statistically significant (*P*= 0.925).

If further analysis was carried out where the magnitude of the BI was only assessed in the group that has smoked or in other words, the BI of those who have never smoked was excluded from the analysis, it was observed that the mean BI in the control group was much higher than the intervention group (580 vs 418). This might be related to the number of smokers with severe BI category, which was more common in the control group (44%), compared to the intervention group (15%). However, the increase in mean BI occurred evenly in all groups, and the statistical analysis did not indicate any significant differences (*P*= 0.210).

The nutritional status of the subjects in this study was generally good, with a mean BMI of 21.0. This value implied adequate or normal nutritional status. A similar picture was also seen in the intervention and control groups. The mean BMI in the intervention group was 21.6, while in the control group was 20.4, however, each was still within the normal range of BMI and adequate nutritional status. The intervention group had a mean BMI slightly higher than the control group. The control group had more study subjects with less nutritional status than the intervention group, namely 35% in the control group and 20% in the intervention group. On the other hand, these two groups had the same proportion of study subjects with excess nutritional status (10%). Despite the above conditions, statistical analysis indicated that the difference in nutritional status between the two groups was very small and not statistically significant (*P*= 0.243).

Table 2. The correlation between inspiratory muscle training using a respirometer and FEV_1

Group	FEV_1 *pre* (ml) (Mean±SD)	%Prediction (mean)	FEV_1 *post* (ml) (Mean±SD)	%Prediction (Mean)	Difference of FEV_1 *pre-post* (ml) (Mean±SD)	*P*
All (n= 40)	1615±553	59.6	1780±568	65.7	165±69	0.0001
Intervention (n=20)	1822±541	65.6	1996±554	71.9	175±80	0.0001
Control (n=20)	1409±496	54.1	1565±506	60.1	156±58	0.0001

Table 3. Correlation of inspiratory muscle exercise using a respirometer and FVC

Group	FVC *pre* (ml) (Mean±SD)	% Prediction (Mean)	FVC *post* (ml) (Mean±SD)	% Prediction (Mean)	Difference of FVC *pre-post* (ml) (Mean±SD)	*P*
All (n= 40)	1970±632	58.9	2210±676	66.1	240±102	0.0001
Intervention (n=20)	2170±631	63.6	2442±642	71.6	272±108	0.0001
Control (n=20)	1770±580	54.8	1979±643	61.3	209±87	0.0001

The pulmonary function tests among the subjects in this study showed a significant increase in FEV_1 and FVC after 6 days, both in the intervention group and control group.The FEV_1 value was appeared to increase in all subjects from 1615±553 ml (59,6% prediction) to 1780±568 ml (65,7% prediction) with *P*=0.0001, while the FVC value increased from 1970±632 ml (58.9% prediction) to 2210±676 ml (66.1% prediction) with *P*=0.0001.

Table 3 indicates that an increase in the FVC value occurred after 6 days in all study subjects (n=40) with a mean difference between pre-and post-evaluation FVC for 6 days of 240±102 ml (*P*= 0.0001). Table 2 and 3 shows the magnitude of the increase in FEV_1 and FVC values in the intervention and control groups after 6 days.

Although both groups represented an increase in FEV_1 and FVC values after 6 days of exercise/observation, the improvement in lung function in the intervention group was better than the control group. Table 4 exhibits that the increase in the FEV_1 value in the pre-and post-inspiratory muscle exercise of intervention group using a respirometer for 6 days was slightly higher than the control group with a mean difference of 19 ml where the difference in the mean FEV_1 value in the intervention group was 175±80 ml and the control group 156±58.

Nevertheless, this difference was not statistically significant (*P*=0.456). The increase in FVC value after 6 days of inspiratory muscle training using a respirometer in the intervention group was also greater than the control group with the difference in the intervention group of 272±108 ml and 209±87 ml in the control group. In contrast to the FEV_1 value, the difference in the FVC value in the intervention group compared to the control group showed a statistically significant difference (*P*=0.019).

Table 4. The correlation between inspiratory muscle training using a respirometer and lung function

Lung Function	Intervention	Control	*P*
FEV_1 (mean difference), ml	175±80	156±58	0.456
FVC (mean difference), ml	272±108	209±87	0.019

In the intervention group before the inspiratory muscle exercise, the majority of the subjects (60%) described the dyspnea severity as 'slightly short of breath' (Borg scale 0.5). Three subjects (15%) had a 'very mild shortness of breath' (Borg 1), and 1 subject (5%) had mild shortness of breath (Borg 2). Four subjects (20%) experienced 'no shortness of breath at all' (Borg scale 0). After inspiratory breathing muscle exercise using a respirometer for 6 days, there were improvements in the dyspnea severity. There were no subjects who were on the Borg 2 scale or Borg 1 scale. Most of the subjects (80%) felt 'no shortness of breath' (Borg scale 0), and only 4 subjects (20%) still felt 'slightly short of breath' (Borg scale 0.5). Statistical analysis indicated a significant improvement in the dyspnea severity after performing inspiratory muscle training using a respirometer for 6 days with *P*=0.0001.

Improvements in the dyspnea severity were also experienced by subjects in the control group who did not receive inspiratory muscle training using a respirometer. The majority of subjects (75%) in the control group at the beginning of the study felt 'slightly short of breath' (Borg scale 0.5). Two subjects (10%) complained of 'mild shortness of breath' (Borg 2), and 3 subjects (15%) experienced 'very mild' shortness of breath (Borg 1). None of the subjects experienced 'no shortness of breath at all' (Borg scale 0) at the beginning of the study.

After 6 days later, the dyspnea severity was re-assessed. Improvements were found as there were no more subjects in the Borg scale 1 and 2. In addition, the majority of the subjects (70%) already felt 'no shortness of breath at all' (Borg 0) and 6 subjects were still on Borg Scale 0.5 (slightly short of breath). The improvement in shortness of breath after 6 days of observation in the control group was also statistically significant (*P*=0.0001).

Table 5. The correlation between inspiratory muscle training using a respirometer and the dyspnea severity

Borg Scale	Intervention (n= 20)		Control (n= 20)		*P*
	Pre n (%)	*Post* n (%)	*Pre* n (%)	*Post* n (%)	
0	4 (20)	16 (80)	0 (0)	14 (70)	0.0001
0.5	12 (60)	4 (20)	15 (75)	6 (30)	
1	3 (15)	0 (0)	3 (15)	0 (0)	
2	1 (5)	0 (0)	2 (10)	0 (0)	

DISCUSSION

This study involved 40 study subjects who were homogeneously distributed in the intervention and control group. In other words, the two groups had similar demographic characteristics. This was expected to minimize sampling bias.

This study pointed out that TB pleurisy was more common in men than women. This was in line with previous studies, which explained that the prevalence of TB pleurisy was more common in men than women, with a ratio of 2:1. It could be associated with daily conditions where men were more exposed to TB risk factors such as smoking.[12]

The literatures stated that in countries with a high TB burden such as Indonesia, the incidence of pleural effusion complications in TB infection was more common at younger age with a mean age of 34 years, however, in developed countries, complications of pleural effusion in TB infection were more common at older ages.[13] In this study, the mean age of TB patients with pleural effusion was 42 years. This result was greater than the mean age of TB pleurisy in countries with a high TB burdenbut closer to the mean age of TB pleurisy in developed countries with low TB burdens of 49 years.[13]

The nutritional status of the study subjects was generally good, with a mean BMI of 21.0. Tuberculosis is often associated with malnutrition because of its effect on the immune system,[14] but the incidence of pleural effusion in TB is associated with better nutritional status. The previous study revealed that immune status affected the incidence of TB pleurisy. It was because the main mechanism of pleural effusion in TB patients was delayed hypersensitivity reactions. Therefore, immunocompromised individuals were less likely to develop TB pleurisy than immunocompetent individuals.[1]

Pleural effusion could cause shortness of breath, pleuritic chest pain, cough, and a feeling of pressure. This is directly related to the extent of the effusion which occurs. Shortness of breath with effusion is usually caused by hypoxemia resulting from intra-pulmonary shunting. The abnormality was not immediately corrected after thoracentesis.[5,15] It explained why the subjects in this study still experienced shortness of breath although the pleural fluid had been evacuated.

Pleural effusion could cause shortness of breath due to several factors such as impaired gas exchange, changes in respiratory mechanics such as decreased diaphragm, reduced efficiency of respiratory muscle function, and hemodynamic disturbances in massive pleural effusions. Thoracentesis can correct shortness of breath by restoring the abnormalities, but the actual mechanism is not fully understood.[16] The improvement in shortness of breath in this study could be caused by thoracentesis or inspiratory muscle training using a respirometer or a combination of both. To minimize the bias, dyspnea severity was measured after thoracentesis was completed.

Improvement of dyspnea progressed slowly post-thoracentesis in pleural effusion patients with a mechanism that is not fully understood. This improvement is characterized by improved lung function, increased work efficiency of the respiratory muscles, and particularly improvement in diaphragm function, which was previously depressed by the effusion fluid.[17] On the other hand, inspiratory muscle training using a respirometer could also improve the atelectasis in pleural effusions and help re-expanding the alveoli and air spaces that were previously closed.[9] These two factors influence the improvement of dyspnea previously felt by patients with pleural effusions. In addition, several other studies had also found that respirometers could improve lung function in patients with pleural effusion.[7]

There have been no studies assessing the dyspnea severity in pleural effusion patients using inspiratory muscle training, but there was a study which focused at how the use of respirometer could improve shortness of breath in COPD patients. The study assessed the dyspnea severity in COPD patients given respiratory muscle training with a portable device compared to those who received breathing exercise and incentive spirometry. Each group performed exercises 2 times a day in 15 minutes daily for 5 days per week accumulated in 8 weeks. After 8 weeks, there were no significant difference between the improvement in dyspnea severity between the two groups, so it could be concluded that respiratory muscle training using a respirometer improved shortness of breath complaints as well as other respiratory muscle exercises in this case, namely the respiratory muscle training device.[18]

This study revealed that inspiratory muscle breathing exercises using a respirometer improved lung function by increasing the value of FEV_1 and FVC. In addition, the improvement in lung function in the intervention group was greater than in the control group, and this difference was also statistically significant.

A previous study that assessed lung function in pleural effusion patients who received respirometer exercise also found a similar finding. There was a significant increase in FEV_1 and FVC values after exercise using a respirometer compared to before exercise. In addition, Valenza, et al. showed that incentive spirometry and mobilization combined with chest drainage and medication in patients with pleural effusion led to better clinical improvement and shorter treatment periods. Statistical analysis comparing pre-and post-treatment spirometry parameters in patients receiving intervention pointed out significant changes in vital capacity, FEV_1, and forced expiratory flow values compared to the control group. The value of vital capacity increased from 73.1±12.6% to 72.13±13.7% (P< 0.001), while the FEV_1 value increased from 72.13±13.7% to 78.98±16.9% (P< 0.001). The value of forced expiratory currents also increased from 64.8±35.1% to 76.78±35.3%, although this last change was not statistically significant (P= 0.198). The duration of treatment was also shorter in the intervention group (26.7±8.8 days) compared to the control group (38.6±10.7 days) with P-value of 0.014.[7]

Respirometer is also able to improve lung function and to increase exercise capacity when combined with physical exercise. This was similar with the study conducted by Weiner, et al. that obtained a significant increase in lung function after 8 weeks of exercise in the intervention group, namely an increase in the FEV_1 value of 570 ml post lobectomy and 680 ml in post pneumonectomy cases compared to the previous predicted value.[11] Although this study was not impemented in cases of pleural effusion, it could more or less provide information about the role of respirometer in improving lung function.

Other literature stated that exercise using incentive spirometry or respirometer could be used to enable patients in breathing deeper and to increase respiratory capacity to restore collapsed alveoli and improve oxygenation. They observed that volume-oriented incentive spirometry resulted in a higher increase in lung volume than flow-oriented incentive spirometry, even though both resulted in the same lung and abdominal compartments displacement.[19] Incentive spirometry has been widely used for prevention and managing pulmonary complications following thoracic, cardiac, and abdominal surgery. However, a recent systematic review suggested that its benefits were controversial. They also mentioned that this was due to the poor quality of previous study methods.[20]

Another thing that could affect the assessment of the respirometer effectiveness was patient's adherence in using respirometer, both in terms of technique and frequency. For example, a study found the level of patient disobedience in using a respirometer reached 86.0%, with the excuse of forgeting (83.5%), not using it effectively (74.4%), and not performing the exercise with the instructed frequency (70.7%).[21] The success of exercise using a respirometer depends on the patient's adherence to the instructions. Unfortunately, one study obtained that poor adherence and suboptimal use could reduce the potential benefits of respirometers.[22] This study used persuasive and checklist methods to help improve patient compliance.

CONCLUSION

From the results of this study, there was a significant improvement in lung function and shortness of breath after 6 days in all subjects, which was marked by an increase in the value of FEV_1 and FVC as well as the Borg scale either with or without inspiratory muscle training using respirometer. Although improvement in lung function was seen in both groups, the increase in FVC value after performing inspiratory muscle training using respirometer in the intervention group was greater. However, this exercise did not provide a significant increase in the FEV_1 value. Therefore, we conclude that inspiratory muscle exercise using respirometer improved lung function and could be considered as an additional therapy to assist lung expansion, particularly in patients with TB pleurisy.

REFERENCES

1. Jeon D. Tuberculous Pleurisy : An Update. Tuberc Respir Dis. 2014;3536:153–9.
2. Light RW. Update on tuberculous pleural effusion. Respirology. 2010;15(3):451–8.
3. Mitrouska I, Klimathianaki M, Mitrouska I, Klimathianaki M. Effects of pleural effusion on respiratory function. Can Respir J. 2004;11(7).
4. Krell W, Rodarte J. Effects of acute pleural effusion on respiratory system mechanics in dogs. J Appl Physiol. 1985;(59):1458–63.
5. Jardins T Des, Burton GG, Phelps TH. Clinical Manifestations and Assessment of Respiratory Disease. Seventh Ed. Elsevier; 2016.
6. Loscalzo J, Fauci AS, Kasper DL, Braunwald E, Hauser SL, Jameson JL, et al. Harrison's Pulmonary and Critical Care Medicine. McGraw Hill; 2010.
7. Valenza-Demet G, Valenza MC, Cabrera-Martos I, Torres-Sánchez I, Revelles-Moyano F. The effects of a physiotherapy programme on patients with a pleural effusion: A randomized controlled trial. Clin Rehabil. 2014;28(11):1087–95.
8. Ramírez-Sarmiento A, Orozco-Levi M, Güell R, Barreiro E, Hernandez N, Mota S, et al. Inspiratory muscle training in patients with chronic obstructive pulmonary disease: Structural adaptation and physiologic outcomes. Am J Respir Crit Care Med. 2002;166(11):1491–7.
9. Hiling L, Bakow E, Fink J, Kelly C, Sobush D, Southorn PA. Incentive Spirometry - AARC Clinical Practice Guideline. Respir Care J. 1991;36(12):1402–5.
10. Agarwal K, Solomen S. Comparative study between chest mobility exercises with incentive spirometry versus chest mobility exercises with stacked breathing on chest expansion in subjects with unilateral pleural effusion. Int J Dev Res. 2016;6(6):8034–8.
11. Weiner P, Man A, Weiner M, Rabner M, Waizman J, Magadle R, et al. The Effect of Incentive Spirometry and Inspiratory Muscle Training on Pulmonary Function After Lung Resection. J Thorac Cardiovasc Surg. 1997;113(3):552–7.
12. Yanti B, et al. Clinical and Demographic Characteristics Differences between M.tuberculosis and M.bovis Infection in Bronchiolveolar Lavage of Pulmonary Tuberculosis Patients. J Respirologi Indones. 2019;39(4):238–44.
13. Zhai K, Lu Y, Shi H. Tuberculous pleural effusion. J Thorac Dis. 2016;8(7):486–94.
14. Narasimhan P, Wood J, Macintyre CR, Mathai D. Risk factors for tuberculosis. Vol. 2013, Pulmonary Medicine. Hindawi Publishing Corporation; 2013. p. 11.
15. Broaddus VC, Murray JF, Nadel JA, Mason RJ, Ernst JD, Lazarus SC, et al. Murray & Nadel's Textbook of Respiratory Medicine. 6th Editio. Broaddus C, editor. Elsevier; 2016.
16. Thomas R, Jenkins S, Eastwood PR. Physiology of breathlessness associated with pleural effusions. 2015;21(4):338–45.
17. Jindal S, Shankar P, Raoof S, Gupta D, Aggarwal AN, Agarwal R. Textbook of Pulmonary & Critical Care Medicine. First Edit. Jaypee Brothers Medical Publishers; 2011.
18. Scherer TA, Spengler CM, Owassapian D, Imhof E, Boutellier URS. Respiratory Muscle Endurance Training in Chronic Obstructive Pulmonary Disease Impact on Exercise

Capacity , Dyspnea , and Quality of Life. Am J Respir Crit Care Med. 2000;162:1709–14.

19. Paisani DDM, Lunardi AC, Cristine C, Marques B, Porras DC, Tanaka C, et al. Volume Rather Than Flow Incentive Spirometry Is Effective in Improving Chest Wall Expansion and Abdominal Displacement Using Optoelectronic Plethysmography. 2013;1360–6.
20. Carvalho C, Paisani D, Lunardi A. Incentive spirometry in major surgeries: a systematic review. NCBI. 2011;15(5):343–50.
21. Eltorai AEM, Baird GL, Eltorai AS, Pangborn J, Jr VA, Cullen HA, et al. Incentive Spirometry Adherence : A National Survey of Provider Perspectives. Respir Care. 2018;63(5).
22. Narayanan A, Hamid S, Supriyanto E. Evidence regarding patient adherence with incentive spirometry interventions after cardiac, thoracic and abdominal surgeries: A systematic review. Can Respir J. 2016;25(1):17–26.