Middle-East Journal of Scientific Research 18 (1): 85-90, 2013
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2013.18.1.10365

Inspiratory Muscle Training Versus Aerobic Exercise on Diaphragmatic Excursion Post Thoracotomy

Akram Abdel Aziz Sayed, Mohamed Abdel Halim M. Shendy and Samah M. Ismail

Department of Physical Therapy for Cardiovascular/Respiratory Disorder and Geriatrics, Faculty of Physical Therapy, Cairo University, Giza, Egypt

Abstract: Diaphragmatic dysfunction is a major factor in the etiology of postoperative pulmonary complications after lung decortications. This study was designed to compare between the effect of inspiratory muscle training versus aerobic training on pulmonary functions post thoracotomy on diaphragmatic excursion. Thirty patients of both sexes, second day post lung decortication surgery participated in this study. Their ages ranged from 20-50 years old. Patients were assigned randomly into two equal groups in number. All patients in each group were received 12 sessions of treatment, 6 sessions each week, Group (I) consisted of 15 patients would receive inspiratory muscle training (IMT) in addition to conventional chest physiotherapy, Group (II) consisted of 15 patients received aerobic training (AT) in addition to conventional chest physiotherapy. Diaphragmatic excursion was measured for each patient pre and post the study (2 weeks). Results showed that the diaphragmatic excursion of group I pre treatment was 2.2±0.26 cm and post treatment was 3.51±0.33 cm with a percentage improvement (increase) of 59.54%, while the diaphragmatic excursion of group II pre treatment was 2.2±0.26 cm and post treatment was 3.94±0.28 cm with a percentage of improvement (increase) of 79.09%. It was concluded that both IMT and AT effectively increase the diaphragmatic excursion which lead to decrease the work of breathing. So, these programs should be considered in rehabilitation of patients underwent lung decortications surgery.

Key word: Aerobic exercise · Inspiratory muscle training · Diaphragmatic excursion · Lung decortication

INTRODUCTION

Thoracotomy is a common surgical procedure. The indications for thoracotomy are wide including the management of mediastinal and bronchogenic carcinoma, chest trauma, empyema, recurrent pneumothorax etc [1].

Decortication is done to remove the lining of the pleural cavity, called the pleura, when this lining becomes thick and inelastic, restricting lung expansion. It is also done to remove tumors in the pleura [2]. The goals of the operation are to reexpand the lung and fix the problems affecting the pleural space to improve lung function [3]. Decortication may be necessary to help patients with pleurisy, empyema, fibrothorax and mesothelioma [4].

Respiratory muscle function and strength after thoracic surgery may be affected directly by damage to the muscle itself or to the nerves as a consequence of the incision, or indirectly as a result of changes in the mechanics of the respiratory system. Distortion of chest wall configuration may reduce the chest wall compliance and increase the work of breathing leading to a decrease in the mechanical efficiency of the respiratory muscles. The efficiency of the respiratory muscles may be further reduced by a decrease in lung compliance due to atelectasis [5].

Thoracic surgery may cause reduced respiratory function with associated increased risk of mortality. The risk of postoperative pulmonary complications is relatively high following thoracic surgery. major thoracic surgical procedures, such as thoracotomy, may lead to severe depression of pulmonary function through atelectasis, secretion retention, altered chest wall mechanics and abnormal breathing pattern [6].

Postoperative complications have been reported to be as high as 30% for thoracotomy and lung decortication in patients with chronic obstructive pulmonary disease.

Corresponding Author: Samah M. Ismail, Department of Physical Therapy for Cardiovascular/Respiratory Disorders and Geriatrics, Faculty of Physical Therapy, Cairo University, Giza, Egypt.
E-mail: samahm_mahmoud@hotmail.com.

Most of the complications are due to respiratory muscle dysfunction and surgery-related changes in chest wall mechanics. In general, preoperative optimisation of medical therapy combined with chest physiotherapy and early extubation and mobilisation may improve clinical outcomes in high-risk surgeries, including upper abdominal and thoracic surgery in patients with severe emphysema [7].

Like other skeletal muscle, the rationale for inspiratory muscle training is that increase the endurance or strength of the respiratory muscles can reduce the severity of dyspnea, improve clinical outcomes and enhance the ability of individuals to perform daily activities [8].

Diaphragmatic excursion is the movement of the diaphragm during breathing. It is the difference between the end maximum inspiration and the end maximum expiration[9]. Its reduction was the main determinant of respiratory function impairement [10].

Ultrasonography is used to investigate the changes in diaphragmatic excursion. It has many advantages including portability, visualization of structures of the thoracic bases and upper abdomen, lack of ionizing radiation and the ability to quantify diaphragmatic motion [11].

Inspiratory muscle training for three weeks in post-operative thoracotomy can significantly improve the ventilatory function and decreased the duration of post-operative hospitalization which may be due to improvement of diaphragm strength in addition to improvement of mechanics of breathing for this group of patients [12].

The respiratory system responds to aerobic training (AT) by the immediate increase in the pulmonary ventilation, largely through stimulation of the respiratory centers in the brain stem from the motor cortex and through feedback from the proprioceptors in the muscles and joints of the active limbs [13].

The current work aimed to compare the efficacy of inspiratory muscle training versus aerobic training on diaphragmatic excursion post lung decortications.

MATERIAL AND METHODS

Subjects: Thirty subjects of both sexes (17 males and 13 females) with the mean age of 33.8±9.11 years and body mass index (BMI) of 24.05±2.54 kg/m² of second day after thoracotomy surgery were included in the study. The study was applied in El-kasr al ainy Hospital-Cardiothoracic Department.

Inclusion Criteria: Patients participated in the current study have met the following criteria:

- Underwent unilateral pleural decortication surgery.
- All patients post open technique of pleural decortication surgery.
- All patients had posterolateral incision approach.
- All patients had two chest tube placement (anterior,posterior) intraoperative.
- All patient sufferd from decrease in diaphragmatic muscle strength and depression in pulmonary ventilation post lung decortication.

Exclusion Criteria: Patients were excluded from the study if they had any of the following criteria:

- Any medical condition that had been contraindicated to exercise (eg. General myopathy, osteoarthritis knee,hip and bone deformity in spine and lower limb).
- Unwilling to participate in the exercise program as defined by the protocol.
- Uncontrolled hypertension, cardiac illness, psychiatric condition.
- Cognitive dysfunction.
- Addict patients.
- Heavy smoker patients (above 20 c/d).

All the participants included underwent thoracotomy surgery (lung decortication). They suffered from decreasing in diaphragmatic excursion after thoracotomy. Whereas subjects with any other medical condition that had been contraindicated to exercise (e.g. General myopathy, osteoarthritis knee, hip and bone deformity in spine and lower limb), Uncontrolled hypertension, cardiac illness, psychiatric condition or addict patients were excluded from the study. This study was reviewed and was approved by the Ethics Committee of Faculty of Physical therapy, Cairo University.

Material and Procedures

Evaluatinon Equipment

Ultraosnography: (Thoracic Ultrasound): Siemens SONOLINE G60 Ultrasound Machine,Germany), For measurement of diaphragmatic excursion.

Height and Weight Scale: (Seca Apparatus, Made in China): It was used to measure the height and the weight of the patient.

Training Equipment

Threshold Inspiratory Muscle Training: (Hs730Eu-010/USA) Threshold IMT, applies resistance (weight) training to the inspiratory muscles in order to increase the inspiratory muscle strength. The Threshold trainer is a small hand held device supplied by Respironics. It includes a mouthpiece and a calibrated springloaded valve. The valve controls a constant inspiratory pressure training load and the patient must generate the inspiratory pressure in order for the inspiratory valve to open and allow inhalation of air. The valve is calibrated and can be adjusted according to a percentage of the patient's maximum inspiratory pressure (PI max)[14].

Stationary Bicycle Ergometer: stationary bicycle supplied with adjustable electronic digital heart rate monitor used for aerobic exercises,Stop watch to adjust the time for each exercise phase (warming up, active phase and cooling down phase).

Procedures of the Study

Evaluative Procedures

- Each patient had full explanation of the objectives of the study, demonstration on equipments and procedures. Those patients who agreed to participate in the study would be signed an informed consent for participation.
- Data concerning each patient characteristics had collected in the first session including age, height, weight and BMI.
- Diaphragmatic excursion would be measured pre and post the study program for each patient.
- Calibration of instruments would be performed before each session.

Treatment Procedure: Subjects who met the inclusion criteria were randomly assigned into two groups as I and II (n=15) subjects in each group. Both groups performed conventional chest physiotherapy. Group I received IMT (threshold inspiratory muscle training device) and group II received AT (bicycle ergometer).

Each patient in group I received inspiratory muscle training (IMT) in addition to conventional chest physiotherapy. IMT starting resistance equal to 30% of their maximal inspiratory pressure (MIP), duration 30 minutes/ day, was divided into two session 15 minute each one performed at (morning / evening). The resistance had been increased incrementally based on the rate of perceived exertion (RPE) scored by the patient on the Borg Scale [15]. Each patient in-group (II): received aerobic training program in addition to conventional chest physiotherapy. They participated in an established moderate intensity aerobic exercise program on stationary ergometer bicycle at 60-70% of HR_{Max}. and in regarding to moderate work load at score 12-14 on Borg scale for rate of perceived exertion(RPE) (According to Borg scale) [16] for 30 minutes / session, 6 session/ week for two weeks with total 12 sessions. The session was consisted of warming up 5 minutes, active training phase 20 minutes and cooling down 5 minutes [17].

Diaphragmatic excursion was measured by ultrasound device at a lower frequency transducer 1-3 MHz (greater depth and Less spatial resolution) and M mode to measure excursion of the diaphragm (greater posteriorly than anteriorly, greater laterally than medially) at 2nd day post-operative and after the program (2 weeks) [18, 19].

Statistical Procedures: For the statistical analysis of the data, Descriptive statistics and t-test for comparison of the mean age, weight, height and BMI between both groups (I and II), Dependent and independent t-tests were used to determine the differences in mean values of diaphragmatic excursion,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 19 for windows.

RESULTS

Results of Demographic Data in Both Groups: A total of 30 patients underwent lung decortication surgery participated in this study. The mean values of the patients' age, body weight, height and body mass index (BMI), in each group is detailed in Table 1. Paired t-test for the two groups revealed that there is no significant difference between the groups in age (p=0.65), body weight (p=0.62), height (p=0.73), BMI (p=0.56). This indicates that the two groups are matched in age, body weight, height and BMI.

Frequency Distribution of Sex in Group I and II: The sex distribution of group I revealed that there were 6 female with reported percentage of 40% and 9 male with reported percentage of 60%. The sex distribution of group II revealed that there were 7 female with reported percentage of 47% and 8 male with reported percentage of 53% as shown in Table (2).

Results of Diaphragmatic Excursion: Multiple pairwise comparison showed that there was no significant difference in the mean values of diaphragmatic excursion pre treatment between group I and group II (p = 0.96). However, there was a significant increase in the mean values of the diaphragmatic excursion post treatment in the group II compared with group I (p = 0.001) Table (3).

Table 1: Demographic data for patients in both groups (I, II).

	Group I	Group II				
	x̄±SD	x̄±SD	MD	t- value	p-value	Sig
Age (years)	33.8±9.11	35.13±6.7	-1.33	-0.45	0.65	NS
Weight (kg)	75.46±5.98	76.33±3.14	-0.87	-0.49	0.62	NS
Height (cm)	177.4±6	176.66±5.93	0.74	0.33	0.73	NS
BMI (kg/m²)	24.05±2.54	24.51±1.61	-0.46	-0.59	0.56	NS

x̄: Mean SD: Standard Deviation MD: Mean difference
t value: Unpaired t value p value: Probability value NS: Non significant

Table 2: The frequency distribution of sex in group I and II:

	Group I		Group II	
	Female	Male	Female	Male
No.	6 (40%)	9 (60%)	7 (47%)	8 (53%)
Total	15 (100%)	15 (100%)		

Table 3: Mean values of diaphragmatic excursion pre and post treatment of group I and II:

Diaphragmatic excursion (cm)			
Group I		Group II	
x̄±SD		x̄±SD	
Pre	Post	Pre	Post
2.2±0.26	3.51±0.33	2.2±0.26	3.94±0.28

Two way mixed MANOVA

Within group comparison (effect of time)

F = 4582.89 *p = 0.0001*

Between group (effect of treatment)

F = 4.22 *p = 0.04*

Interaction effect (time* treatment)

F = 92.71 *p = 0.0001*

Multiple pairwise comparison (bonferroni correction)

		MD	p-value	Sig
Pre vs Post	Group I	-1.31	0.0001	S
	Group II	-1.74	0.0001	S
Group I vs Group II	Pre treatment	0	0.96	NS
	Post treatment	-0.43	0.001	S

x̄: Mean SD: Standard Deviation MD: Mean difference
p value: Probability value S: Significant NS: Non significant

Interaction Effect: There was a significant interaction between time and treatment effect (p = 0.0001) Table (3).

DISCUSSION

Postoperative pulmonary complications (PPC) present high rates of morbidity, mortality, increase hospital costs and prolonged hospital stay predominantly in cardiac, thoracic and abdominal surgery. The incidence of PPC varies according to the previous diagnosis of the candidates for surgery, the incidence rates vary dramatically, ranging from 3 to 42%, pulmonary complications is relatively high following thoracic surgery, rates have been recorded at between 18 and 61%, compared with only 16 and 17% for upper abdominal surgery and 0% and 5% for lower abdominal surgery [20].

This study was conducted to determine the response of diaphragmatic excursion after application of inspiratory muscle training versus aerobic exercise for patients undergoing lung decortication. There was a significant increase in diaphragmatic excursion with a percentage of improvement (increase) of 59.54 and 79.09% in group (I) compared to group (II) respectively.

Our result was in agreement with Valkenet *et al.* [21] who stated that preoperative respiratory muscle training may prevent postoperative pulmonary complications by increasing inspiratory muscle strength in patients undergoing thoracic surgery.

In continuation, Kulkarni *et al.* [22] have demonstrated that inspiratory muscle training for two weeks before upper abdominal surgery increased inspiratory muscle strength.

In contrast, there are other studies conducted by Ora *et al*. [23] in which the authors used a 3–4 week IMT with a training load of 60–80% of the maximum voluntary ventilation in obese individuals. Although the authors did not observe significant changes in inspiratory muscle strength, there was a significant increase in maximum voluntary ventilation in the group that performed the experimental protocol. their training was comparable with that of the present study, however, differences existed in frequency six versus three session per week.

Savci *et al*. [24] found that a non-intensive 4-week training programme of resistive breathing in patients undergoing coronary artery bypass graft surgery led to an increase in exercise capacity and a decrease in dyspnoea when assessed by symptom limited exercise testing. these changes were associated with significant increases in the velocity of diaphragmatic excursions during quiet breathing and sniffing.

This results come in agreement with Adamo *et al.* [25] who reported that the ventilatory muscles receive a training stimulus from whole-body aerobic exercise. It was found that increased inspiratory and expiratory muscle strength increased respectively by 12 and 13% and diaphragm excursion increased by 11%.

Also, Elaine *et al*. [26] found that greater structural dimensions of the diaphragm (thickness, internal diameter and cross-sectional area) and excursion improvement were shown in aerobic -trained individuals relative to controls**.**

The findings on diaphragmatic excursion are supported also by Paulin *et al.* [27] who reported that IMT alone and IMT in conjunction with a general exercise program, significantly improves diaphragmatic thickness and excursion.

CONCLUSION

The findings of this study demonstrated that a program of IMT or AE in post lung decortications patients for two weeks revealed significant improvement in the diaphragmatic excursion while, aerobic trainning lead to more improvement (increase). So, both types of training are safe and can be used in rehabilitation of patients underwent lung decortications and thoracic surgery rehabilitation programmes.

REFERENCES

1. Onat, S., R. Ulku, A. Avci, G. Ates and C. Ozcelik, 2011. Urgent thoracotomy for penetrating chest trauma: Analysis of 158 patients of a single center. Injury, 42: 900-904.
2. Treasure, T., L. Lang-Lazdunski, D. Waller, J.M. Bliss, C. Tan, J. Entwisle, M. Snee, M. O'Brien, G. Thomas, S. Senan, K. O'Byrne and L.S. Kilburn, 2011. Extra-pleural pneumonectomy versus no extra-pleural pneumonectomy for patients with malignant pleural mesothelioma: clinical outcomes of the Mesothelioma and Radical Surgery (MARS) randomised feasibility study. Lancet Oncol., 12: 763-772.
3. Sensakovic, W.F., S.G. Armato, A. Starkey, H.L. Kindler and W.T, 2011. Vigneswaran. Quantitative measurement of lung reexpansion in malignant pleural mesothelioma patients undergoing pleurectomy/decortication. Acad. Radiol., 18: 294-298.
4. Cao, C.Q., T.D. Yan, P.G. Bannon and B.C McCaughan, 2010. A systematic review of extrapleural pneumonectomy for malignant pleural mesothelioma. J. Thorac. Oncol.; 5: 1692-1703.
5. Welvaart W.N., M.A. Paul, G.J. Stienen, H.W. van Hees, S.A. Loer, R. ouwman, H. Niessen, F.S. de Man, C.C Witt., H. Granzier, A. Vonk-Noordegraaf and C.A. Ottenheijm, 2011. Selective diaphragm muscle weakness after contractile inactivity during thoracic surgery. Ann. Surg., 254: 1044-1049.
6. Welvaart, W., M. Paul, G. Stienen, H. Van Hees, S. Loer, *et al*., 2011. Selective diaphragm muscle weakness after contractile inactivity during thoracic surgery. Ann. Surg., 254: 1044-1049.
7. Ferreyra, G., Y. Long and V.M. Ranieri, 2009. Respiratory complications after major surgery. Current Opinion in Critical Care, 15: 342-348.
8. Murray, J. and D. Mahler, 2009. Inspiratory muscle training pulmonary rehabilitation.Guidlines to success, Mosby, Elsvier,4th ed,ch (11): 143-153.
9. West, J.B., 2000. Respiratory Physiology,the essentials,6th ed.Williams and Wilkins, Baltimore.
10. Ford, E., G.S. Mageras, E. Yorke, K. Rosenzweig, L. Braban, E. Keatley and S.A. Leibel, 2003. Fluoroscopic evaluation of diaphragmatic motion reduction with a respiratory gated radiotherapy system. J. Appl. Clin. Med. Phys., 30: 505-513.

11. Gerscovich, E.O., M. Cronan, J.P. McGahan, K. Jain,, C.D. Jones and C. McDonald, 2001. Ultrasonographic evaluation of diaphragmatic motion. J. Ultrasound Med., 20: 597-604.
12. Arbane, G., D. Tropman, D. Jackson and R. Garrod, 2011. Evaluation of an early exercise intervention after thoracotomy for non-small cell lung cancer (nsclc), effects on quality of life, muscle strength and exercise tolerance. randomized controlled trial. Lung Cancer, 71: 229-234.
13. Kemi, O.J. and U. Wisloff, 2010. High-intensity aerobic exercise training improves the heart in health and disease. J. Cardiopulm. Rehabil. Prev., 30: 2-11.
14. Illi, S., U. Held, I. Frank and C. Spengler, 2012. Effect of respiratory muscle training on exercise performance in healthy individuals. a systematic review and meta-analysis. Sports Med., 42: 707-724.
15. Enright, S.J. and V.B. Unnithan, 2011. Effect of inspiratory muscle training intensities on pulmonary function and work capacity in people who are healthy: a randomized controlled trial. Phys. Ther., 91:894-905.
16. Jones, L.W., P.S. Douglas, N.D. Eves, P.K. Marcom, W.E. Kraus, J.E. Inman, J.D. Allen and J. Peppercorn, 2010. Rationale and design of the Exercise Intensity Trial (EXCITE): a randomized trial comparing the effects of moderate versus moderate to highintensity aerobic training in women with operable breast cancer. BMC Cancer, 10: 531.
17. O'Connor, C.M., D.J. Whellan, K.L. Lee, S.J. Keteyian, L.S. Cooper, S.J. Ellis, E.S. Leifer, W.E. Kraus, D.W. Kitzman, J.A. Blumenthal, D.S. Rendall, N.H. Miller, J.L. Fleg, K.A. Schulman, R.S. McKelvie, F. Zannad and I.L. Piña, 2009. Efficacy and safety of exercise training in patients with chronic heart failure. HFACTION randomized controlled trial. JAMA, 301: 1439-1450.
18. Vivier, E., D.A. Mekontso, S. Dimassi, F. Vargas, A. Lyazidi, A.W. Thille and L. Brochard, 2012. Diaphragm ultrasonography to estimate the work of breathing during non-invasive ventilation. Intensive Care Med., 38: 796-803.
19. Kim, S.H., J.S. Choi, S. Shin and S.O. Koh, 2010. An evaluation of diaphragmatic movement by M-mode sonography as a predictor of pulmonary dysfunction after upper abdominal surgery. Anesth. Analg., 110: 1349-1354.
20. Ferreyra, G., Y. Long and V.M. Ranieri, 2009. Respiratory complications after major surgery. Current Opinion in Critical Care, 15: 342-348.
21. Valkenet, K., I.V. de Port, J. Dronkers, W. de Vries, E. Lindeman and F. Backx, 2011. The effects of preoperative exercise therapy on postoperative outcome. a system-atic review. Clin. Rehabil., 25: 99-111.
22. Kulkarni, S.R., E. Fletcher, A.K. McConnell, K.R. Poskitt and M.R. Whyman, 2010. Pre-operative inspiratory muscle training preserves postoperative inspiratory muscle strength following major abdominal surgery. randomized pilot study. Annals of the Royal College of Surgeons of England, 92: 700-707.
23. Ora, J., P. Laveneziana, K. Wadell M. Preston, K.A. Webb and D.E. O'Donnell, 2011. Effect of obesity on respiratory mechanics during aerobic and inspiratory resistive training in COPD. J. Appl. Physiol., 111: 10-19.
24. Savci, S., B. Degirmenci, M. Saglam, H. Arikan, D.I. Ince and H.N. Turan, 2011. Short-term effects of inspiratory muscle training in coronary arterybypass graft surgery. a randomized controlled trial. Scand Cardiovasc. J., 45: 286-293.
25. Adamo, P.S., J.P. Schmid, Laoutaris I.D.P. Dendale, C. Doulaptasis, A. Kouloubinis, D. Poershcke, A. dritsas and H. Saner, 2011. Combined whole body aerobic/ventilatory muscle training versus whole body aerobic training in patients with chronic heart failure. The VENT-HEFT trial: a prospective randomized Multi-European trial. Europ. Revent, 2: 112-117.
26. Elaine P., A. F. Brunetto, C.R. and Fernandes, 2003. Effects of a physical exercise program designed to increase thoracic expansion in chronic obstructive pulmonary disease patients. J. Pneumologia, 29: 363-370.
27. Paulin, E., W.P. Yamaguti, M.C. Chammas, S.R.S. Stelmach, A. Cukier and C.R. Carvalho, 2007. Influence of diaphragmatic mobility on exercise tolerance and dyspnea in patients with COPD. Respir. Med., 101: 2113-2118.