Effect of Diaphragmatic Strengthening Exercises on Lung Function and Diaphragmatic Motility in Children with Chronic Lung Disease

Eman M. Fouda *, Safaa K. Mohamed*, Ahmed M. El-Kahky, Hala A. El-Sayed***, Amaal H. Ebrahim**** and Hasaan B. Moustafa***

Departments of Pediatrics, Faculty of Medicine, Ain Shams University*.
Medical Department, Institute of Post-Graduate Childhood Studies, Ain Shams University**.
Faculty Of Physical Therapy, Misr For Science and Technology University***.
Basic science department, Faculty of Physical Therapy, Cairo University****.

ABSTRACT

The respiratory muscles constitute a complex pump system. Breathing under all circumstances requires a coordination of different respiratory muscles. The most important inspiratory muscle is the diaphragm. The diaphragm is the inspiratory muscle most shortened during hyperinflation, which is inevitable consequence of severe obstructive airway diseases. It maintains a constant volume and increases its circumference minimally as it shortens. Assessment of diaphragm function can be carried out by the use of ultrasonography through measurement of its thickness and motility (excursion). Short term exercise training for the diaphragm has been found to improve physical fitness and to result in a decrease in the number of asthma attacks, emergency room visits, and hospitalization The aim of this study was to evaluate the diaphragm thickness and motility in asthmatic children and those with chronic lung diseases and also to assess the effect of a specific training program for the diaphragm "diaphragm strengthening exercise" on those patients. The work included 52 children, divided into three groups: (BA) group comprised 32 children with bronchial asthma, with ages ranged from 6-13 years. (CLD) group comprised 20 children with various causes of chronic lung disease (CLD) with ages range from 6-11 years and control group comprised of 12 healthy children were used as a control, with ages ranged from 5-10 years. All studied groups were subjected to clinical examination for assessment of clinical severity, plain X-ray chest, spirometric pulmonary function tests and ultrasonographic assessment of diaphragm thickness and excursion (motility). The patients were subjected to a special program of physical training for the diaphragm "diaphragm strengthening exercise", twice per week for 3 months. Reassessment after the exercise program showed a statistically significant lower values of all spirometric pulmonary functions (FEV 1, FVC, FEV%, PEF25-75% SVC ad MVV) in asthmatic patients and in those with CLD compared to control ($P<0.05$). Also diaphragmatic thickness by ultrasonography revealed less thickener diaphragm in both asthmatics (9.28±1.88 mm) and children with CLD (9.32±1.79 mm) compared to control values (10.41±1.31 mm). Assessment of diaphragmatic excursion or motility by ultrasonography revealed less mobile diaphragm in asthmatics (11.06±3.82) and in those with CLD (10.05±2.23 mm) compared to control values (12.05±2.23 mm). There was no statistical significant difference between asthmatics and patients with CLD as regards diaphragm thickness and motility. Also there was an improvement of asthma scoring and asthma severity. In conclusion, diaphragmatic training programs may be of value in improving symptoms and severity of patient with asthma and CLD through its effect on diaphragmatic thickness and motility.

INTRODUCTION

The respiratory muscles are skeletal muscles, and in essence their structural and functional properties are within the range of other skeletal muscles located in the limbs. Adaptations to their specific function, however, make them distinctly different from other skeletal muscles in a number of respects. First, limb muscles are essentially designed to produce movements. And hence, primarily work against inertial loads. Respiratory muscles mainly have to overcome resistive and elastic loads. Second, peripheral muscles contract rhythmically during movements, while respiratory muscles contract rhythmically and continuously, and they are the only skeletal muscles on which life depends[5].

The respiratory muscles constitute a complex pump system. Breathing under all circumstances requires a coordination of different respiratory muscles. The most important inspiratory muscle is the diaphragm.

These vital muscles thus have to be well equipped to sustain continuous rhythmic contraction. These adaptations include high fatigue resistance, high oxidative capacity, greater capillary density, and greater maximal blood flow, and they depend upon structural and functional properties of the muscles[5,6].

In patients with chronic lung diseases, the inspiratory muscles are faced with an increased loads. Airflow obstruction increases resistive work and the developed hyperinflation creates a threshold load that needs to be overcome with each breath[13].

The diaphragm is the inspiratory muscle most shortened during hyperinflation, which is inevitable consequence of severe obstructive airway diseases. It maintains a constant volume and increases its circumference minimally as it shortens. Assessment of diaphragm function can be carried out by the use of ultrasonography through measurement of its thickness and motility (excursion)[11].

Short term exercise training for the diaphragm have been found to improve physical fitness and to result in a decrease in the number of asthma attacks, emergency room visits, hospitalization and days of absence from school. Also a significant improvements in lung function values and in asthma symptoms and CLD patients may occur[16].

Aim of the study

The aim of this study was to evaluate the diaphragm thickness and motility in asthmatic children and those with chronic lung disease and also to assess the effect of a specific training program for the diaphragm "diaphragm strengthening exercise" on those patients.

SUBJECTS AND METHODS

The study was conducted on 52 children attending the Outpatient Chest Clinic of Pediatrics Hospital, Ain Shams University and they were divided into two groups and were compared with a 12 healthy child consisted the control group:

Bronchial asthma group (BA):

32 children with bronchial asthma (18 males and 14 females), their mean age was (9.44±2.71 years) and their mean duration of illness was (6±3.08 years). They were classified according to GINA guidelines (2002) into mild persistent asthma (20 cases) (62.5%) and moderate persistent asthma (12 cases) (37.5%).

Chronic lung disease group (CLD):

20 children with various causes of

chronic lung diseases: 8 patients with bronchiectasis (40%), 8 patients with interstitial fibrosis (40%) and 4 patients with cystic fibrosis (20%), all patients were males, their mean age was (8.4±2.37 years) and their mean duration of illness was (5.4±6.2 years).

A third group of 12 healthy children, age and sex matched with the studied groups was selected as a control group. They were 7 males (58.3%) and 5 females (41.7%), their mean age was (7.5±1.88 years). All three groups were subjected to:

1. Thorough history and clinical examination laying stress on clinical severity assessment by Modified GINA Guidelines (2002), daily medication score and symptom score or patients with asthma.
2. Plain X-ray chest.
3. Spirometric pulmonary function tests, by the use of MIR Spirobank equipment in Outpatient Chest Clinic, Pediatric Hospital, Ain Shams University.
4. Ultrasonographic assessment of diaphragmatic thickness and excursion by the use of a high frequency probes (5-7.5 MHz) to observe the diaphragm at the zone of apposition (ZOA) which is that part of diaphragm in contact with lateral chest wall below the inferior border of the costophrenic sinus, as the following:

a. Patient lies in supine and the transducer is aligned parallel to the midline.
b. A picture of the liver and diaphragm is taken in full inspiration and then in full expiration from the same point.
c. A line is drown between the angle of the picture and the dome of the diaphragm in both sides in full inspiration and full expiration.
d. The difference between both points is considered the diaphragmatic excursion and the "thickness" of the diaphragm is measured directly.

5. Patients were subjected to a special program of physical training for the diaphragm "diaphragm strengthening exercise", twice per week for 3 months. This exercise was done for diaphragm through abdominal weights in the following sequence:

a. Patient lies in Crock-lying position.
b. The abdominal weights are sand weights connected to the upper abdomen with adhesive straps to be applied firmly.
c. Weights were graduated from half kilogram till three kilograms according to each patient's ability aiming to strengthen the diaphragm as the main respiratory muscle.
d. Exercise were applied as 2 sessions per week for about 3 months each session takes about 30 minutes while the patient asked to inspire deeply 3 times each minute.

Patients were re-assessed by:

- History taking for assessment of symptom score, medication score and clinical severity.
- Clinical re-assessment.
- Pulmonary function tests.
- Ultrasonography of the diaphragm for thickness and motility.

RESULTS

Table (1): Comparison between the three groups as regards number, sex, age, age of illness onset and duration.

Variable		Bronchial Asthma n=32	Chronic Lung Disease n=20	Control N=12
Age (years)	Range	6-13	6-11	5-10
	Mean	9.44±2.71	8.4±2.37	7.4±2.37
Sex	Male	9 (56%)	10 (100%)	7 (59%)
	Female	7 (44%)	0 (0%)	4 (42%)
Age of onset (Years)	Range	2-5	0-10	---
	Mean	4±1.45	3±9.15	---
Duration of illness (years)	Range	2-11	1-8	---
	Mean	6±3.08	5.4±2.46	---

Comparison between the three groups as regards the number, sex, age, and age of illness onset and illness duration in patients groups showed a non significant difference in all parameters (table 1).

Table (2): Statistical comparison between the control, asthmatic and chronic lung disease groups as regards spirometric pulmonary function before diaphragmatic strengthening exercises (DSE).

Pulm. Function Test (% of predicted)	Control	BA	Control	CLD
FEV 1(L/m)	103.67±15.32	49.31±6.63	103.67±15.32	47.2±14.64
	<0.001 (S)		<0.001 (S)	
FVC (L/m)	101.92±15.47	83±121.31	101.92±15.47	56±22.19
	<0.01 (S)		<0. 01 (S)	
FEV1/FVC	90.42±9.83	82.25±14.32	90.42±9.83	87.8±19.91
	<0.05 (S)		<0.01 (S)	
PEF (L/m)	98.92±16.03	62±18.58	98.92±16.03	36.2±4.92
	<0.001 (S)		<0.001 (S)	
FEF_{25} (L/m)	99.5±15.95	58.25±20.39	99.5±15.95	29.2±4.87
	<0.001 (S)		<0.001 (S)	
FEF_{50} (L/m)	103.25±17.15	63.06±21.14	103.25±17.15	38.6±11.25
	<0.001 (S)		<0.001 (S)	
FEF_{75} (L/m)	107.75±19.75	65.38±17.21	107.75±19.75	36.6±11.05
	<0.001 (S)		<0.001 (S)	
FEF_{25-75} (L/m)	112±19.94	65.5±19.19	112±19.94	36.6±9.39
	<0.001 (S)		<0.001 (S)	
LVC (L/m)	91.33±3.65	81.69±11.12	91.33±3.65	51.6±11.67
	<0.01 (S)		<0.001 (S)	
MVV (L/m)	98.1±9.5	60.41±10.7	98.1±9.5	50.5±10.6
	<0.01 (S)		<0.01 (S)	

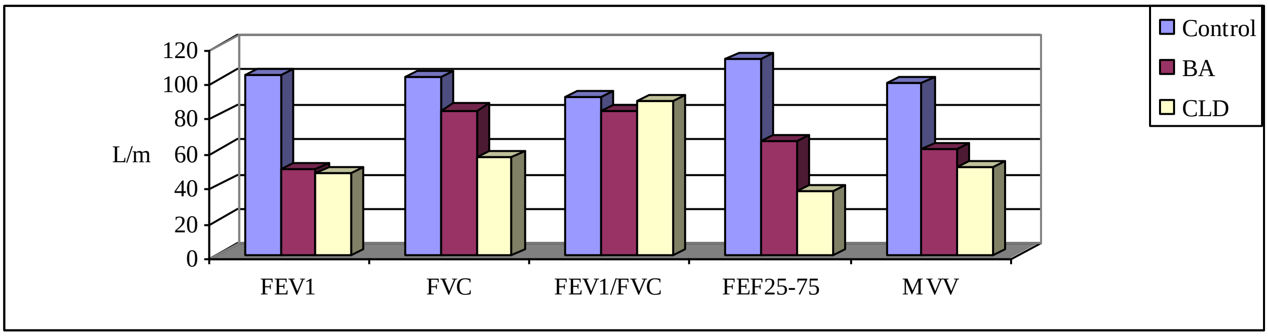

Fig. (1): Statistical comparison between the three groups as regards spirometric pulmonary function before DSE.

Table (2) shows that there was a significant difference in all spirometric pulmonary function before DSE between the control group and asthmatic and chronic lung disease groups (figure 1).

Table (3): Statistical comparison as regards ultrasonographic evaluation of diaphragm thickness and excursion in the three groups before DSE.

	Control	BA	Control	CLD	BA	CLD
Diaph. Thickness (mm)	10.4±1.31	9.28±1.88	10.4±1.31	9.32±1.79	9.28±1.88	9.32±1.79
	<0.05 (S)		<0.05 (S)		>0.05 (NS)	
Diaph. Excursion (mm)	12.05±2.23	11.06±3.82	12.05±2.23	10.26±3.66	11.06±3.82	10.26±3.66
	<0.05 (S)		<0.05 (S)		>0.05 (NS)	

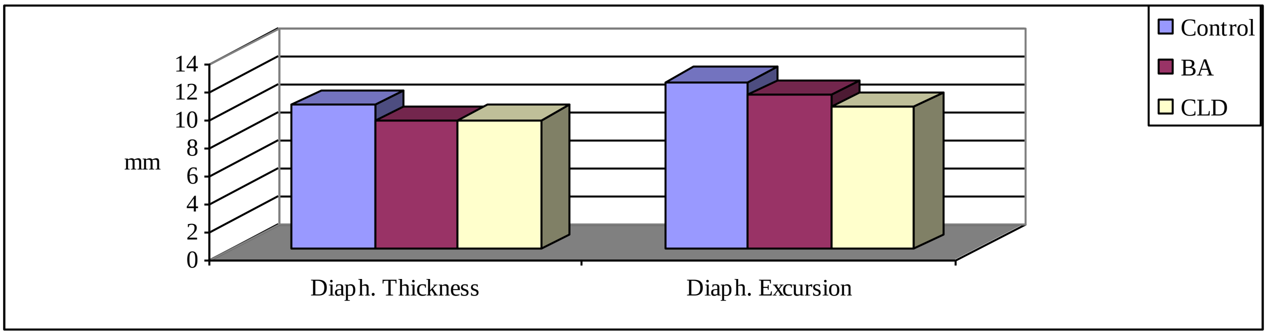

Fig. (2): Statistical comparison as regards ultrasonographic evaluation of diaphragm thickness and excursion in the three groups before DSE.

Table (3): Shows that there was a significant difference in ultrasonographic evaluation of diaphragm thickness and excursion in the three groups before DSE (figure 2).

Table (4): Statistical comparison of spirometric pulmonary functions in BA and CLD groups before and after DSE.

Pulm. Function Test (% of predicted)	BA		CLD	
	Before	After	Before	After
FEV 1(L/m)	49.31±6.63	85.94±6.32	47.2±14.64	60.2±13.79
	<0.01 (S)		<0.01 (S)	
FVC (L/m)	83±121.31	86.69±5.72	56±22.19	60±16.64
	>0.05 (NS)		>0.05 (NS)	
FEV1/FVC	82.25±14.32	99.13±4.08	87.8±19.91	99.2±6.71
	<0.05 (S)		<0.01 (S)	
PEF (L/m)	62±18.58	78.06±14.74	36.2±4.92	51±8.62
	<0.00 (S)		<0.01 (S)	
FEF_{25} (L/m)	58.25±20.39	57.31±18.86	29.2±4.87	32.3±1.49
	>0.05 (NS)		>0.05 (NS)	
FEF_{50} (L/m)	63.06±21.14	61.75±19.32	38.6±11.25	40±11.79
	>0.05 (NS)		>0.05 (NS)	
FEF_{75} (L/m)	65.38±17.21	65.44±16.78	36.6±11.05	36.8±8.32
	>0.05 (NS)		>0.05 (NS)	
FEF_{25-75} (L/m)	65.5±19.19	80.19±14.89	36.6±9.39	52.2±8.6
	<0.01 (S)		<0.001 (S)	
LVC (L/m)	81.69±11.12	86.69±8.87	51.6±11.67	56.8±10.49
	<0.01 (S)		<0.001 (S)	
MVV (L/m)	60.41±10.7	82.41±8.7	50.5±10.6	62..72±13.81
	<0.01 (S)		<0.01 (S)	

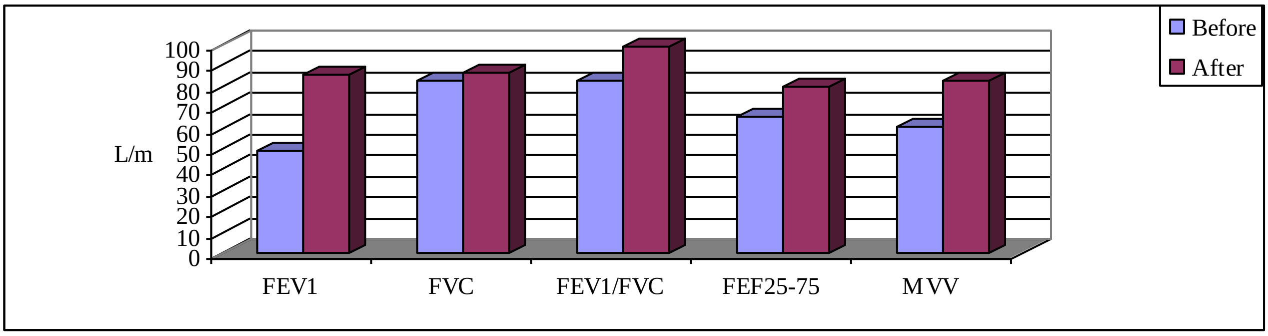

Fig. (3): Statistical comparison of spirometric pulmonary function in BA group before and after DSE.

Comparison of all tested spirometric pulmonary functions in bronchial asthma group before and after the diaphragm strengthening exercise program (DSE) showed a significant difference as p value was <0.01 (Table 4, figure 3).

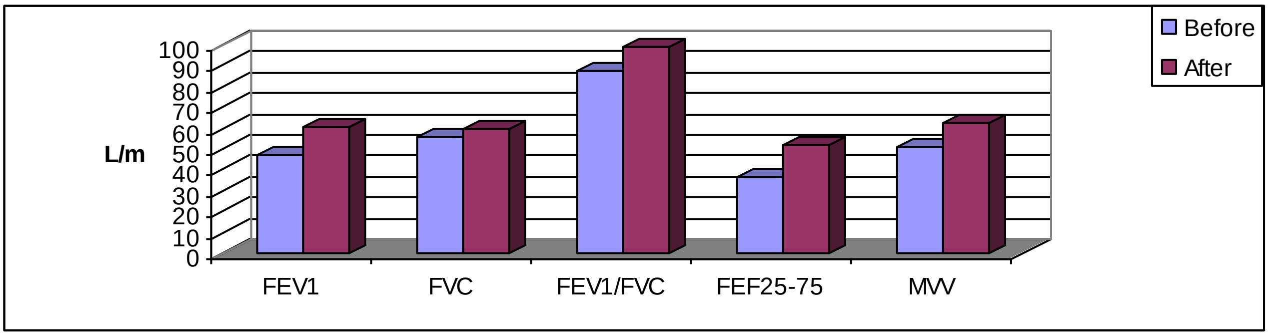

Fig. (4): Statistical comparison of spirometric pulmonary function in CLD group before and after DSE.

Comparison of all tested spirometric pulmonary functions in chronic lung disease group before and after the diaphragm strengthening exercise program (DSE) showed a significant difference as p value was <0.01 (Table 4, figure 4).

Table (5): Percentage of change in diaphragm thickness and motility (excursion) in BA and CLD groups before and after DSE.

Variables	BA			CLD
	Before	After	Before	After
Diaph. Thickness (mm)	9.28±1.88	9.47±1.94	9.32±1.79	10.11±1.76
%	2		8.4	
Diaph. Excursion (mm)	11.06±3.82	11.32±3.55	10.26±3.66	10.68±3.58
%	2.3		4	

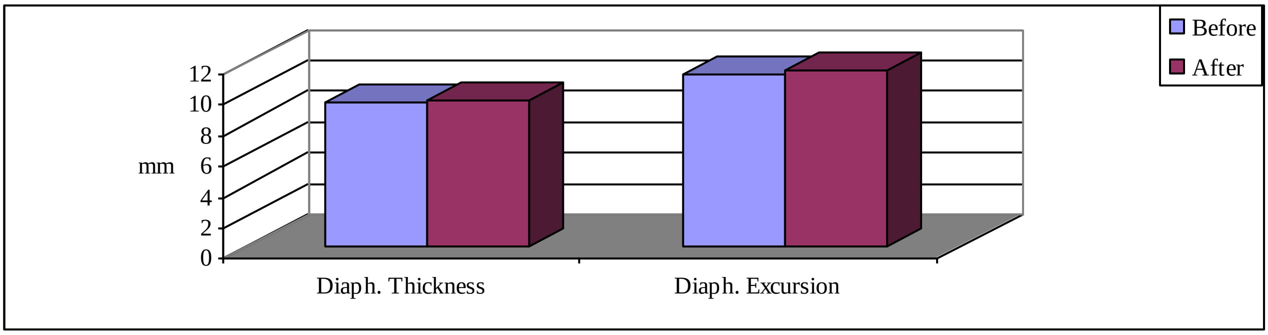

Fig. (5): Statistical comparison as regards ultrasonographic evaluation of diaphragm thickness and excursion in bronchial asthma group before & after DSE.

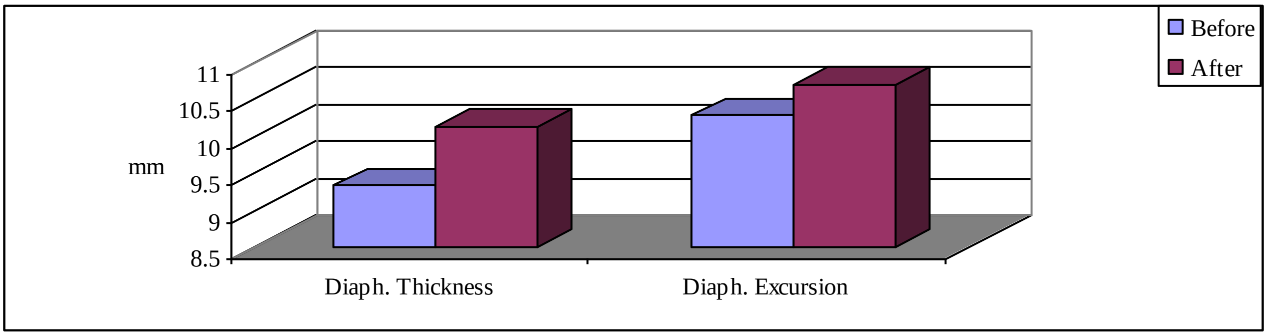

Fig. (6): Statistical comparison as regards ultrasonographic evaluation of diaphragm thickness and excursion in chronic lung disease group before & after DSE.

Comparison of diaphragm thickness and excursion in asthmatic and chronic lung disease groups before and after the diaphragm strengthening exercise program (DSE) showed a significant difference in both parameters as p value was <0.01 (Table 5, figure 5 & 6).

DISCUSSION

An important goal in managing patients with chronic airway or lung disease should be the reduction of symptoms especially breathlessness. As respiratory muscle function is frequently compromised in those patients and it may contribute to the sensation of breathlessness, inspiratory muscle training may be valuable for improving functional status and reducing dyspnea.

This study aimed to assess the diaphragmatic motion and thickness in asthmatic children and those with chronic lung disease (CLD) and to correlate this effect of special exercise training for diaphragm for 12 weeks.

This study showed a statistical significant lower values of spirometric pulmonary functions in asthmatic children compared to control (P<O.05), which was in accordance with many investigators documented these findings as pulmonary function tests are useful way for objective measurement of the degree, location and reversibility of airway obstruction in asthmatics[7].

Amin et al., Awadalla et al. and Emam et al., documented that there were significant lower values of spirometric pulmonary functions in asthmatic children compared to healthy children [2,3,8].

Abdel-Aziz et al. stated that airway obstruction in asthmatics is multifactorial e.g., airway smooth muscle contraction, oedema of the bronchial wall, cellular infiltration, mucus secretions and airway remodeling. All these factors lead to decrease in airway flow and forced exhaled volumes, the decreased FVC in asthma is due to air trapping and increasing in residual volume[1].

This study revealed a statistical significant decreased thickness of the diaphragm in asthmatic patients (9.28±1.88 mm) compared to control group (10.4±1.31 mm) (P<0.05). Which was in accordance with Sanchez et al. (1985) who recorded less thicker diaphragm in patients with obstructive airway disease, and they explained this binding by a significant reduction in the diameter of type I (slow twitch) and type II (fast twitch) fibers.

El-Zorkany et al., studied 30 patients with bronchial asthma and evaluated diaphragmatic excursion and thickness by ultrasonography. They revealed a statistical significant thinner and less mobile diaphragm in asthmatics compared to control[7].

This study also showed less diaphragmatic excursion "motion" in asthmatics compared to control (11.06±3.82 mm in asthmatics Vs 12.05±2.23 mm in control).

Several studies have been reported on the effect of airway obstruction on diaphragmatic movement. However, hyperinflation was proved by many workers to be the main underlying aetiology. Hyperinflation forces the diaphragm to operate in an inefficient way for its force-length relationship. Which will decrease the ability of the diaphragm to generate negative pressure during inspiration. Also hyperinflation causes flattening of the diaphragm which in turn places it in a serious mechanical disadvantage being curved upward[11].

Also hyperinflation associated with obstructive airway disease leads to loss of axial direction of diaphragmatic fibers and become directed medially or inwards. Also as the contractile force increase in order to develop the inspiratory pressure necessary to inflate hyperinflated lungs, the diaphragm blood supply may be altered[11].

Several reports about effect of medications used in bronchial asthma in affecting diaphragmatic performance have been mentioned.

Salome et al., documented that although inhaled steroids decreased airway inflammation, it enhances the perception of inspiratory muscle effort during histamine-induced brochoconstriction[18].

Reid et al., stated that patients with chronic lung disease have increased plasma levels of tumor necrosis factor- α, which decreases diaphragmatic strength through several mechanisms decrease in muscle anabolism, increase in muscle catabolism and inhibition of contractility[17].

This work showed that, diaphragm was affected in children with various causes of chronic lung diseases. Diaphragmatic thickness and motility were significantly lower in patients with CLD compared to control (thickness was 9.32±1.79 mm in CLD Vs 10.4±1.31 mm in controls) and (excursion "motility" was 10.26±3.66 mm Vs 12.05±2.32 mm in controls).

Heunks and Dekhuijen stated that dysfunction of respiratory muscles especially diaphragm is common in patients with CLD as a part of generalized process involving all respiratory and peripheral skeletal muscles. Causative factors for diaphragm dysfunction in patients with CLD include; disturbance in electrolytes, hypercarpia and prolonged use of oral steroids[10].

Unal et al., studied diaphragmatic movement with MR fluoroscopy in 23 patients with chronic lung disease and 15 control group, and compared their results with pulmonary functions. They stated that there was a significant statistical difference in diaphragmatic movement (excursion) between the two groups and that FEV1 is best correlated pulmonary function to diaphragmatic excursion[19].

Mac Gowan et al., added that altered geometry of thorax in severe emphysema associated with CLD, compromises the ventilatory pump function of the diaphragm. Also malnutrition which frequently occurs in moderate to severe CLD could also play a role in diaphragmatic dysfunction[12].

Barbarito et al., stated that diaphragm undergoes structural and functional changes during the coarse of CLD. Diaphragm has to cope with an increased load, an intrinsic weakness and a mechanical disadvantage especially in the diaphragmatic length-force relationship[4].

Orozco-Levi et al., concluded that sarcomere disruption of respiratory muscles and diaphragm is common in patients with chronic lung disease and is more higher after inspiratory load[15].

Chronic lung disease could alter mass, thickness, area and length of diaphragm muscle in several ways, for example the diaphragm may become hypertrophied in response to the increased work of breathing. Alternatively, diaphragm in those patients may be atrophic due to under weight[11].

Heunks and Dekhuijzen stated that the chronically increased load imposed on the diaphragm in severe CLD may enhance generation of free radicals which in turn may further impair contractility of the diaphragm. Also they stated that produced oxygen free radicals in both asthma and CLD can affect excitation-contraction coupling of respiratory muscles. Also it affects mitochondrial respiration and insulin-independent glucose uptake in muscle fibers[10].

This work showed a positive correlation between PEFR and diaphragmatic motility ($r = 0.62$) ($P < 0.01$).

This was in accordance with MacGowan et al., who reported a positive correlation between pulmonary functions and changes in diaphragm in asthmatic patients. As severity of airflow obstruction increases, the proportion of abnormal diaphragmatic functions increases[10].

This study explored the effect of 12 weeks of special training of the diaphragm "diaphragm strengthening exercise" in asthmatic children and those with CLD. A significant statistical lower asthma scoring was noticed after training ($P< 0.01$). Also there was regression in the severity of asthma after training (37.5% of cases were moderate persistent asthma, regress to mild asthma and became only 18.7%).

McConnel et al., examined the changes induced by 3 weeks of inspiratory muscle training (IMT) in mild/moderate asthmatics. They found reduction in exertional dyspnea and improvement of lung functions within 3 weeks of IMT[14].

Weiner et al., studied the effect of specific inspiratory muscle training (JMT) in patients with asthma. They found that IMT resulted in a significant improvement in respiratory muscle performance, this was associated with a decrease in the sensation of breathlessness and a decrease in $ß_2$-agonist consumption. They explained that by the increased inspiratory muscle strength in trained patients[20].

This study revealed a statistical significant higher values of FEV1, FEV1/FVC, PEF, VC and MVV in asthmatic patients and in patients with CLD after training of the diaphragm.

This was in agreement with McConnel et al., (1998) as they found improvement of lung functions in mild and moderate asthmatics within 3 weeks of inspiratory muscle training.

Emam et al., studied the effect of respiratory exercise (in the form of massage, biofeedback and relaxation therapies) on 45 asthmatic children, they observed a significant improvement in pulmonary function parameters after massage, biofeedback, and relaxation therapies[8].

This study revealed an increase in both diaphragmatic thickness and excursion in asthmatics after training of the diaphragm (the percentage of increase was 2% for thickness and 2.3% for excursion). Also an increase in both diaphragmatic thickness and excursion in patients with CLD after training (the percentage of increase was 8.4% for thickness and 4% for excursion).

Ramirez-Sarmiento et al., evaluated the effect of a specific training for all inspiratory muscles on the structure of inspiratory muscles in patients with chronic obstructive pulmonary disease. They observed an increase in both the strength and endurance of diaphragm after training. This improvement was associated with increase in proportion of type I fiber and decrease in type II fibers. In addition both fiber types exhibited an increase in cross-sectional area. They concluded that diaphragm training induces a specific functional improvement of the inspiratory muscles and adaptive changes in the structure[16].

REFERENCES

1. Abdel-Aziz, M., El-Seify, M.Y., Fouda, F.M., AbdAl-Rahman, L.A. and Radwan, M.A.: Airway remodeling in asthmatic children assessed by high resolution computerized tomography. M.Sc. Thesis, Pediatrics, Faculty of Medicine, Ain Shams University, 2002.
2. Amin, D.A., Abd El Khalek, K.A. and Shalzin, M.A.: Pulmonary function testing for assessment of different treatment modalities in asthmatic children. M.Sc. Thesis in Pediatrics, Ain Shams University, 2003.
3. Awadallah, M.A., Farid, M., Khazbak, M.A. and Abu-Elhana, S.: The ratio of serum metaboproteinase-9 to tissue inhibitors of metalloproteinase-1 in relation to interleukin-8 and bronchial asthma severity in pediatrics. M.D. Thesis in Pediatrics, Ain Shams University, 2003.
4. Barbarito, N., Ceriana, P. and Nava, S.: Respiratory muscles in chronic obstructive pulmonary disease and asthma Minerva. Anestesiol., 67(9) : 653-658, 2001.
5. Decramer, M.: The respiratory muscles in fishman AP (ed.): Pulmonary diseases and disorders, international edition, chapter 3, 63-71, 1998.
6. Edwards, R.H. and Faulkner, J.: Structure and function of the respiratory muscles, in roussos (ed.); The thorax, part A, physiology. New York, Marcel Dakker, pp. 185-217, 1995.
7. El-Zorkany, M.M., Hassanien, K.H., El-Garem, N.M. and Sabry, E.Y.: Ultrasonic evaluation of diaphragmatic muscle performance before and after treatment of bronchial asthma by variable regimens. M.Sc. Thesis in Chest diseases, Cairo University, 1999.
8. Emam, E.L., Deraz, T.E., Saad, A.M. and Abd El-Hady, H.S.: Massage therapy, relaxation therapy and biofeedback in management of childhood asthma. M.Sc. Thesis in Pediatrics, Ain Shams University, 2003.
9. GINA: Global initiative for asthma based on the work shop report Global strategy for asthma management and prevention. National Heart, Lung, and Blood Institute. NIH Publication, No. 02-3658, 2002.
10. Heunks, L.M. and Dekhuijzen, R.P.: Respiratory muscle function and free radicals from cell to COPD, Thorax., 55: 704-716, 2000.
11. Laghi, F. and Tobin, M.J.: Disorders of the respiratory muscles. Am. J. Respir. Cri. Care. Med., 1.68:10-48, 2003.
12. Mac Gowan, N.A., Evans, K.G., Road, J.D. and Ried, W.D.: Diaphragm injury in individuals with airflow obstruction. Am. J. Respir. Crit. Care. Med., 163(7): 1654-1569, 2001.
13. Mador, M.J., Kufel, T.J. and Pineda, L.A.: Diaphragmatic fatigue and high intensity exercise in patients with chronic obstructive pulmonary disease. Am. J. Respir. Crit. Care Med., 161: 118-123, 2000.
14. McConnell, A.K., Caine, M.P., Donovan, K.J., Toogood, A.K. and Miler, M.R.: Inspirator muscle training improves lung function and reduces exert ional dyspnea in mild/moderate asthmatics. Clinical Scienco., 95: 98, 1998.
15. Orazco-Levi, M., Loreta, J., Minguella, J., Serrano, S., Broquetas, J.M. and Gea, J.: Injury of the human diaphragm associated with exertion and chronic obstructive pulmonary disease. Am. J. Respir. Crit. Care. Med., 164(9): 1734-1739, 2001.
16. Ramirez-Sarmiento, A., Orozco-Levi, M., Guell, R., Barreiro, F., Hernandez, N., Motas, S.M., Broquetas, J.M., Casan, P. and Gea, J.:

Inspiratory muscle training in patients with chronic obstructive pulmonary disease. Am. J. Respir. Crit. Care. Med., 166: 1491-1497, 2002.

17. Reid, M.B., Lannergren, J. and Westerblad, H.: Respiratory and limb muscle weakness induced by tumor necrosis factor- α: involvement of muscle myofilaments. Am. J. Resp. Crit. Care Med., 166: 479-484, 2002.
18. Salome, G.M., Reddel, H.K., Ware, S.I., Robert, A.M.: Effect of budesonid on the perception of induced airway narrowing in subjects with asthma Am. J. Respir. Crit. Care. Med., 165: 15-21, 2002.
19. Unal, O., Arslan, H., Uzun, K., Ozbay, B. and Sakarya, M.E.: Evaluation of diaphragmatic movement with MR fluoroscopy in chronic obstructive pulmonary disease. Clin. imaging; 24(6): 347-350, 2000.
20. Weiner, P., Azgad, Y. and Ganarn, R.: Inspiratory muscle training in patients with bronchial asthma, 1357-1361, 1992.
21. Weiner, P., Berar-Yanay, N., Davidorich, A., Magadle, R. and Weiner, M.: Specific inspiratory muscle training in patients with mild asthma, high consumption of ß2 agonists Chest., 117: 722-727, 2000.

الملخص العربي

تأثير تمرينات التقوية للحجاب الحاجز على وظائف الرئة وحركة الحجاب الحاجز فى الأطفال المصابين بأمراض الرئة المزمنة

تشكل عضلات التنفس نظام ضخى متطور وتحتاج عملية التنفس تحت كل الظروف الى التنسيق مابين عضلات التنفس والحجاب الحاجز الذى يعتبر من أهم هذه العضلات خاصة فى عمليه الشهيق . ويتعرض الحجاب الحاجز لتغيرات عند اصابة الرئة او الشعب الهوائية مما قد يزيد من تأثير هذه الأمراض على وظائف الجهاز التنفسى ومايصاحبها من أعراض ويمكن تقييم وظائف الحجاب الحاجز من خلال قياس سمكه وحركته بأستخدام الموجات فوق الصوتيه . ويعتبر تطبيق برنامج علاج طبيعى خاص على عضلة الحجاب الحاجز من الطرق التى تؤدى الى تحسن فى لياقة المريض وتقلل من تكرار الأزمات الربوية ومن زيارة المريض الى أقسام الطوارئ وتحسن فى قياسات وظائف الرئة . كان الهدف من هذه الدراسة هو تقييم سماكة وحركة الحجاب الحاجز فى الأطفال المصابين بالربو الشعبى والأطفال المصابين بأمراض الرئة المزمنة وكذلك دراسه تأثير برنامج علاج طبيعى خاص على عضلة الحجاب الحاجز . اشتملت هذة الدراسة على 52 طفلا من المترددين على عيادة الصدر بمستشفى الأطفال بجامعة عين شمس وتم تقسيمهم الى مجموعتين : المجموعة الأولى أحتوت على عدد 32 طفلا مصابين بالربو الشعبى بأعمار تتراوح بين 6-13 عاما والمجموعة الثانية أحتوت على 20 طفلا مصابين بأمراض الرئة المزمنة بأعمار تتراوح بين 6-11 عاما. وتم أختيار مجموعة ثالثة من الأطفال الأصحاء (12 طفل) وتتراوح أعمارهم بين 5-10 أعوام (المجموعة الضابطة). وقد خضع جميع من شملتهم الدراسة لأستقصاء كامل للتاريخ المرضى والى الفحص الأكلينيكى الدقيق وذلك لتقسيمهم اكلينيكيا حسب شدة الحالة (طفيف – متوسط- شديد) بالأضافة الى اشعة عادية على الصدر وقياس وظائف التنفس وكذلك قياس سمك وحركة الحجاب الحاجز بأستخدام الموجات فوق الصوتية . وقد خضع جميع المرضى لبرنامج علاج طبيعى خاص لعضلة الحجاب الحاجز أسبوعيا لمدة ثلاثة أشهر ثم تم أعادة تقييمهم أكلينيكيا وبأعادة قياس وظائف التنفس وحركة الاحجاب الحاجز . وأظهرت النتائج وجود دلالة احصائية على انخفاض وظائف التنفس فى الأطفال المصابين بالربو الشعبى والأطفال المصابين بأمراض الرئة المزمنة مقارنة بالأطفال الأصحاء كما وجد أن سماكة وحركة الحجاب الحاجز أقل الأطفال المصابين بالربو الشعبى والأطفال المصابين بأمراض الرئة المزمنة مقارنة بالأطفال الأصحاء ولم يستدل على وجود فارق بين الأطفال المصابين بالربو الشعبى والأطفال المصابين بأمراض الرئة المزمنة . أيضا اظهرت النتائج وجود دلالة احصائية على انخفاض فى عدد مرات حدوث الأزمات الربوية وكذلك تحسن فى شدة هذة الازمات بعد تطبيق برنامج العلاج الطبيعى ووجود تحسن فى وظائف الرئة مع وجود تحسن فى سمك وحركة الحجاب الحاجز بعد برنامج العلاج الطبيعى بنسب متفاوتة . وخلصت هذه الدراسة الى أهمية عمل برنامج خاص بزيادة كفاءة عضلات التنفس ومنها الحجاب الحاجز لما لهذا من تأثير فى تحسن أعراض الأزمات الربوية وامراض الرئة المزمنة فى الأطفال وكذلك تحسن فى وظائف تنفسهم كنتيجة لتحسن وظائف الحجاب الحاجز وعضلات التنفس الأخرى .