Biofeedback Breathing Retraining Combined with Aerobic Exercises in Management of Ventilatory Function of Asthmatic Obese children

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ABSTRACT

The aim of this study was to investigate the combined effects of weight control through diet and aerobic exercise training and breathing retraining via using modified incentive spirometer biofeedback system on ventilatory function in asthmatic obese children. Thirty asthmatic obese children (14 boys and 16 girls) participated in the study, their age ranged from six to ten years. They were divided randomly into two groups of equal number (A and B). The two groups received aerobic training on a bicycle ergometer three times weekly for two successive months with measurement of ventilatory function before starting and finally at the end of the treatment program. In addition, group A received breathing retraining with the modified incentive spirometer biofeedback system. The results showed that the forced expiratory volume at one second, the forced vital capacity, the peak expiratory flow and the forced mid expiratory flow were improved in the two groups but the percentage of improvement of all the variables were significantly higher in group A. There was also reduction in body mass index of the children in the two groups.
Key words: *Asthma, Obesity, Children, Breathing Retraining.*

INTRODUCTION

Asthma is a growing problem, it is the most common chronic chest illness of childhood, characterized by airway inflammation and manifested by reversible airway obstruction, and evidence of bronchial hyperactivity[1,2]. Asthmatic attacks associated with many symptoms as wheezing, cough particularly at night or in the early morning, chest tightness, and breathlessness[15].

Increasing body mass index BMI among children is a risk factor for asthma, which may in reality, be obesity-related chest symptoms that mimic asthma[4,6]. Obesity in children and adolescents has reached alarming levels. Twenty to twenty five percent of children and adolescents are overweight or obese, and 4.9% of boys and 5.4% of girls are obese[21,11]. Higher body mass index (BMI) is associated with a higher prevalence of symptoms of wheeze and cough that are attributed to asthma in children, also it was found that inhaler use was more common in obese children than in non-obese children[8,28].

Physical inactivity may independently promote obesity and asthma, and a large number of dietary factors may be implicated. Patients with chronic respiratory diseases tend to show less tolerance to exercise due to pulmonary limitation, self-restriction of activities, or lack of physical activity secondary to medical advice or family influence[3]. Thus, children with bronchial asthma, primarily those with a clinically more severe disease, tend to have a sedentary lifestyle and therefore be inclined to have lower aerobic fitness than their healthy non-asthmatic peers[9,14].

Consequently the economic burden is huge, therefore the development and evaluations of non-pharmacological interventions to prevent asthma, reduce its severity or improve its prognosis are essential[20,19].

The modern management of asthma includes a wide variety of drugs and delivery devices, allergy avoidance measures, patient education, and exercise conditioning. So this allows asthmatics to lead normal life, participate competitively in sport with the achievement of the best quality of life and maximize self-management capabilities[9,3].

Physical therapy is an important part of the treatment of asthma[17]. Physiotherapeutic interventions in asthma management include breathing control and re-education, relaxed breathing postures, education about the disease and instructions about the correct use of inhalers and nebulisers relieve their symptoms[13]. The modified incentive spirometer biofeedback had advantages of reusability, less cost and equal emphasis of both inspiration and expiration as it provides the child and his parents easy feedback about expiratory flow rate and relaxation[26].

The aim of this study was to investigate and compare the effects of breathing retraining by the use of the modified incentive spirometry biofeedback system and aerobic exercise program on ventilatory function and body weight in obese asthmatic children.

SUBJECTS, MATERIALS AND METHODS

Methods

- **Subjects:**

Thirty asthmatic children (16 girls and 14 boys) with age ranging from 6 to 10 years chosen from the Pediatric Department of Abbasia Chest Diseases Hospital. They were diagnosed as having moderate persistent asthma according to the GINA guidelines (2004)[15]. They were divided randomly into two groups of equal number (A and B). The obesity was determined according to their BMI- for- age percentiles, when BMI was greater than the 95th percentile suggests obesity[4]. The mean BMI for group A was 32.81± 5 $Kg \,/\, m^2$ with a mean height of 117.5±6.6 cm. and a mean weight of 45.3±9.1Kg. The mean BMI for group B was 32.62 ± 4 $Kg \,/\, m^2$ with a mean height of 116.4±5.7 cm. and a mean weight of 44.2 ± 6.7Kg. Although they were physically active, none was following a regular exercise training program. Medical follow up was performed by the same staff physician. All patients were on an inhaled corticosteroid (beclomethasone 500–1500 µg/day). The children were in a stable phase of the disease, with no exacerbation during the 15 days before the start of the tests. A written informed consent was obtained from the patients and their parents to allow their children to participate in the study and they received a thorough explanation about the significance of the study, the procedures and the duration of the study. The child who had one or more of any chronic diseases was excluded as; congenital heart diseases, neurological disorders, mental disorders, diabetes mellitus, pleural diseases, recent thoracic or vertebral fractures and kyphosis or scoliosis.

- **Study protocol**

A clinical and medication history were obtained from all subjects, followed by physical examination, spirometric tests and a progressive incremental cardiopulmonary exercise test on a cycle ergometer. This protocol was conducted in both groups at two occasions:
1) Initially before receiving any treatment as a data base of values.
2) Finally after 2 months (after 24 sessions).

- **Instrumentations:**

Electronic Spirometry: Datospir 120-Sibelmed, made in Barcelona. It was used for ventilatory functions measurement.
Weight and Height scale: Health made in China. It was used for measuring the weight and the height of each child in order to determine the predicted values of ventilatory function and to select the obese children.
The modified incentive spirometry biofeedback system: is a wooden frame with a fine paper hanged from one side[26].
Bicycle ergometer: (Monark 818 E, made in Swedish), modified with child pedal cranks which used for training of children in both groups.

- **Evaluation:**

1) BMI by measuring of body weight, height and calculating BMI to determine the percentile according to age and sex.
2) Ventilatory function measurement by Spirometry: include forced vital capacity (FVC), forced expiratory volume in first second ($FEV_{1,}$), forced expiratory flow 25-75% (FEF25-75%) and peak expiratory flow (PEFR%).
*The ventilatory function was measured from standing position, the child wearing the nose clips and firmly closing his mouth around the mouthpiece.
*The above procedures were repeated 3-5 times with 2-3 minutes rest in between and the maximum value will be recorded for evaluation.
3) Evaluation of maximum work load for bicycle: The child pedaled at a work rate of 20-30 w. for 3 minutes as a warm up period. The work load was increased 20 w / every minute until the child was unable to continue due to either: leg fatigue, or shortness of breath. The maximum work rate was calculated according to the conversion table bicycle.

- **Training program:**

Each child in the two groups received three sessions per week for 2 months. They under went specific diet regime. For group (A) each session lasted 45 minutes, each session consisted of breathing retraining via using of modified incentive spirometer biofeedback system and aerobic exercise on the bicycle ergometer. While for group B, each session consisted of aerobic exercise on the bicycle ergo meter only. Each session continued for 45 minutes.

Pedaling training on the Bicycle ergometer for both groups

Each child was allowed to sit up-right on the bicycle after adjusting the seat height according to each one. They were asked to pedal for 3-5 minutes as warming up period at a work rate of 20-30 ramp ⁄ minute. Then the work rate increased to 60% of his maximum work rate, then reduced to 40% and increased again as an interval work load. This alteration was carried out every 5 minutes for a total exercise period of 30 minutes[24].

Diet control (low calorie diet) followed by both groups

Children in both groups received 1500 calories per day. Fifty percent of these calories were in the form of carbohydrates. The diet regimen used was being compatible with the type of food consumed by the Egyptian society and being within the financial reach of patients of Abbasia Chest Diseases Hospital.

Breathing training procedures using the modified incentive spirometry biofeedback system for group (A)

The child assumed a comfortable sitting position with shoulders relaxed, arms and back well supported. Therapist positioned the apparatus at 10 cm distance from the mouth of the child, with the upper edge of the apparatus at the level of the nose of the child and therapist's hand at the abdomen of the child to guide the movement and to ensure that expiration was a relaxed process without contraction of the abdominal muscles. Then the child was instructed to take a deep and slow inspiration through the nose followed by holding the breath for 5 seconds, then blow out slowly and evenly with O-shaped mouth to keep the paper attached to the horizontal bar as long as possible. Each session the child performed 30 repetitions of the breathing technique divided into several sets, each set contains 3-5 repetitions with rest about 1-2 minutes in between sets[26].

RESULTS

The collected raw data for both groups were statistically analyzed to show the mean and standard deviation of BMI and ventilatory functions (FVC%, FEV_1%, PEF% and $FEF_{25-75\%}$) before and after two months of treatment. The student t-test was then calculated to test the significance of change in each group.

Ventilatory function analysis of group A

Statistical analysis and comparison of the ventilatory function measurements before and after two months of treatment revealed highly significant statistical improvement in the BMI and all measured ventilatory functions (P <0.001), table (1) and fig. (1).

Table (1): Comparison between pre and post treatment mean values of ventilatory functions and BMI in group A.

Variable	Pre treatment	Post treatment (after 2 months)	Level of sig.
	χ ± SD	χ ± SD	P-Value
FVC%	71.3±10.4	86.3±11.9	<0.001
FEV_1%	70.3±16.6	84.5±14.5	<0.001
PEF%	61.86±11.9	79.84±10.9	<0.001
$FEF_{25-75\%}$	64.93±11.1	80.2±11.7	<0.001
BMI	33.25±4.4	24.61±5	< 0.001

SD= standard deviation. χ =mean. FVC/L=forced vital capacity per liter
FEV_1/L=forced expiratory volume at one second per liter P <0.001 = highly significant.
PEF/L=peak expiratory flow per liter $FEF_{25-75\%}$=forced mid expiratory flow
BMI =body mass index.

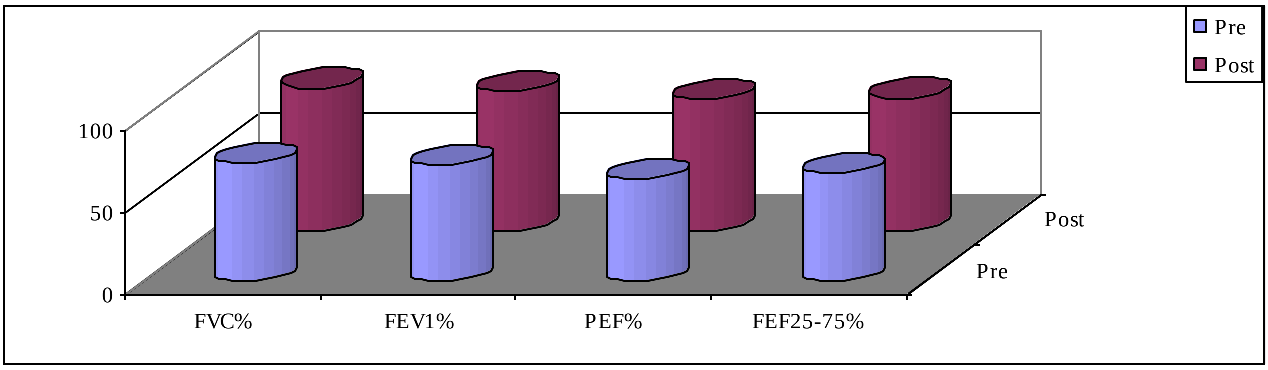

Fig. (1): Mean values of ventilatory function in group A at pre and post treatment.

Ventilatory function analysis of group B:

Analysis of the ventilatory function measurements, before and after two months of treatment revealed highly statistical significant improvement in BMI and all measured ventilatory functions (FVC, FEV_1, PEF, and $FEF_{25-76\%}$) (P<0.001), table (2) and fig. (2).

Table (2): Comparison between pre and post treatment mean values of ventilatory functions and BMI in group B.

Variable	Pre treatment	Post (after 2months)	
	$\chi \pm$ SD	$\chi \pm$ SD	P-Value
FVC%	75.55±12.44	89.5±11.9	<0.001
FEV_1%	74.3±10.6	85.6±10.3	<0.001
PEF%	67.12±14.6	80.5±11.2	<0.001
$FEF_{25-75\%}$	58.81± 5	76.8 ±4.8	<0.001
BMI	32.81±5	26.19±3.5	<0.001

Pre = pre treatment
Post- treatment= after the treatment (after 2 months of treatment)
SD= standard deviation.
χ =mean.
FVC/L=forced vital capacity per liter
FEV_1/L=forced expiratory volume at one second per liter
P <0.001= highly significant.
PEF/L=peak expiratory flow per liter
$FEF_{25-75\%}$=forced mid expiratory flow
BMI (KG/m^2) = body mass index

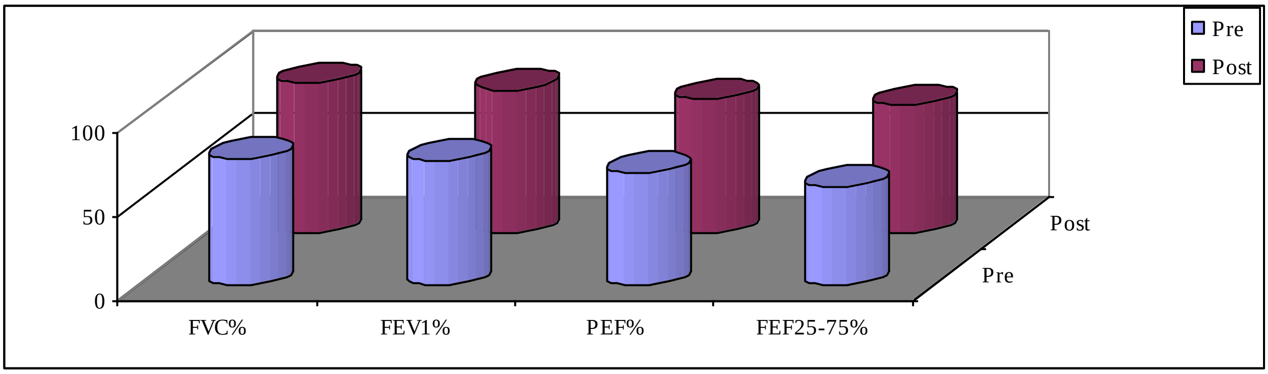

Fig. (2): Mean values of ventilatory function in group B at pre and post treatment.

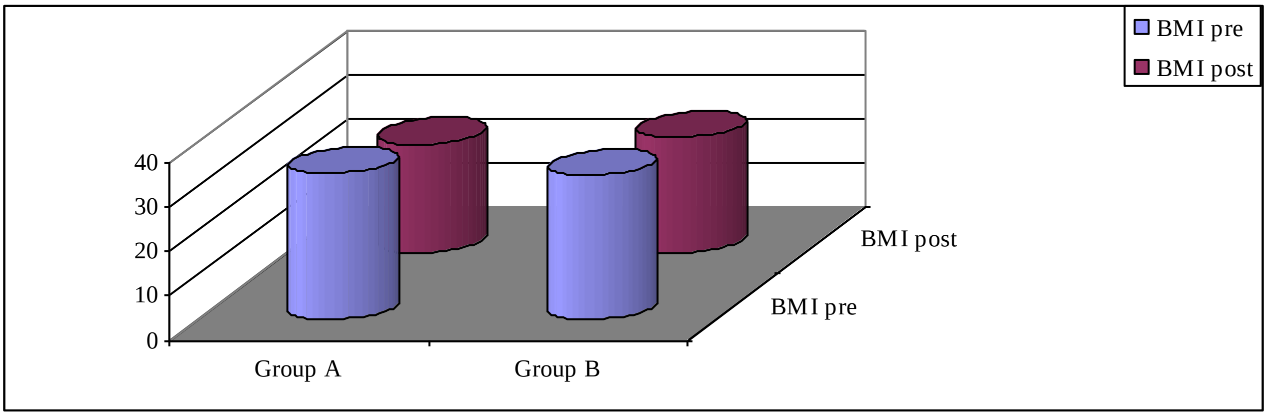

Fig. (3): Mean values of BMI changes in both groups at pre & post treatment.

Comparing the mean values of BMI in the two groups (A and B) as shown in tables (1and 2) and fig (3), denotes highly significant reduction both groups after the training program.

Table (3): Comparison of the percentage of improvement of ventilatory functions and BMI between groups A and B, post-treatment.

Variable	% of improvement in group (A)	% of improvement in group (B)	Sig.
BMI	- 25.98	- 20.18	<0.05
FVC%	21.04	18.46	>0.05
FEV1%	20.2	15.2	<0.05
PEF%	29.07	19.9	<0.05
$FEF_{25-75\%}$	23.5	15.11	<0.05

As shown in tables 1 and 3, the mean values of the percentage of improvement in ventilatory functions and BMI among the measuring values (before and after two months of treatment) in groups A and B, demonstrated none statistical significant difference before treatment (P>0.05).While analysis of the percentage of improvement between the two groups after training revealed high significant improvement regarding BMI, EFV1, PEF and $FEF_{25-75\%}$, in favor of group A (P<0.05). Although there was non-statistical significant difference regarding FVC (P > 0.05).

DISCUSSION

The results of the present study proved that aerobic exercise training combined with breathing retraining with the use of modified incentive spirometer feedback system in obese children with bronchial asthma have the most favorable effects on ventilatory function (forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), peak expiratory flow (PEF) and forced mid expiratory flow ($FEF_{25-75\%}$) than aerobic training alone.

Breathing retraining techniques have been used for managing ventilatory problems of asthmatic patients for many years. However, there has been increasing interest in the use of breathing retraining with breath hold techniques to control the ventilatory problems of asthmatic children.

The ventilatory function of both groups was improved which could be related to the effect of aerobic training on bicycle as both groups received that form of training.

Improvement of FEV_1 may be due to improvement in the strength of the diaphragm as a result of the training program. In addition, the mechanism of marked increase in FEV_1in group (A) may be related to the greater motivation of the patients due to the feedback they received from the apparatus and also due to increased alveolar ventilation during the breath holding time that included in the technique of training. Also, reduction in upper airway narrowing as a result of O-shaped mouth expiration which increase the intra-tracheal pressure and maintain opening of large airways[26].

While the improvement of FVC following the breathing retraining can be explained by the improvement in the strength of respiratory muscles, in particularly diaphragm and abdominal muscles, as a result of training, which leads to increase in the tidal volume and more efficient expiratory maneuvers.

The result of the current study was previously proved by[16] Girodo et al. (1992) who postulated that the training of respiratory muscles through application of respiratory exercises is associated with an increase in FVC.

Also, previously it was found that the frequency of breathing and breath-holding time correlate with severity of airflow obstruction in acute asthma attacks and breath-holding time correlates inversely with the magnitude of dyspnea when it is present at rest[23,12].

One of the recent studies that support the results of the current study was applied by[27] Weiner et al. (2000) who found that inspiratory muscle training in asthmatic patients increased the inspiratory muscle strength and therefore increase the expiratory flow. As asthmatic patients are exposed to airway obstruction and hyperinflation, which by itself adversely affects the inspiratory muscles by forcing them to operate in an inefficient part of the force-length relationship.

The greater improvement of ventilatory volumes following the training program of breathing exercises could be explained by increasing the tidal volume as a result of the training, reduction in the resistance to airflow, the resistance to airflow varies with lung volume and it is less at higher lung volume, and increased of the excursion of diaphragm in expiration[23].

The results also proved the association between increased BMI and the presence of bronchial asthma. This comes in agreement with Figueroa et al. (2001)[14] who reported that higher BMI but lower sum of skin fold is associated with asthma in children. Also they attributed that to the sedentary life due to asthma and overweight which cause more increase in body fat. Also sedentary life may contribute to airway narrowing and asthma by reducing the extent to which bronchial muscle is stretched. Recently, metabolic mechanisms have been discussed. Obesity and metabolic syndrome are related to insulin resistance, which, in turn is also related to impaired lung function among males In addition, it has been suggested that obesity acts through non-allergic mechanisms or gastroesophageal reflux in asthma development[8].

It is clear from the statistical analysis of the results between the pre, and post treatment values in both groups, that there is significant improvement of all variables after two months. On comparing the results of each group regarding the percentage of improvement of each variable separately, it can be noticed that the difference in the percentage of improvement between the two groups was more in favor of group (A).

This greater improvement of ventilatory function in asthmatic obese children which associated with reduction in BMI could be related to the effects of diet control and aerobic training program in addition to breathing retraining they received throughout the study as participation in physical activity is an important part of a child's normal psychosocial development and self-image. Physical activity is especially important in children with asthma; activities such as running and bicycling are associated with improved fitness and decreased severity of asthma symptoms[24,10].

This comes in agreement with Neder et al.[22] who stated that supervised aerobic training program in children with stable asthma, improved the cardio respiratory fitness. The degree of response to training was strongly influenced by the level of fitness in the initial evaluation; beneficial effects were shown only in the less fit patient. Also, exercise training for the most untrained children can have a role, at least in the short term, in reducing the daily use of both inhaled and oral steroid, independent of the severity of the disease.

The results obtained in this study support the findings of Cheng et al. (2003)[7] who studied the role of physical activity in healthy people and revealed that people with higher levels of physical activity tend to have higher levels of cardio respiratory fitness; also it has been found that people with higher physical activity levels had higher levels of FEV_1 and FVC. Supervised aerobic training program for 2 months, 3 sessions weekly for a minimum 30 minutes per session in children with moderate to severe, but stable asthma, improved the cardio respiratory fitness[22,25].

There is evidence of bronchodilatation seen after the interval work load training which can be explained as the circulating catecholamine concentration increases during exercise in normal as well as asthmatic subjects causing bronchodilatation. The increase in catecholamine during exercise is dependent on the work load and is modest at submaximal work load. Several authors noted similar sympatho-adrenal response to repetitive bouts of exercise in normal and asthmatics[5]. Johnson et al., 1995[18] related changes in interval work load protocol to balance between bronchodilators influence and bronchoconstrictors influence with dominant effect of bronchodilators.

Finally, these surprising results of high percentage of improvement of the asthmatic obese children after respiratory training and aerobic training program still in need for more investigations in future studies, in order to give a clear and deep explanation of this observation.

In conclusion, there is clear evidence that fatness is associated with asthma in children. Aerobic training program combined with breathing retraining can be an effective non pharmacological modality in dealing with the ventilatory problems of either asthmatic obese children or normal weight asthmatic children with the most beneficial effects on the asthmatic children with obesity.

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الملخص العربي

التغذيه العكسيه لتدريبات التنفس بالأضافه الى التمرينات الهوائية في علاج الوظائف التنفسية لدى الأطفال البدناء المصابين بالربو الشعبي

يهدف البحث الى دراسة تأثير النظام الغذائي للتحكم فى الوزن مع التمرينات الهوائية بأستخدام نظام الرد الفعلي العكسي لجهاز الحافز التنفسي على وظائف التهوية لدى الأطفال البدناء المصابين بالربو الشعبي. و أجريت الدراسه على ثلاثون طفل بدين مصاب بالربو الشعبي (16 بنت و 14 ولد) تراوحت اعمارهم بين 6 ال 10 سنوات و تم تقسيمهم عشوائيا ال مجموعتين متساويين فى العدد (أ ، ب) . و قد خضعت المجموعتين الى برنامج للتدريبات الهوائيه بواسطة العجلة الثابته ثلاث مرات اسبوعيا لمدة شهرين متتاليين بالأضافة الى نظام غذائي خاص مع العلاج الدوائي . اما المجموعه (ب) فقد خضعت ايضا الى تدريبات تنفسيه بأستخدام جهاز الحافز التنفسي المعدل . كما تم قياس وظائف التنفس و معدل كتلة الوزن قبل بدء البرنامج وبعد الأنتهاء منه . وقد أظهر التحليل الأحصائي للنتائج تحسن ملحوظ فى وظائف التهويه التنفسيه المختارة لكلا المجموعتين و لكن عند مقارنة نسبة التحسن فى كل القياسات وجد ان نسبة التحسن فى المجموعة (أ) تفوق نظيرتها فى المجموعة (ب) . كما ظهر نقص ذو دلاله احصائيه فى معدل كتلة الوزن فى المجموعتين .