Egypt J Pediatr Allergy Immunol 2012;10(1):33-37.

Original article

Ventilatory functions response to breathing training versus aerobic training in asthmatic children

Background: *There is worldwide public interest in physical therapies for asthma.*

Objective: *To compare the effects of a program of breathing training and aerobic training on ventilatory functions in children with bronchial asthma.*

Methods: *Forty asthmatic children from both genders (22 boys and 18 girls) were recruited to participate with age range 6-13 years. The children were divided into two groups of equal number, group A received a program of breathing training and group B received a program of aerobic training on cycle ergometer three times per week for three months. Ventilatory functions were measured before beginning and after finishing the training.*

Results: *The results showed high statistical significant differences in the FVC, FEV_1, PEF, $FEF_{25-75\%}$ and MVV within each group while on comparing the two groups, the ventilatory functions were comparable.*

Conclusion: *Breathing training and aerobic training can be used as a safe complement to medical treatment in asthma.*

Keywords: Asthmatic children; ventilatory functions, breathing training; aerobic training.

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INTRODUCTION

Pharmacologic therapy remains the primary mode of treatment for patients with asthma and despite recent advances in pharmacological intervention, there is worldwide public interest in physical therapies for asthma[1,2].

Breathing techniques are among the most popular physical therapy modalities used by people with asthma[3]. Breathing training is an important component in physical therapy programs designed for patients with asthma to correct the symptoms produced by abnormal breathing. These include unsteadiness and irregularity of breathing and a predominantly upper chest rather than diaphragmatic breathing. Abnormal breathing results in significant morbidity including respiratory symptoms such as breathlessness, chest tightness and chest pain, and non-respiratory symptoms such as anxiety, light headedness, and fatigue[4].

Many previous studies used breathing training techniques in asthmatic patients and revealed significant improvement in ventilatory functions[5,6], quality of life[7-9], and the clinical status of the subjects, reduction in the frequency of the attacks and lowering the medication demands[10,11].

Aerobic conditioning program is considered an essential part in the comprehensive management of asthma[12]. Although physical exertion may induce acute episodes of asthma in the majority of children, exercise also an important part of the therapy for asthma and motor development of children with asthma[13].

Lower aerobic fitness in asthmatic children is related to how capable they perceive themselves than to asthma severity. The exercise limitation in a child with asthma is the result of several factors including the lack of ventilatory reserve, muscle deconditioning, cardiac limitation, the severity of the airway obstruction and the level of habitual activity[14].

The aim of this study was to compare the effects of breathing training program and aerobic training program on the ventilatory functions in asthmatic children and determine the best physical therapy intervention for this group of patients.

METHODS

Forty asthmatic children (22 boys and 18 girls) were recruited from the Allergy Clinic of the Specialized Pediatric Hospital of Cairo University.

Inclusion criteria:

- All of children were diagnosed as having moderate persistent asthma according to GINA classification.
- Age range from 6-13 years.

Exclusion criteria:

- Evidence of other chronic chest problems.
- Child with congenital heart disease or any systemic disease.
- Evidence of chest infection or emergency visits within the last two months.

They were divided into two groups:

- Group A: which comprised 20 children who received breathing training program.
- Group B: that comprised 20 children underwent aerobic conditioning program on a cycle ergometer.

Both groups underwent the selected program for three months and continuing their medical treatment along the study. The parents of all children had signed consent of approval to allow their children to participate in the study.

Measurement of lung function

The children were examined and the data sheets were fulfilled for each child then the height and weight were measured. Baseline lung function testing (using the ergospir spirometer, model 800, Germany) was done for all children participated in the study including: forced vital capacity (FVC), forced expiratory volume in first second (FEV_1), peak expiratory flow (PEF), forced expiratory flow between 25% and 75% of FVC ($FEF_{25-75\%}$) and maximum voluntary ventilation (MVV). The values were expressed as percentage of the predicted value. This measurement was performed twice; before beginning the program and at the end of the training program for both groups (3 months).

In order to set the aerobic exercise intensity for the children in group B, the maximum heart rate (HR_{max}) was measured for each child through a noninvasive incremental symptom-limited exercise test using a digital computer based exercise system (Zan 800, Germany) and a calibrated electrically braked cycle ergometer with adjustable seat height (Ergometrics 800, Germany).

Intervention

Subjects were randomized to either breathing training or aerobic training groups. Study attendance for both groups consisted of three sessions per week for three months (total of 36 sessions). The three months supervised training programs performed by the asthmatic children in both groups were carried out in the outpatient clinic of the Faculty of Physical Therapy-Cairo University.

Training program for group A (breathing training)

In this group, explanation of normal breathing pattern was provided with advice to avoid over-breathing, mouth breathing and upper chest breathing. The children were asked to take a deep breath from the nose moving the lower chest, holding the breath at the end of inspiration for 5 seconds and then expire slowly through the pursed lips. The child practiced this maneuver of breathing for 15-20 minutes in sets, each set was 5 times with rest periods between sets.

Training program for group B (aerobic training)

Children in this group practiced moderate aerobic conditioning program on a cycle ergometer (Universal aerobicycle, USA). The training program was individualized to each patient and ranged from 50%-70% of the HR_{max} achieved by the patient during the exercise test. Typical training session consisted of warming up and cool down that consisted of 5-10 minutes pedaling on the cycle ergometer at low resistance and the active training phase which consisted of 15-40 minutes pedaling on the cycle ergometer on intensity that ranged from 50-70% of the maximum heart rate achieved by the patient in the initial assessment.

Statistical analysis:

Data was collected and statistically analyzed using the SPSS software package. Values are given as means ± SD and range. The student paired t-test was used to compare paired samples pre and post the test in each group and unpaired t-test was used to compare two independent groups. P-value ≤ 0.05 was considered significant.

RESULTS

Participants' characteristics

The asthmatic children in group A and group B were similar regarding the demographic data including age, height and weight (P> 0.05) as shown in table (1).

Changes in the lung function measurement

Comparison of the ventilatory functions before and after the training program in each group showed a highly statistical significant difference in all variables measured (P<0.001) as shown in table (2).

Comparison of the values of the ventilatory functions between both groups revealed no statistical significant differences (P> 0.05) either before or after the training as shown in table (3).

Comparison of percentage of improvement in ventilatory functions between the studied groups

There were no statistical significant differences in the percentage of improvement of all variables between both groups (P>0.05) as shown in table (4).

Table 1. Demographic data of the studied groups

Character	Group A		Group B		t-value	p-value
	Range	Mean ± SD	Range	Mean ± SD		
Age (Yrs)	6-13	8.25±2.05	6-13	8.55±1.96	0.05	>0.05
Height (cm)	112-151	130.05±12.31	114-147	130.85±30.05	0.07	>0.05
Weight (Kg)	21-50	28.65±8.40	23-55	30.05±7.36	0.13	>0.05

SD: standard deviation, Yrs: years, Cm: centimeter, Kg: kilogram, P > 0.05: non-significant.

Table 2. Changes in ventilatory functions before and after the training program in each group

Variable	Group A				Group B			
	Before	After	t-value	p-value	Before	After	t-value	p-value
	Mean ± SD	Mean ± SD			Mean ± SD	Mean ± SD		
FVC	53.8±12.84	78.3±13.32	6.71	<0.001	54.85±11.31	79.75±7.5	11.14	<0.001
FEV_1	56.75±10.04	80.40±13.61	9.44	<0.001	55.55±14.09	79.55±9.94	10.33	<0.001
PEF	46.45±9.65	65.45±10.55	9.92	<0.001	47.7±6.55	66.7±8.61	9.57	<0.001
$FEF_{25\text{-}75\%}$	45.85±14.2	67.1±12.46	6.47	<0.001	44.30±9.87	66±11	10.75	<0.001
MVV	30.9±10.4	43.2±11.91	8.54	<0.001	30.55±8.82	42.15±8.92	7.36	<0.001

SD: standard deviation, FVC: forced vital capacity,FEV_1: forced expiratory volume in one second, PEF: peak expiratory flow, $FEF_{25\text{-}75\%}$: forced expiratory flow between 25% and 75% of FVC, MVV: maximum voluntary ventilation, P < 0.001: highly significant

Table 3. Comparison of the ventilatory functions between the studied groups before and after the training program

Variable	Before training				After training			
	Group A	Group B	t-value	p-value	Group A	Group B	t-value	p-value
	Mean ± SD	Mean ± SD			Mean ± SD	Mean ± SD		
FVC	53.8±12.84	54.85±11.31	0.45	> 0.05	78.3±13.32	79.75±7.5	0.63	> 0.05
FEV_1	56.75±10.04	55.55±14.09	0.53	> 0.05	80.40±13.61	79.55±9.94	0.16	> 0.05
PEF	46.45±9.65	47.7±6.55	0.55	> 0.05	65.45±10.55	66.7±8.61	0.47	> 0.05
$FEF_{25\text{-}75\%}$	45.85±14.2	44.30±9.87	0.4	> 0.05	67.1±12.46	66±11	0.57	> 0.05
MVV	30.9±10.4	30.55±8.82	0.14	> 0.05	43.2±11.91	42.15±8.92	0.41	> 0.05

SD: standard deviation, FVC: forced vital capacity,FEV_1: forced expiratory volume in one second, PEF: peak expiratory flow, $FEF_{25\text{-}75\%}$: forced expiratory flow between 25% and 75% of FVC, MVV: maximum voluntary ventilation, P > 0.05: non-significant.

Table 4. Comparison of percentage of improvement in ventilatory functions between the studied groups

Variable	Group A	Group B	t-value	p-value
	Mean ± SD	Mean ± SD		
FVC	46.68±29.57	51.04±23.82	1.08	> 0.05
FEV_1	44.23±30.31	48.86±25.58	1.17	> 0.05
PEF	45.44±34.35	41.73±23.76	1.03	> 0.05
$FEF_{25-75\%}$	58.37±50.81	52.56±25.56	1.09	> 0.05
MVV	44.66±23.23	43.13±29.11	0.45	> 0.05

SD: standard deviation, FVC: forced vital capacity, FEV_1: forced expiratory volume in one second, PEF: peak expiratory flow, $FEF_{25-75\%}$: forced expiratory flow between 25% and 75% of FVC, MVV: maximum voluntary ventilation, $P > 0.05$: non-significant

DISCUSSION

The results of the current study revealed that a program of breathing training or aerobic training improved the ventilatory functions of the children with asthma and the magnitude of improvement by both types of training was comparable.

In the breathing training group there was significant improvement in all ventilatory functions measured. The improvement in FEV_1 and FVC may be due to improvement in the strength of the diaphragm and other respiratory muscles as a result of correction of abnormal breathing pattern and improvement of the efficiency of alveolar ventilation by the effect of the breath holding time included in the technique of training. The increase in the strength of the diaphragm causes increase in the tidal volume that consequently leads to more efficient expiratory maneuvers.

The increase in PEF following the breathing training can be explained by the increase in the tidal volume, the reduction in the resistance to airflow and the increased use of diaphragm in expiration. Also, the reduction of respiratory rate and the correction of breathing pattern are considered two important causes of such improvement. The improvement in $FEF_{25-75\%}$ could be explained by improvement of inhalation volumes and reduction of airway collapse, so the airflow in the small airways was improved. The improvement that occurred in the MVV reflects the effects of breathing training on improving not only the strength but also the endurance of the respiratory muscles.

The results of the present study were supported by a previous study conducted by Weiner et al., 1992[5] who attributed the improvement in ventilatory functions following inspiratory muscles training in asthmatic patients by the reduction in the degree of hyperinflation that forces the muscles to act in an efficient part in the length-tension relationship, which had an advantageous effect on the respiratory muscles, and the reduction in the resistance to airflow as a result of increasing the lung volumes.

Improvement of the respiratory muscle performance caused by the increase in the strength and endurance of respiratory muscles following the training is also considered an important cause of the increase in the ventilatory functions[6].

In the aerobic training group the ventilatory functions increased significantly after the training. The improvement in FVC by this type of training can be explained from a mechanical point of view as during cycling there is a reduction in the end expiratory lung volume, which is considered an objective indirect measure of stored potential energy for inspiration[15]. By using the abdominal and lower limbs muscles, which mechanically elevate the intra-abdominal pressure leading to increased excursion of the diaphragm during the exercise and increasing its strength which positively affects the lung function. The improvement in FEV_1 is mainly due to increased diaphragmatic strength. Increasing the oxidative capacity of the upper airway muscles through regular exercise training, which is very important to maintain the airways opened, is considered an important mechanism for improving the expiratory flow rate[16]. The greater improvement of MVV is due to the reduction of air trapping as a result of conditioning program which change the position of the flat diaphragm into a position of more mechanical advantage leading to improvement in the MVV. In addition, MVV may be improved due to increased respiratory muscles oxidative capacity that results in elevation of the respiratory muscles endurance[16].

These results are supported by many other previous trials that showed that aerobic exercise training improved ventilatory functions[17-19]. Aerobic adaptation of asthmatic children, as concluded by many other trials, has many other health benefits including improvement of cardiopulmonary fitness, improved quality of life, reduction of the need of medications, decreased emergency visits and decreased anxiety associated with exercise[17,18,20,21].

Although each type of training showed significant improvement in the ventilatory functions, the comparison of the percentage of improvement in each variable measured between both groups showed no significant change which indicated that both breathing training and aerobic exercise training have the same effects of improving the strength and endurance of the respiratory muscles in children with bronchial asthma. An important subjective finding of this study is the report made by most of the children in the aerobic training group that they were symptomatically better when exercising and none of them had asthma attack throughout the study.

A program of breathing training or aerobic training in children with bronchial asthma for three months revealed significant improvement in the ventilatory functions due to increasing the respiratory muscles strength and endurance which indicated that both types of training are safe and can be used for children with bronchial asthma to improve their general condition and quality of life.

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