Pulmonary Rehabilitation in Asthmatic Children

Shadia A. Mohamed, M.D. and Khaled A. Mamdouh, M.D.
Department of Physical Therapy for Growth and Development Disorders, Faculty of Physical Therapy, Cairo University.

ABSTRACT

Bronchial asthma is characterized by persistent air way inflammation that is associated with increased air way responsiveness, airway limitation and respiratory symptoms as wheezing, coughing and dyspnea. Rehabilitation programs are recommended and widely applied in asthmatic patients, so exercise prescription is a keystone of these programs. The objective of this study was to investigate the efficiency of pulmonary rehabilitation programs in asthmatic children. Twenty eight children, with age ranged from 7 to 10 years were included in this study. They were subdivided into two matching groups: A study group included 16 children (9 females and 7 males) and a control group, which included 12 children (6 females and 6 males). For both groups, pulmonary function tests, in the form of forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), maximum voluntary ventilation (MVV) and peak expiratory flow rate (PEFR) were done for all patients before and after one month of treatment. For both groups, a corticosteroid therapy and the traditional physical therapy modalities were administered, in the form of localized deep breathing exercises with frequent coughing and postural drainage according to the affected lobe. For the study group, an incentive spirometry was added. The groups did not differ in all parameters before the study ($p > 0.05$). A statistically significant decrease was found in symptoms, medication scores and also pulmonary function measures in the experimental group versus the control. It can be concluded that pulmonary programs could improve quality of life and pulmonary functions, so these programs should be placed as a component in management of asthmatic children.

Key words: *Asthma, pulmonary rehabilitation, incentive spirometry.*

INTRODUCTION

Bronchial asthma is defined as chronic inflammatory disease, involving many interaction cells, which release a whole variety of inflammatory mediators that activate several target cells in the airways. This results in broncho constriction, micro vascular linkage, edema, mucus hyper secretion and stimulation of neural reflexes[5,8,9].

The normal infant has been demonstrated to have a level of air way reactivity greater than that of the older child or adult. This reactivity may be directly related to airway tone in infancy, to cellular and mediator reactions rate or to the recurrence of wheezing associated with viral upper respiratory tract illness[2,4,6]. Measures employed for determining severity include symptoms, signs, medication requirements, biological test, chest radiographs and bronchoscopy[9,13].

According to the precipitating factors, asthma is divided into two major types. It is either extrinsic asthma, caused by external or environmental agents or intrinsic asthma, that occurs in the absence of or without clear evidence of an antigen antibody reaction[1,18].

During an asthma attack, the smooth muscles surrounding the small airways constrict in response to a particular stimulus. In time, the smooth muscle layers hypertrophy and may increase to three times their original size. Goblet cells proliferate and the bronchial mucous glands enlarge. The airways become filled with thick, whitish, tenacious mucus, so extensive mucus plugging and atelectasis may develop. The bronchial mucosa is edematous and infiltrated with eosinophils and other inflammatory cells. The cilia are damaged and the basement membrane of the mucosa is thicker than normal. As a result of smooth muscle constriction, bronchial mucosal edema, mucus hyper secretion, air trapping and alveolar hyperinflation develop[18,21]. The major pathologic or structural changes observed during an asthmatic episode include smooth muscle construction of bronchial air ways (bronchospasm), excessive production of thick, whitish, tenacious bronchial secretions, hyper inflation of alveoli (air trapping) and mucus plugging in addition to atelectasis in severe cases[16,22].

Chest physiotherapy for the child with respiratory disease, whether acute or chronic, was only a part of the overall management plan. Moreover, the communication with other members of the multidisciplinary team was essential to ensure optimal treatment and maximum therapeutic value[5,14]. Regular physical activity and participation in sports are considered to be useful in the management of asthma, especially in children and adolescents[20,22].

Physical training programs have been designed for patients with asthma for improving physical fitness, neuromuscular coordination and self confidence. Subjectively, many patients reported that they are symptomatically better when fit but the physiological basis of this perception has not been systematically investigated[23]. Ventilatory rehabilitation comprises breathing training to reduce dyspnea and restore ventilatory capacity. Furthermore, the hyper ventilation for inspiratory and expiratory muscles enhances respiratory muscle endurance and ameliorates dyspnea[6,12].

So, this study was designed to investigate the effect of pulmonary rehabilitation programs in asthmatic children.

MATERIALS AND PROCEDURES

Subjects

Twenty eight children, suffering from bronchial asthma were included in this study, with age ranged from 7 to 10 years. They were 15 females and 13 males. They were divided into two matching groups: a study group, which included 16 children (9 females and 7 males), with mean age of 8.6 $\pm$ 2.11 years and a control group, including 12 children (6 females and 6 males), with mean age of 8.65 $\pm$ 2.25 years. Their criteria were as follows:

- Mild persistent or moderate bronchial asthma.
- All children were in a stable phase of the disease, with no exacerbation during the last 15 days before the start of the study.
- The subjects were referred from the Children's Asthma Management Department in chest hospitals in Abbasia.
- A written informed consent was obtained from their parents before they were included in the study.

Materials

- Discovery portable computerized spirometer unit: Cat. Model no. 42.000.
- Incentive spirometer: Triflo II, Model no. 8884 - 717395.

Procedures

- ***Methods used for evaluation***

Ventilatory function tests

- Forced vital capacity (FVC). The child was asked to breath in and out normally through the mouth piece and then to inspire maximally and to blow out (exhale completely) as hard and fast as he could through the mouth piece. With nasal clip applied to the nose, the child was asked to continue to exhale for three times. It is measured in ml.
- Forced expiratory volume in the first second (FEV1). The volume of gas expired over the given time interval (1 sec), during the performance of forced vital capacity is recorded in ml.
- Maximum voluntary ventilation (MVV). The child was asked to breath as rapidly and deeply as possible, for three times. The measured volume was multiplied by 4 to give the results in liter / min.
- Peak expiratory flow rale (PEFR): The child was asked to breathe in as deep as possible through the mouth piece then to blow out as hard and fast as possible. It is measured in ml.

General principles during the evaluating procedures:

- Sitting position was used in all procedures.
- Nasal clip and mouth piece were used during the application of the procedures.
- The highest value of three consecutive trials was recorded for each test done.

The ventilatory functions were done for both study and control groups before and a month after treatment.

- ***Methods used for treatment***

For both groups, corticosteroid therapy and traditional physical therapy program were conducted, which included localized deep breathing exercises, with frequent coughing and postural drainage according to the affected lobe. Moreover, a special lung expansion maneuvers, with the use of incentive spirometry was done for the study group only. The incentive spirometry is a form of low-level resistance training that emphasizes sustained maximal inspiration. It is a flow-sensitive device with three chambers, each containing a plastic ball. On inspiration, these balls rise in their chambers for as long as the flow is maintained. The patient inhales through the spirometer that provides visual feed back through the colored balls, as the patient breaths in as deeply as possible, in addition to the auditory feed back given by the voice of the therapist to encourage and motivate the child. The procedures were as follows:

- The patient was placed at a constable semi-upright position, holding the incentive spirometer in upright position.
- Firstly, the patient was asked to take three to four slow, easy breaths and then maximally exhale with the fourth breath.
- Then, the patient was instructed to place the mouth piece of the device in his/her mouth and maximally inhale at a rate sufficient to raise the balls (1-3), according to his effort with inspiratory hold for 3 seconds. This sequence was repeated 5 to 10 times in each set of exercise, with rest in between, for three times / day.

RESULTS

The results collected from the present study were statistically analyzed to obtain the mean, standard deviation (SD) and mean

difference (MD). The paired t-test was utilized to compare between means and hence, to test the significance of such results. The data collected from the patients in both groups, before starting of the treatment revealed non-significant difference in all measured parameters ($t > 0.05$).

As shown in table (1), the mean value of the FVC in the study group before treatment was 147.5 ± 7.0 ml, which increased after the suggested period of treatment to 184.5 ± 2.0 ml, with a mean difference of 37.0 ml and a percentage of change of 25.08 %, showing a statistically significant difference ($t = 13.36$, $P < 0.01$). Meanwhile, the mean value of the FVC in the control group before treatment was 150.1 ± 6.5 ml, which increased after treatment for one month to 153.0 ± 7.3 ml, with a mean difference of 2.9 ml. The percentage of improvement was 1.07 %, which revealed a non-significant difference ($t = 1.07$, $P > 0.05$) (Fig. 1).

Table (1): Comparison of mean values of forced vital capacity (FVC) in ml, pre and post treatment, for both groups.

FVC	Study		Control	
	Pre	Post	Pre	Post
Mean	147.5	184.5	150.1	153.0
SD	7.0	2.0	6.5	7.3
MD	37.0		2.9	
% of Change	25.08 %		1.93 %	
t	13.36		1.07	
p	< 0.01 (S.)		> 0.05 (N.S.)	

Concerning FEV1, from table (2) it can be revealed that in the study group, the mean value of the FEV1 increased from 115.4 ± 4.6 ml before the treatment program, to 154.5 ± 7.1 ml after the application of the treatment program. The mean difference was 39.1 ml, with a percentage of improvement of 33.88 %, which showed a significant difference ($t = 12.44$, $P > 0.01$). In the control group, the FEV1 mean value was 104.0 ± 6.5 ml before treatment, to be 106.2 ± 5.5 ml after the treatment program. The mean difference was 2.2 ml, with a percentage of improvement of 2.12 %, showing a non-significant change ($t = 0.84$, $P > 0.05$) (Fig. 1).

Table (2): Comparison of mean values of forced expiratory volume in the first second (FEV1) in ml, pre and post treatment for both groups.

FEV1	Study		Control	
	Pre	Post	Pre	Post
Mean	115.4	154.5	104.0	106.2
SD	4.6	7.1	6.5	5.5
MD	39.1		2.2	
% of Change	33.88 %		2.12 %	
t	12.44		0.84	
P	< 0.01 (S.)		> 0.05 (N.S.)	

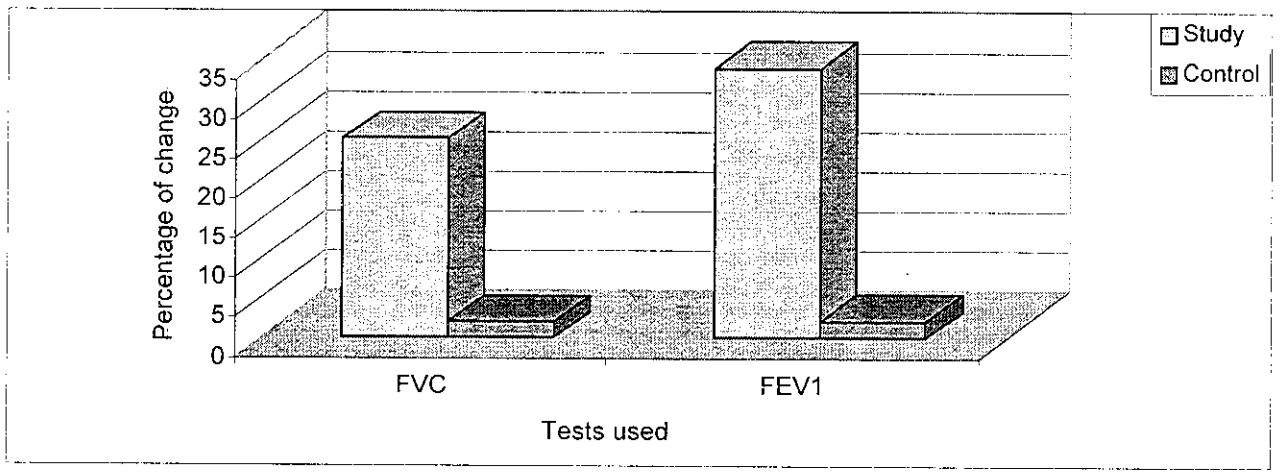

Fig. (1): Percentage of change of FVC and FEV1 in both groups.

The results of the MVV are represented in table (3). Before the start of the treatment program, the mean value of the MVV in the study group was 49.6 ± 4.7 L / min, which increased after one month of treatment to 57.8 ± 5.6 L / min, with a mean difference of 8.2 and a percentage of improvement of 16.53 %. A significant improvement was recorded (t = 4.38, $p < 0.05$). Similarly, in the control group, the mean value of the MVV increased from 60.8 ± 4.6 L / min before the treatment program to 61.7 ± 4.5 L / min after the program, with a mean difference of 0.9 L / min. The percentage of change was 3.49 %, revealing a non-significant improvement (t = 0.33, $P > 0.05$) (Fig. 2).

Table (3): Comparison of mean values of maximum voluntary ventilation (MVV) in Liter / min, pre and post treatment for both groups.

MVV	Study		Control	
	Pre	Post	Pre	Post
Mean	49.6	57.8	60.8	61.7
SD	4.7	5.6	4.6	4.5
MD	8.2		0.9	
% of Change	16.53 %		3.49 %	
t	4.38		0.33	
P	< 0.05 (S.)		> 0.05 (N.S.)	

As revealed from table (4), before treatment of the study group, the mean value of PEFR was 188.0 ± 13.0 Liter / min, which underwent an increase after the training to be 242.0 ± 14.0 Liter / min. The mean difference was 54.0 Liter / min, with a percentage of change of 7.06 %, which was statistically significant (t = 4.14, $P < 0.05$). Before treatment of the control group, the mean value of PEFR was 204.0 ± 12.0 Liter / min, which increased after training to 209.0 ± 13.0 Liter / min. The mean difference was 5.0 Liter / min, with a percentage of change of 2.45 %, which was statistically non-significant (t = 1.12, $P > 0.05$) (Fig. 2).

Table (4): Comparison of mean values of peak expiratory flow rate (PEFR) in Liter / min, pre and post treatment for both groups.

PEFR	Study		Control	
	Pre	Post	Pre	Post
Mean	188.0	242.0	204.0	209.0
SD	13.0	14.0	12.0	13.0
MD	54.0		5.0	
% of Change	28.72 %		2.45 %	
t	4.14		1.12	
P	< 0.05 (S.)		> 0.05 (N.S.)	

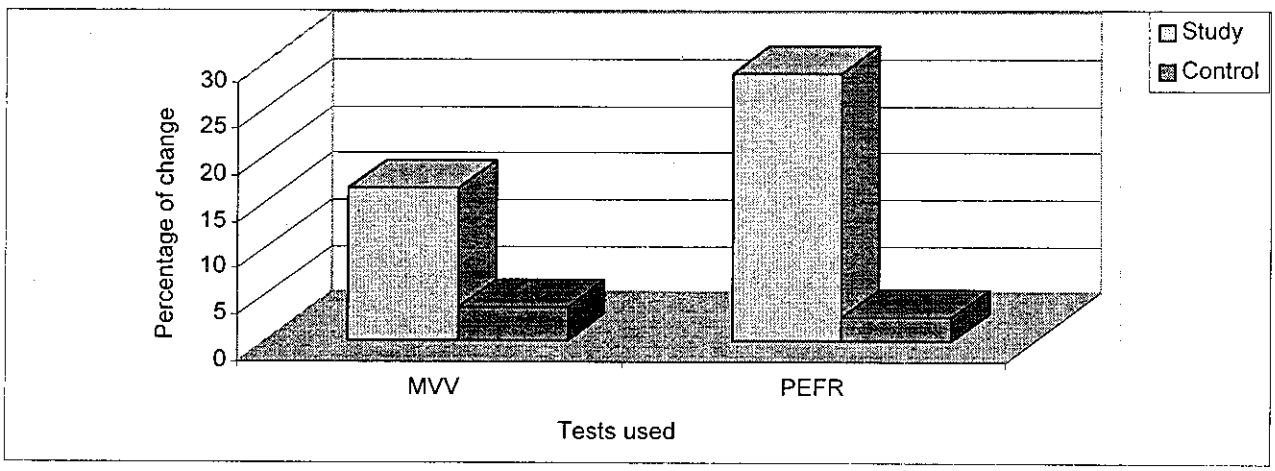

Fig. (2): Percentage of change of MVV and PEFR in both groups.

DISCUSSION

The aim of this study was to investigate the effectiveness of pulmonary rehabilitation program in asthmatic children in order to reduce the complications following the disease.

For the control group, who received the traditional respiratory treatment, the post-treatment results indicated non-significant improvement in all parameters measured ($P > 0.05$). Although there was no significant improvement in the results of the control group, the physical therapy program applied to them prevented the complications or decreased their incidence. For the study group, trained with the incentive spirometer in addition to the traditional physical therapy program, the post-training results revealed significant improvement in all ventilatory parameters measured in this study.

The results of the present study came in agreement with many other studies. The incentive spirometry was used to increase the volume of inspired air and to prevent alveolar collapse[17,20]. The value of the use of incentive spirometer for children is that it provides visual in addition to auditory feed back, which adds more benefit from training[16,22].

Most of the previous studies have failed to show a clinical advantage of the improvement in fitness with training[19]. Lundwick et al., (1986)[13] found that normalization of cardio pulmonary endurance

in severe asthmatic children was not related to an improvement in pulmonary function. Later on, Robinson et al. (1992)[18] announced that significant aerobic improvement with training was not associated with changes in the use of medications, symptoms or bronchial responsiveness to histamine.

Physical training programs, designed for asthmatic patients, aim at improving physical fitness, neuromuscular co-ordination and self confidence[4,19]. When the patient performed a slow inspiration and an inspiratory hold, using the incentive spirometer, the well ventilated alveoli would donate air to the under-ventilated alveoli (whose small airways are plugged with mucus), through pores of Kohn. In addition, the inspiratory hold for 3 seconds is helpful to allow for better collateral ventilation to occur[17,22]. Consequently, breathlessness and the possibility of provoking exercise-induced asthma will be reduced. Exercise training may also reduce the perception of breathlessness through other mechanisms including strengthening of respiratory muscles[5,11].

The results of the present study were also coincide with the results of Girodo et al.,[9] who reduced the incidence of pulmonary complication when incentive spirometer was used three times / day. Further study was done by Satta (2000)[19], who found an increase in vital capacity after training with incentive spirometery for asthmatic children. Few other studies found no difference in pulmonary complications or outcome when using incentive spirometer[7,15].

The improvement may be due to increased expansion and mobility of the chest and aeration of collapsed alveoli due to removal of secretions, allowing for collateral ventilation to occur. The improvement which was recorded may be attributed to the ability of the patient to clear his air ways, which abolished the reflex spasm after the training with the incentive spirometer[3,23].

A possible mechanism is that any increase in the regular physical activity increases the aerobic fitness. In turn, this will rise the ventilatory threshold, thereby lowering the minute ventilation during mild and moderate exercises[8,16].

CONCLUSION

From the results of this study and other related studies, it can be concluded that the incentive spirometer may represent an effective and safe additional modality to be utilized in the prevention of pulmonary complications.

REFERENCES

1- Cochrane, L.M. and Clark, C.J.: Benefits and problems of a physical training program for asthmatic patients. Thorax (45): 345 51, 1990.

2- Combach, W., Nettter, J., Nery, L., Silva. A. and Cabral, A.: The effects of community-based pulmonary rehabilitation program on exercise tolerance and quality of life: Randomized controlled trial. Eur. Respir. J (10): 104 13, 1997.

3- Dean, M., Thio, B. and Ketal, A.: A short exercise and living course for asthmatics. British J. of diseases of the chest (82): 155 61, 1988.

4- Edenbrant, L., Brenda, C. and Matt, G.: Effects of physiotherapy in asthmatic children, a one year follow up after physical training once a week. Acta paediatr. Scand (79): 973 975, 1990.

5- Emtner, M., Finne, M. and Stalenhein, G.: High - intensity physical training in adults with asthma. A Comparison between training on land and in water. Scand J. Rehabil. Med, 30 (4): 201-209, 1998.

6- Engstron, I., Delcol, G. and Boner, E.: Physiological and respiratory effects of a

physical exercise program on boys with severe asthma. Acta Pediat. Scand (80): 1058-1082, 1991.

7- Felix, F.R., Stewart, M.R. and Peter, N.B.: Effects of physical training in asthma: A systematic review. Br. J. sports Med. (34): 162-167, 2000.

8- Fink, G., Kaye, C. and Blan, H.: Assessment of exercise capacity in asthmatic children with various degrees of activity. Acta Pediatr. Scand, (15): 41-43, 1993.

9- Girodo, M., Ekstrand, K.A. and Metivier, G.J.: Deep diaphragmatic breathing rehabilitation exercises for the asthmatic patient. Arch. Phys. Med. Rehabil. (73): 717 20, 1992.

10- Gorfinkel, S., Melboume, E. and Melhzer, S.: physiologic & non physiologic determinants of aerobic fitness in mild to moderate Asthma. Am. Rev. Respir. Dis., (145): 741-745, 1992.

11- Haas, F., Geary, M. and Crawford, B.: Effect of aerobic training on ferced expiratory air flow in exercising asthmatic hemsans. J. appl. Physiol. (63): 1230-1235, 1987.

12- Henriksen, J.M. and Melsen, T.T.: Effect of physical training on exercise-induced broncho constriction. Acta paediatr. Scand (72): 31-36, 1983.

13- Lundwick, S., Gones, J. and Jones, T.: Normalization of cardiopulmonary endurance in severely asthmatic children after bicycle ergometer therapy. J Paediatr. (109): 446-451, 1986.

14- Me Fadden, E.: Exercise performance in the asthmatic. Am. Respir. Dis. (129): 584-487, 1984.

15- Neder, J.A., Elias, J. and Sishman, A.: Short term effects of aerobic training in the clinical management of severe asthma in children. Thorax (54): 202-206, 1999.

16- Orenstein, D.M.: Asthma and sports. The child and the adolescent athlete. London: Blackwell: 433-454, 1996.

17- Ram, F.S., Rabinson, S.M. and Black, P.N.: Physical training for asthma: A systematic review. Br. J. sports Med., 34 (3): 162-167, 2001.

18- Robinson, D., Egglestane, D. and Hilp, D.: Effect of physical conditioning program in asthmatic patents. N. Z. Med. J., (137): 253-256, 1992.

19- Satta, A.: Exercise training in asthma. J. sports Med Phys Fitness, 40 (4): 277-283, 2000.

20- Sautuz, P., Brennan, M., Gazzaniga, B. and Hanson, L.: Exercise performance in children with asthma: Is it different from that of healthy controls. Eur. Respir. J (10): 1254-1256, 1997.

21- Thomas, M., McKinley, R.K., Freeman, E., Foy, C., Prodger, P. and Price, D.: Breathing retraining for dysfunctional breathing in asthma: A randomized controlled trial. Thorax, 58(2): 110-115, 2003.

22- Thomas, P.S., Geddes, D.M. and Barnesp, J.: Pseudo-steroid resistant asthma. Thorax (54): 352-356, 1999.

23- van Veldhoven, N.H., Vermeer, A., Bogaard, J.M., Hessels, M.G., Wijnro, L., Colland, V.T. and van Essen-Zandvliet, E.E.: Children with asthma and physical exercise: Effects of an exercise program. Clin. Rehabil., 15(4): 360-370, 2001.

الملخص العربي

برنامج تأهيلي للأطفال المصابين بالربو الشعبي

يتميز الربو الشعبي بالتهاب في المجري الهوائي مصحوب بزيادة حساسيته، بالإضافة إلى بعض الأعراض الخاصة بالجهاز التنفسي مثل الكحة وضيق التنفس، ولذلك يهدف هذا البحث إلى تقييم تأثير برنامج التأهيل علي هذه الحالات، اشتملت العينة المختارة علي ٢٨ طفلا من المصابين بالربو الشعبي (١٥ ذكر و ١٣ أنثي)، تراوحت أعمارهم من ٧ إلى ١٠ سنوات، تم تقسيمهم إلى مجموعتين متناظرتين: تجريبية تضم ١٦ طفلا، وضابطة ضمت ١٢ طفلا.

وقد خضع هؤلاء الأطفال في المجموعتين إلى علاج دوائي (الكورتيزون) مع برنامج العلاج الطبيعي المعتاد، وتمت إضافة جهاز المحفز التنفسي بالنسبة للمجموعة التجريبية فقط بغرض تقييم دوره في تحسين الوظائف التنفسية لدي هؤلاء المرضي، وقد خضع الأطفال في المجموعتين إلى إجراء اختبارات لوظائف التنفس التي اشتملت علي قياس السعة الهوائية، وكمية خروج الهواء في الثانية الأولي، ونسبة السعة الهوائية، وتم إجراء هذه القياسات قبل وبعد العلاج الذي استمر لمدة شهر، ثلاث مرات أسبوعيا.

وقد أوجدت النتائج تحسنا ذا دلالة إحصائية في وظائف التهوية الهوائية بالنسبة للمجموعة التجريبية عند مقارنتها بالمجموعة الضابطة، وبذلك يمكن التوصية بأهمية إضافة جهاز المحفز التنفسي إلى برنامج العلاج الطبيعي للأطفال المصابين بالربو الشعبي.