Exercise-induced asthma and cardiovascular fitness in asthmatic children

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Abstract

Background **– The role of physical training in the management of children with exercise-induced asthma is controversial. A study was undertaken to determine whether a relationship could be found between the occurrence of exercise-induced asthma and the degree of cardiovascular fitness in asthmatic children.**

Methods **– Twenty eight children aged 6–13 with mild to moderate asthma and dyspnoea during or after physical exercise were tested. All patients had a basal forced expiratory volume in one second (FEV_1) of >80% predicted. Twelve patients were taking corticosteroid maintenance medication by inhalation and 16 were not. Two exercise tests were performed on a treadmill to assess peak oxygen consumption rate ($\dot{V}O_2max$) and the percentage decrease in FEV_1 after exercise.**

Results **– There was no correlation between the $\dot{V}O_2max$ and the percentage decrease in FEV_1. Patients not taking steroids showed a greater fall in FEV_1 than those receiving corticosteroid medication (mean fall in FEV_1 28·7% versus 6·6%). Four of the 12 children treated with steroids and two of the 16 children not taking steroids had a level of cardiovascular fitness lower than the 5th percentile for healthy Dutch children.**

Conclusion **– Normal cardiovascular fitness does not prevent exercise-induced asthma.**

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Keywords: exercise-induced asthma, exercise test, asthma, physicai fitness, inhaled corticosteroid.

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Exercise-induced asthma is a frequently encountered symptom in asthmatic children,[1] preventing them from taking part in normal play and sports with their peers.[2] It has been suggested that normalising cardiovascular fitness is beneficial for the prevention of exercise-induced asthma,[3,4] in which case a relationship between the degree of cardiovascular fitness and the occurrence of exercise-induced asthma may be apparent. A study was performed to determine whether such a relationship could be found.

Methods

SUBJECTS

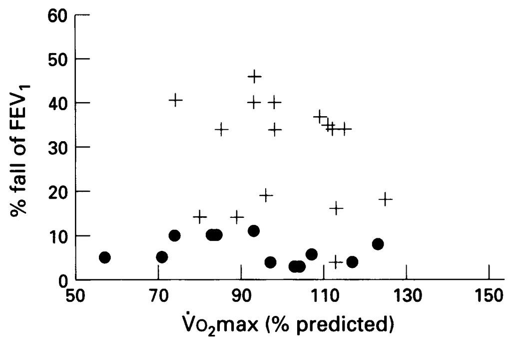
Thirty one children (19 boys) aged 6–13 years with mild to moderate asthma took part in the study. All had a history of dyspnoea during or after physical exercise leading to problems in play and sports with their peers. All patients had a basal forced expiratory volume in one second (FEV_1) of >80% predicted on both study days. There had been no exacerbations of asthma for at least three weeks. Two boys and one girl dropped out of the study because they stopped the test before they had reached their maximum exercise level. Of the other children 12 took inhaled corticosteroids – seven budesonide (daily dosage 800 µg in three patients and 400 µg in four) and five beclomethasone (daily dosage 400 µg in four patients and 200 µg in one). Five patients took cromoglycate and 11 did not use maintenance medication. All patients took salbutamol as required.

STUDY DESIGN

The children performed two exercise tests – a maximum oxygen uptake ($\dot{V}O_2max$) test to assess cardiovascular fitness and an exercise-induced asthma test to assess exercise-induced asthma – on two separate days during a two week period. Temperature and humidity were kept stable during all exercise tests at 18–20°C and 40–45%, respectively. Patients were asked not to perform any other exercise on a study day.

$\dot{V}O_2max$ test

The $\dot{V}O_2max$ test was performed on a treadmill (Quinton Q45) using a modified Bruce protocol to reduce the steps.[5] The speed and inclination were increased by half the step of the Bruce protocol every 1·5 minutes rather than every three minutes. One actuation of a salbutamol 200 µg metered dose pressurised aerosol (Ventolin) was administered by a large volume spacer (Volumatic) 15 minutes before each exercise test. The use of salbutamol does not affect $\dot{V}O_2max$.[6] Minute ventilation and mixed expired concentrations of carbon dioxide and oxygen were measured continuously by a verified Mynhardt Oxycon (OX4) to allow calculation of oxygen consumption ($\dot{V}O_2$ in l/min), carbon dioxide production ($\dot{V}CO_2$ in l/min), and the respiratory quotient (R). Heart rate was measured with a Polar Sport tester. $\dot{V}O_2max$ was assumed to be reached when two of the following three criteria were met[7]: (1) the respiratory quotient exceeded 1·0; (2) no further increase in heart rate occurred despite increasing load; and (3) no further increase in oxygen uptake occurred despite increasing load.



Relation of % fall of FEV_1 to % predicted $\dot{V}O_2max$ in asthmatic children taking steroids (●) (r = −0·54) and in children not taking steroids (+) (r = 0·44).

Exercise-induced asthma test

Inhaled bronchodilators were withheld for at least eight hours before the exercise-induced asthma test. Before the start of the exercise test on the treadmill the baseline value of the FEV_1 was obtained with a Sensor-Medics Pulmonet III computerised water spirometer (IBM PS 235X). The test started with two minutes of running on a treadmill. In these two minutes the inclination of the treadmill was set on 10% and running speed was increased so that the heart rate rose to 180 beats per minute. This speed was maintained for five minutes. Children ran wearing a nose clip. After the exercise had stopped (t = 0) we measured FEV_1 at t = 1, 3, 6, 9, 12, 15, 20, 25 and 30 minutes. Exercise-induced asthma (EIA) was calculated as fall of FEV_1 from baseline FEV_1:

$$EIA = \frac{\text{Baseline } FEV_1 - \text{lowest } FEV_1 \text{ after exercise}}{\text{Baseline } FEV_1} \times 100\%$$

DATA ANALYSIS

The $\dot{V}O_2max$ of each child was compared with the predicted value for the $\dot{V}O_2max$ of healthy Dutch children[8] and the percentage of the predicted $\dot{V}O_2max$ was calculated. The Spearman

Table 1 Patient characteristics, percentage predicted $\dot{V}O_2max$, and percentage fall in FEV_1 in children without steroid treatment

Patient no.	*Sex*	*Age (years)*	*Medication*	*$\dot{V}O_2max$ (ml/min·kg)*	*Percentile group*	*Predicted $\dot{V}O_2max$ (l/min)**	*% predicted $\dot{V}O_2max$*	*% fall in FEV_1*
1	M	13	—	46·5	10–25	52·1	89	14
2	F	7		42	25–50	43·8	96	19
3	F	12	—	36	<5	45	80	14
4	M	11	—	38·3	<5	51·6	74	41
5	F	10	Cromoglycate†	41·3	25–50	44·8	93	40
6	M	8		55·6	75–90	50·2	111	35
7	F	8		50·3	75–90	44·6	113	4
8	M	11	—	56·3	75–90	51·6	109	37
9	M	8	—	56·7	90–95	50·2	113	16
10	M	10	Cromoglycate†	57·4	75–90	51·4	112	34
11	F	10		43·8	25–50	44·8	98	40
12	F	11	Nedocromil‡	56·0	>95	44·9	125	18
13	M	11		44·0	5–10	51·6	85	34
14	M	11	Cromoglycate†	50·4	25–50	51·6	98	34
15	M	11		47·8	10–25	51·6	93	46
16	F	12	Cromoglycate†	51·8	90–95	45·0	115	34
Mean (SD)							100·3 (14·3)	28·7 (12.5)

* Reference 8.
† Disodium cromoglycate 5 mg qid.
‡ Nedocromil 2 mg qid.

Table 2 Patient characteristics, percentage predicted $\dot{V}O_2max$, and percentage fall in FEV_1 from baseline after exercise in the steroid treated children

Patient no.	*Sex*	*Age (years)*	*Dose (µg)/steroid*	*$\dot{V}O_2max$ (ml/min·kg)*	*Percentile group*	*Predicted $\dot{V}O_2max$ (l/min)**	*% predicted $\dot{V}O_2max$*	*% fall in FEV_1*
17	F	8	400 BDP	37·0	10–25	44·6	83	10
18	M	8	400 BDP	42·3	<5	50·2	84	10
19	F	8	400 Budesonide	31·1	<5	44·6	71	5
20	M	12	800 Budesonide	38·5	<5	51·9	74	10
21	F	8	400 BDP	25·4	<5	44·6	57	5
22	F	10	400 Budesonide	47·8	50–75	44·8	107	6
23	M	10	800 Budesonide	47·7	25–50	51·4	93	11
24	M	8	400 BDP	58·5	90–95	50·2	117	4
25	M	8	400 Budesonide	51·9	50–75	50·2	103	3
26	M	8	800 Budesonide	52·0	50–75	50·2	104	3
27	M	6	200 BDP	57·4	>95	46·5	123	8
28	M	7	400 Budesonide	46·7	25–50	48·3	97	4
Mean (SD)							92·8 (19·6)	6·6 (3.1)

BDP = beclomethasone dipropionate.
* Reference 8.

rank correlation coefficient (*r*) between percentage predicted $\dot{V}O_2max$ and percentage fall in FEV_1 was calculated. The percentage fall in FEV_1 of the children treated with steroids was compared with those who did not receive steroids using the Student's *t* test.

Results

In 28 of the 31 children the criteria for a $\dot{V}O_2max$ were reached. There was no correlation between the % predicted $\dot{V}O_2max$ and the % fall in the FEV_1 in either the steroid treated children, $r=-0{\cdot}54$ ($-0{\cdot}85/0{\cdot}05$), or those not receiving steroid treatment, $r=0{\cdot}44$ ($-0{\cdot}07/0{\cdot}77$) (figure).

The mean (SD) fall in FEV_1 in the steroid treated children was 6·6 (3·1)% and 28·7 (12·5)% in those who did not receive steroids ($p<0{\cdot}001$). Four of the 12 children in the corticosteroid group and two of the 16 in the non-steroid group had a $\dot{V}O_2max$ lower than the 5th percentile for their age group (tables 1 and 2).

Discussion

Exercise-induced asthma and cardiovascular fitness were not related in either the steroid treated patients or those not taking steroids, which shows that children with severe exercise-induced asthma can attain normal cardiovascular fitness. Furthermore, it indicates that normal cardiovascular fitness in itself does not prevent severe exercise-induced asthma. Patients not on steroid treatment had more severe exercise-induced asthma than the steroid treated patients, which confirms the importance of inhaled steroids in the prevention of exercise-induced asthma.[9] Inhaled corticosteroids reduce the severity of exercise-induced asthma substantially in a relatively short period compared with other indicators of airways responsiveness such as peak flow variability and bronchial responsiveness to methacholine.[10] Most of the steroid treated children showed no substantial exercise-induced asthma. Their symptoms of exercise-induced dyspnoea were probably due to reduced cardiovascular fitness. To keep up with their peers they needed to make a greater effort which may explain their symptoms. We conclude that inhaled steroids are first line therapy for severe exercise-induced asthma. Physical training should be reserved for those children in whom a reduced cardiovascular fitness does not become normal while on treatment with inhaled steroids.

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1 Anderson SD. Exercise-induced asthma. In: *Allergy principles and practice.* Vol II. St Louis: CV Mosby, 1988:1156–75.
2 Croft D, Lloyd B. Asthma spoils sport for too many children. *Practitioner* 1989;**233**:969–71.
3 Henriksen JM, Toftegaard Nielsen T. Effect of physical training on exercise-induced bronchoconstriction. *Acta Paediatr* 1983;**72**:31–6.
4 Svenonius E, Arborelius MJ jr. Decrease of exercise-induced asthma after physical training. *Acta Paediatr* 1983;**72**:23–30.
5 Bruce RA, Kusumi F, Hoshmer D. Maximal oxygen intake and normographic assessment of functional aerobic impairment in cardiovascular disease. *Fundamentals of Clinical Cardiology* 1973;**85**:546–62.
6 Ingeman-Hansen TI, Bundgaard A, Halkjaer-Kristensen J, Siggaard-Andersen J, Weeke B. Maximal oxygen consumption rate in patients with bronchial asthma: the effect of β_2-adrenoreceptor stimulation. *Scand J Clin Lab Invest* 1980;**40**:99–104.
7 Astrand PO, Rodal K. *Textbook of work physiology.* New York: McGraw Hill, 1986.
8 Binkhorst RA, van't Hof MA, Saris WHM. *Maximal exercise by children: reference values for 6–18 year girls and boys.* Netherlands Heart Foundation.
9 Henriksen JM, Dahl R. Effects of inhaled budesonide alone and in combination with low-dose terbutaline in children with exercise-induced asthma. *Am Rev Respir Dis* 1983;**128**:993–7.
10 Waalkens HJ, van Essen-Zandvliet EEM, Gerritsen J, Duiverman EJ, Kerrebijn KF, Knol K. The effect of an inhaled corticosteroid (budesonide) on exercise-induced asthma in children. *Eur Respir J* 1993;**6**:652–6.