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Is exercise testing useful in a community based asthma survey?

T K Ninan, G Russell

Abstract

***Background*—In hospital clinics exercise challenge is used as a simple, non-invasive, non-pharmacological test for asthma in childhood. Little is known of its value in a community setting. An exercise test was therefore evaluated as an adjunct to a respiratory questionnaire in the course of an asthma survey.**

***Methods*—From a cohort of 4003 primary school children, 607 of 799 with respiratory symptoms answered a detailed respiratory questionnaire. From the same cohort 135 of 229 randomly selected asymptomatic children were also interviewed. A stratified selection of one in four of the children interviewed was then invited to take part in a six minute cold air enhanced exercise challenge test; 128 symptomatic and 26 asymptomatic children attended.**

***Results*—Bronchial hyperreactivity, a fall of $FEV_1 \geqslant 10\%$ at five, 10, or 15 minutes following the exercise challenge, was identified in 15 of 128 symptomatic children and in one of 26 asymptomatic children. Bronchial hyperreactivity was found in only one of three children with frequent shortness of breath and one of five with frequent wheeze. It was found in 13 of 58 children whose parents were aware of the diagnosis of asthma; in 10 of 26 children who were on regular prophylactic treatment; in only 11 of 70 children with a history of exercise induced symptoms; and seldom in children with mild symptoms. Gestational age and ventilator support in the neonatal period were significant predictors of bronchial hyperreactivity.**

***Conclusions*—Exercise testing enhanced by cold air adds very little to a well designed respiratory questionnaire in community studies of asthma in childhood.**

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Department of Child Health, University of Aberdeen, Foresterhill, Aberdeen, AB9 2ZD
T K Ninan
G Russell

Reprint requests to:
Dr T K Ninan, Booth Hall Children's Hospital, Charlestown Road, Blackley, Manchester M9 2AA

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Although asthma is commonly described as "reversible airways obstruction," there is no universally accepted definition and establishing the diagnosis on clinical grounds is often difficult. There are no symptoms that are specific for asthma, particularly in children in whom recurrent nocturnal cough may be the sole presenting feature. Various pharmacological stimuli induce bronchospasm in asthmatic children, but provocation tests with bronchoconstrictor agents pose ethical problems in a community based survey, particularly one involving children. The occurrence of exercise induced bronchospasm is, however, common in asthmatic children (70–80%).[1,2] It has been used as a diagnostic test and its severity, expressed as a lability index, correlates closely with the clinical severity of the disease.[3] For screening purposes exercise challenges are felt to be more acceptable than pharmacological stimulation because of the physiological nature of the provocation. In practice this form of challenge can be likened to everyday activities such as running to school, and is readily accepted by parents and children. Most studies of exercise induced bronchoconstriction have been limited to hospital or clinic patients who are unlikely to be representative of the general population.[4,5]

Strauss and coworkers reported that bronchoconstriction could be enhanced when cold dry air was inspired during exercise.[6] We therefore used an exercise challenge while inhaling cold air to identify bronchial hyperreactivity in a community study of respiratory symptoms in school children, and examined the association of parental reporting of exercise induced symptoms and physician diagnosed asthma with the results of the exercise test.

Methods

SUBJECTS

As part of a large epidemiological study[7] the parents of 4003 8–13 year old children from primary schools in Aberdeen were sent a screening questionnaire about respiratory symptoms (period prevalence of wheeze, shortness of breath, and persistent nocturnal cough) and atopic history (life time prevalence of asthma, eczema, and hayfever). Based on the response to the questionnaire 799 symptomatic and 229 randomly selected asymptomatic children from the same population were invited to attend the Royal Aberdeen Children's Hospital. In all, 607 (76%) symptomatic children and 135 (59%) asymptomatic children attended for a detailed questionnaire, clinical examination, and pulmonary function testing. Both questionnaires were developed on the basis of a previous

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study carried out in Aberdeen approximately 25 years ago.[8 9] Information was gathered about birth weight, gestational age, provision of respiratory support, early feeding practices, housing conditions, and parental occupation, smoking habits, and atopic histories. Life time prevalence of asthma and other atopic disorders were based on physician diagnosis. One in four of these children was invited to take part in a cold air enhanced exercise challenge test. Selection for testing was stratified according to the severity of symptoms identified on the screening questionnaire.

The exercise challenge test was performed by 128 symptomatic children and 26 asymptomatic children. Up to two reminder letters were sent and one telephone call made to invite subjects to participate in the study. The questionnaire was validated by applying it to two primary schools outside the study catchment area and to a paediatric asthma clinic population.

BRONCHIAL CHALLENGE

Appointments were made for the families to attend the hospital clinic where the parents were asked detailed standardised questions about perinatal events, current and past respiratory symptoms, triggering agents, drug treatment, and family awareness of the diagnosis of asthma and other atopic disorders. The children were instructed to refrain from using their β_2 agonist for at least 12 hours before a test; all other medication was withheld for at least 24 hours.

Children were allowed to proceed to the exercise challenge if the forced expiratory volume in one second (FEV_1) was more than 60% of predicted normal. Only one child, a boy, was so excluded. The exercise challenge comprised pedalling on a bicycle ergometer (Tunturi) that could operate at variable resistance. The children exercised for six minutes, during which the heart rate was constantly monitored with a three electrode yoke and a cardiorater (Kontron). By varying the resistance we ensured that the subjects exercised to attain 90% of their age predicted maximum heart rate; in all the children the heart rate exceeded 170 beats/minute. Throughout the exercise period the subjects inspired air cooled by passage through a heat exchanger which consisted of a domestic freezer containing multiple baffles. The temperature of the inspired air was monitored for each test and was consistently between +2°C and −2°C. Nose clips were used to prevent breathing air at room temperature. FEV_1 was measured before exercise and at five, 10, and 15 minutes after cessation of the six minute exercise. The best of three efforts was recorded by each child for each episode of measurement. The airway response to exercise was calculated as the percentage fall of FEV_1 from baseline, and the maximum fall was used for analysis.

STATISTICAL ANALYSIS

Data obtained from the second questionnaire were analysed for comparability between the two groups by parametric or non-parametric methods as appropriate. The χ^2 test was used for qualitative data and the two tailed t test for quantitative data. Bronchial hyperreactivity was defined as a fall in FEV_1 of at least 10% from the baseline level. Variables that significantly discriminated for bronchial hyperreactivity were entered into a stepwise discriminant analysis procedure. The possible confounders were sex, gestational age, birth weight, provision of ventilator support, wheeze and frequency of wheeze, shortness of breath and frequency of breathlessness, tightness and frequency of tightness of chest, awareness of diagnosis of asthma, parental smoking, and the reported presence of damp and mould in the house. The analyses were performed using the SPSS package on the University of Aberdeen's main frame computer.

Permission to perform the study was obtained from the Director of Education and the Joint Ethical Committee of the University of Aberdeen and Grampian Health Board.

Results

CHARACTERISTICS OF THE STUDY POPULATION

One hundred and twenty eight children (69 boys and 59 girls) with respiratory symptoms and 26 asymptomatic children (13 boys and 13 girls) took part in the study. The median age for the children was 11·5 years (range 9–14 years). The mean height was 143·5 cm (range 121·4–165·0 cm), and the mean weight was 37·1 kg (range 30·7–69·7 kg). The mean pre-exercise FEV_1 was not significantly different in the two groups studied (table 1).

PERINATAL EVENTS

Data on perinatal events are presented in table 2. Only one child who showed bronchial hyperreactivity was born before 36 weeks gestation. None of the 24 children who weighed <2·5 kg showed bronchial hyperreactivity, and only one of six children who had required ventilatory support in the newborn period showed bronchial hyperreactivity.

PREVALENCE OF SYMPTOMS

Bronchial hyperreactivity was identified in 15 of 128 symptomatic children and in one

Table 1 Demographic and clinical data on asymptomatic and symptomatic children

	Asymptomatic (n=26)	*Symptomatic (n=128)*
Sex		
Male	13	69
Female	13	59
Mean age (years)	11·6	11·5
Mean weight (kg)	38·7	36·7
Mean height (cm)	146·5	143·1
Mean pre-exercise FEV_1 (% predicted)	94·1	94·1
Mean post exercise FEV_1 (% predicted)		
At 5 min	95·4	91·2
At 10 min	95·5	94·1
At 15 min	96·4	94·0

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Table 2 Data on perinatal factors

	BHR positive	BHR negative	p*
Birth weight			
< 2·5 kg	0	24	< 0·05
≥ 2·5 kg	15	89	
Gestational age			
< 36 weeks	1	9	> 0·05
≥ 36 weeks	14	104	
Provision of ventilator support			
Yes	1	5	> 0·1
No	14	108	

BHR—bronchial hyperreactivity.
*p values measured by Fisher's exact test (one tailed)

asymptomatic child. Fourteen children with bronchial hyperreactivity complained of wheeze and nine wheezed frequently (six or more episodes in the past year). Thirteen children with bronchial hyperreactivity complained of shortness of breath and 10 children complained of six episodes or more of shortness of breath in the last year. Ten children complained of tightness of the chest whereas only five children complained of frequent tightness of the chest (more than six episodes in the last year).

ATOPIC DIAGNOSIS

The parents of 13 of 15 children with bronchial hyperreactivity were aware of the diagnosis of asthma. Seven children with bronchial hyperreactivity had a history of eczema and 10 had a history of hay fever. The parents of four children with bronchial hyperreactivity had a history of asthma.

MEDICATION HISTORY

Twelve of 51 children on bronchodilators, six of 18 children on inhaled corticosteroids, and four of eight children on sodium cromoglycate demonstrated bronchial hyperreactivity.

ENVIRONMENTAL EFFECTS

Data on environmental factors are presented in table 3. Damp and mould were reported to be present in the homes of three children with bronchial hyperreactivity. The prevalence of smoking in the household was similar for both groups of children (table 3).

Table 3 Data on environmental factors

	BHR positive	BHR negative	p*
Prevalence of damp housing			
Yes	3	11	> 0·2
No	12	102	
Prevalence of mould in the house			
Yes	3	9	> 0·1
No	12	104	
Prevalence of smoking in household			
One smoker	6	37	
Two smokers	3	45	> 0·2
Three smokers	6	31	

Pearson's correlation coefficient = 2·318

BHR—bronchial hyperreactivity.
*p values measured by Fisher's exact test (one tailed)

Table 4 Summary of discriminant analysis of the variables used to predict bronchial hyperreactivity

Variable	Wilk's lambda	Significance
Birth weight	0·797	0·035
Ventilator support	0·522	0·002

DISCRIMINANT ANALYSIS

Gestational ages and the provision of ventilator support were significant (p < 0·001) discriminators of bronchial hyperreactivity. These variables correctly grouped 88·7% of the population studied (table 4).

Discussion

In this study cold air enhanced exercise in a laboratory setting identified bronchial hyperreactivity in 13 out of 58 children whose parents were aware of the diagnosis of asthma and in only two out of 69 children with symptoms whose parents were unaware of the diagnosis of asthma. Testing added very little information that was not already available from the respiratory questionnaire.

Respiratory questionnaires are frequently used to study the prevalence of asthma; they are usually based on those developed by the American Thoracic Society[10] or the World Health Organisation.[11] This study was primarily designed to examine the changes in the prevalence of asthma over a 25 year period in Aberdeen. It was therefore necessary to base our questionnaire on the questions which had been asked in the MRC Medical Sociological Unit screening questionnaire in 1964 (unpublished) and on the questions used by Dawson and colleagues. We recognise that this necessary restriction makes it difficult to compare our results with those obtained using the internationally accepted questionnaires already cited.

Compared with figures of 60–70% positive exercise tests obtained in hospital based studies of wheezy children of comparable ages,[12 13] the incidence of bronchial hyperreactivity was low in all groups in our population. Exercise testing on a bicycle ergometer enhanced by cold air has been used as part of the routine evaluation of asthmatic subjects referred to the hospital asthma clinic and we have found comparable results with other hospital based studies.[12 13]

The exercise test was carried out by the same person (TN) to minimise observer variation and to ensure consistency in technique. Repeatability studies were not carried out as this was part of a much larger clinicoepidemiological study and there were time constraints to meet. Pierson *et al*,[14] however, have shown that exercise testing using a bicycle ergometer is as repeatable as a running test. It is therefore unlikely that the low incidence of

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bronchial hyperreactivity represents a problem with our technique which was consistent between patients and provided an adequate exercise challenge; no bronchodilator therapy was allowed within at least 12 hours of the test.

Although we did test patients who were on anti-inflammatory drugs which are known to reduce bronchial hyperreactivity, these accounted for only 26 of 128 children (18 on inhaled corticosteroids, eight on sodium cromoglycate) and 10 (six on inhaled corticosteroids, four on sodium cromoglycate) of these children did, in fact, demonstrate bronchial hyperreactivity. We used a fall in FEV_1 of only 10% to define bronchial hyperreactivity, which is the lowest fall in common use for this purpose. It is more likely that the low incidence of bronchial hyperreactivity reflected the selection of children on the basis of their symptoms however mild, rather than because a clinical diagnosis of asthma was suspected or established. In our own everyday clinical experience a cold air exercise test, performed exactly as described above, is a useful adjunct to the diagnosis of asthma at the hospital asthma clinic.

Children from a community based survey are likely to have less severe symptoms, and hence less severe bronchial hyperreactivity, than those attending hospital,[4 5] a point made by Fourie and Joubert[15] who stated that the sensitivity of exercise as a test for asthma in individual patients may vary from 0% in very mild asthmatics to 100% in severe asthmatics. Although our questionnaire focused on frequency rather than severity of symptoms, it was clear that bronchial hyperreactivity was most common in those children with frequent wheeze and frequent shortness of breath (60% of those who demonstrated bronchial hyperreactivity complained of these two symptoms). It was notable, however, that even in the 58 children in whom a diagnosis of asthma was already known to the parents, bronchial hyperreactivity was present in only 13 children.

In the children we studied low birth weight was associated with a significantly lower prevalence of bronchial hyperreactivity (table 2). This contrasts with the finding of Rona *et al*[16] who showed a strong association between gestational ages and wheeze. Given the small numbers involved, however, and the fact that gestational age and birth weight were based on maternal recollection, we feel that it would be inappropriate to place too much emphasis on this finding as our numbers were not large enough to make valid observations.

Although in most cases in whom we demonstrated bronchial hyperreactivity the parents gave exercise as a trigger, it is surprising that only 11 of the 70 children who complained of exercise induced wheeze tested positive in a laboratory setting. This may be because exercise in the laboratory is a single stimulus, whereas playing outdoors may result in multiple complementary stimuli to bronchoconstriction—for example, excitement and other emotional stimuli, exposure to pollens, other allergens, and exposure to atmospheric pollutants.

In common with other studies we found that there are some apparently healthy individuals who develop evidence of bronchoconstriction after exercise.[4 5] In our study no children complained of symptoms in the absence of a fall in FEV_1 of more than 10%.

We conclude that exercise testing is not a useful adjunct in establishing the diagnosis of asthma.

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