

The prevalence of exercise-induced bronchoconstriction in Cape Town schoolchildren

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Summary

An attempt was made to determine: (i) the prevalence of exercise-induced bronchoconstriction among white and coloured schoolchildren in Cape Town; and (ii) the validity of an exercise test for the diagnosis of asthma in the general population. Children (698 white and 494 coloured) were randomly drawn from schools in the northern suburbs of Cape Town. Each child participated in a standard 6-minute exercise test and spirometric measurements were taken before and 10 minutes after exercise with a portable spirometer. The diagnosis of asthma was based on a questionnaire and personal questioning and included those children who, in the past or at present, suffered episodic or continuous airflow obstruction, which was responsive to a bronchodilator. The criterion for the diagnosis of exercise-induced bronchoconstriction was a 10% decline in forced expiratory volume in 1 second after exercise. The prevalence of exercise-induced bronchoconstriction was significantly higher among white children (5,87%) than coloured children (4,05%). The sensitivity of the exercise test was 0,31 and the specificity 0,97. In contrast to the results of hospital-based studies, the negative predictive value of an exercise test (95%) was found to be greater than the positive predictive value (46%). It is therefore concluded that exercise testing is not a useful screening test for epidemiological use; it is probably useful as a challenge test for detecting asthma in the individual patient when the likelihood of the disease is high.

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It is claimed that bronchial asthma affects 2 - 6% of the world's population,¹⁻⁴ and that 70 - 80% of all asthmatics also suffer from exercise-induced bronchoconstriction. Most studies of exercise-induced bronchoconstriction have been limited to hospital or clinic patients and, due to sample bias, these prevalence rates are unlikely to be representative of the prevalence in the general population.^{1,2,5} In the few studies on the prevalence of exercise-induced bronchoconstriction among the general population,^{3,6,7} the differences in reported prevalence rates may be due largely to non-uniformity in the definition of asthma and diagnostic criteria for exercise-induced bronchoconstriction.^{8,9}

The western Cape is regarded as a natural endemic area for allergic asthma.¹⁰ It is estimated that the total number of patients with acute asthma admitted to Groote Schuur Hospital represents 10% of all patients seen in the Casualty Department.¹¹ During a 6-month period, 15,2% of 2469 coloured medical admissions to Tygerberg Hospital were for acute asthma, compared with 3,2% of 622 white admissions.¹⁰ These figures show that asthma is a major problem in both the white and coloured ('mixed race') population of the western Cape.

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However, the prevalence of asthma and exercise-induced bronchoconstriction in the different population groups in this area is not yet clearly established.

Several workers have suggested that an exercise test is a valid — sensitive and specific — test for the diagnosis of clinical asthma.¹²⁻¹⁴ However, these findings are based on results from studies on exclusive groups, such as hospital or asthma clinic patients; it is thus questionable whether they also apply to exercise testing among the general population. The questions thus arise: to what extent does exercise-induced bronchoconstriction relate to asthma, and is an exercise test useful in the diagnosis of asthma in the general population?

Subjects and methods

This cross-sectional study was conducted in the northern suburbs of Cape Town among 1192 white and coloured children between the ages of 6 years and 20 years. The 698 white children were drawn from 6 schools serving predominantly social classes 1 and 2 and the 494 coloured children were drawn from 3 schools serving predominantly social classes 3 and 4.

All subjects were randomly selected from their physical education classes: every child in the class was assigned a number corresponding to his/her desk position in the class and approximately 25 numbers were then randomly selected from each school class (approximately 125 children per school) by using a computerised Random Number Generator (Statgraphics V. 2.1). After random selection, each child received a personal general health questionnaire, which also enquired specifically into any history of respiratory disorders. Together with the health questionnaire, the parents also received a consent form, which fully explained the nature and aims of the study, the potential risk of developing bronchospasm and its immediate treatment if the child became symptomatic.

The parents were required to complete and sign both forms before the child was admitted into the study group. All questionnaires were adequately completed and returned; only 1 child could not participate because her parents objected to the study. The study was approved by the Ethics Committee of the Faculty of Medicine, University of Stellenbosch.

For the purposes of this study, asthma was defined as the occurrence of episodic or continuous airflow obstruction in the past or at present, which was responsive to a bronchodilator; this information was obtained from the parents and by direct questioning of the child, using the relevant section of the epidemiological questionnaire recommended by the American Thoracic Society (ATS).¹⁵ Asthmatic children were asked to withhold anti-asthmatic drugs for at least 12 hours before exercise; no child was taking long-acting oral bronchodilators. Compliance with this request was confirmed by direct questioning before testing. Four white asthmatic subjects, who were clearly symptomatic on the day of testing, were excluded from the test but, because they complained of symptom aggravation by exercise, were taken into account in determining the prevalence of exercise-induced bronchoconstriction.

A portable pneumotachometer-type spirometer (Minato Autospiro) was used for the spirometric measurements and was calibrated daily using a calibration syringe. After the

measurement of height and weight, a standardised 6-minute running test was performed on a rugby field. According to many workers,^{16,17} this 6-minute running test, which guarantees a heart rate of 170/min, is the best provocation for exercise-induced bronchoconstriction. This heart rate response was confirmed in a pilot study and we therefore did not measure pulse rate in the definitive study.

Spirometric measurements were taken before and 10 - 15 minutes after the exercise test.¹⁶ At least three forced expiratory volume in 1 second (FEV₁)-measurements, of which two values were within 5%, were taken on each occasion and the test selected for calculation had the greatest sum of FEV₁ and forced vital capacity (FVC).¹⁸ A decline in FEV₁ of more than 10% of the baseline value 10 - 15 minutes after exercise was used for the diagnosis of exercise-induced bronchoconstriction.¹⁹

A group of healthy, age-matched children (37 white and 20 coloured) without a history of respiratory disease and with a negative exercise test were randomly selected from the original sample. A comparison was made between the pre-exercise pulmonary function of children with exercise-induced bronchoconstriction and the age-matched controls, using the paired Student's *t*-test.

The prevalence of exercise-induced bronchoconstriction was calculated as the ratio between the number of subjects with a positive response to the exercise test (a greater than 10% reduction in FEV₁ after exercise) and the total number of subjects. For convenience, the ratio was expressed as a percentage. Differences in prevalence rates between the groups were tested for statistical significance using the χ^2 test. The sensitivity and specificity and the positive and negative predicted values of the exercise test were calculated with standard formulae.²⁰

Results

Table I shows the anthropometric data of the children who completed the exercise test; the coloured children were both shorter and lighter. According to the response to the health questionnaire and direct questioning, 65 white children and 25 coloured children had a history of asthma, either in the past or at present. At the time of the study, 39 whites (5,6%) and 16 coloureds (3,2%) were receiving treatment for asthma, while the remaining children with a history of asthma had been symptom-free for at least 2 years. The prevalence of exercise-induced bronchoconstriction was 5,87% among white children

(41/698) and 4,05% among coloured children (20/494) — a statistically significant difference ($P < 0,01$). Table II relates the clinical history of asthma to the prevalence of exercise-induced bronchoconstriction in the sample.

TABLE II. PREVALENCE OF EXERCISE-INDUCED BRONCHOCONSTRICTION IN SAMPLE POPULATION IN RELATION TO ASTHMA HISTORY

	Whites (N = 698)	Coloureds (N = 494)
History of asthma	35,4% (23/65)	20,0% (5/25)
No history of asthma	2,84% (18/633)	3,20% (15/469)

The age-specific prevalence rates of exercise-induced bronchoconstriction (expressed as a percentage of the number of children from each age group) are shown in Fig. 1. Exercise-induced bronchoconstriction was more prevalent in coloured children at a younger age (6 - 9 years) than among white children. The ratio between boys and girls with exercise-induced bronchoconstriction in the white population was equal (1:1), but was 1:2 in coloured children.

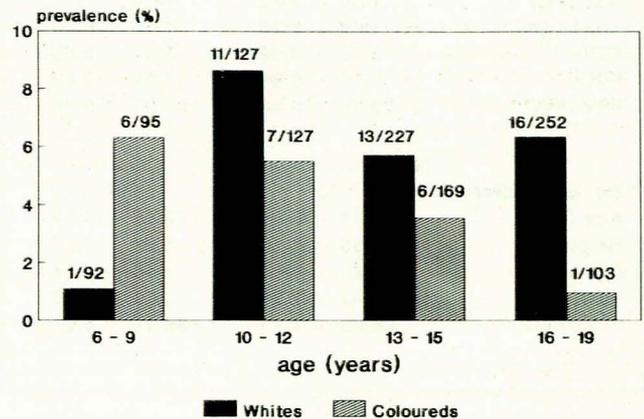


Fig. 1. Age distribution of children with exercise-induced bronchoconstriction. Note the higher prevalence in younger coloured children.

TABLE I. ANTHROPOMETRIC DATA FOR WHITE AND COLOURED CHILDREN

	Whites (N = 698)		Coloureds (N = 494)	
	Mean ± SD	Range	Mean ± SD	Range
Boys and girls				
Age (yrs)	13,7 ± 3,2	6-19	12,5 ± 3,3	6-20
Height (m)	1,58 ± 0,16	1,12-1,92	1,46 ± 0,16	1,07-1,78*
Weight (kg)	51,5 ± 15,7	19,1-107,3	39,6 ± 13,0	16,8-75,0*
Boys				
Age (yrs)	13,6 ± 3,2	6-19	12,7 ± 3,3	6-19
Height (m)	1,61 ± 0,18	1,12-1,92	1,48 ± 0,17	1,07-1,78*
Weight (kg)	53,1 ± 17,0	19,1-97,7	39,4 ± 13,1	17,3-75,0*
Girls				
Age (yrs)	13,8 ± 3,3	6-19	12,3 ± 3,3	6-20
Height (m)	1,60 ± 0,1	1,13-1,83	1,44 ± 0,15	1,07-1,7*
Weight (kg)	49,8 ± 14,1	19,6-107,3	39,6 ± 12,8	16,8-70,5*

* $P < 0,01$.

Boys: white N = 349, coloured N = 255; girls: white N = 349, coloured N = 239.

The specificity of the exercise test was 0,97, but the sensitivity was much lower: 0,46. The positive and negative predictive values were calculated from the sensitivity and specificity of the exercise test and the prevalence of the disease. The negative predictive value, an indicator of the number of healthy children with a negative exercise test, was 95% and was much higher than the positive predictive value of 46%.

The results of pulmonary function testing before exercise in children who developed exercise-induced bronchoconstriction and in a reference group of healthy children who did not develop exercise-induced bronchoconstriction (matched for sex, age and height) are shown in Table III. Asthmatic children who developed exercise-induced bronchoconstriction had lower FEV₁ and FEV₁/FVC values than the reference group; lung function in the group of children with exercise-induced bronchoconstriction, but no history of asthma, did not differ significantly from the lung function in the reference group of healthy children.

TABLE III. PRE-EXERCISE PULMONARY FUNCTION IN WHITE AND COLOURED CHILDREN WITH EXERCISE-INDUCED BRONCHOCONSTRICTION AND CONTROLS (MEAN ± SD)

	History of asthma	Controls
No. of children	28	28
Age (yrs)	14,0 ± 2,22	14,0 ± 2,22
Height (m)	1,57 ± 0,10	1,57 ± 0,10
FEV ₁ *	3,16 ± 0,99	3,61 ± 0,65
FVC	4,36 ± 0,89	4,39 ± 2,20
FEV ₁ /FVC*	72,48 ± 6,40	82,23 ± 5,56
	No history of asthma	Controls
No. of children	33	33
Age (yrs)	12,44 ± 6,69	12,44 ± 6,69
Height (m)	1,50 ± 0,16	1,50 ± 0,17
FEV ₁	3,0 ± 1,14	3,18 ± 1,17
FVC	3,44 ± 1,35	3,59 ± 1,38
FEV ₁ /FVC	88,09 ± 7,25	89,46 ± 6,27

*P < 0,01.

Discussion

The primary purpose of this study was to determine the prevalence of exercise-induced bronchoconstriction in the school-going population and, secondarily, to determine the validity of an exercise test for the diagnosis of asthma. The prevalence of exercise-induced bronchoconstriction was significantly higher among white children than coloured children and the exercise test proved to be more useful in clinical practice, than in epidemiological studies.

Although this study was limited to a sample population of the northern suburbs of Cape Town, there is no reason to believe that the prevalence of exercise-induced bronchoconstriction is different from other Cape Town suburbs. We suggest, therefore, that the results of this study are representative of the school-going population in Cape Town. Since there may be an early school drop-out factor among disadvantaged (ill) children, we are cautious in extrapolating our findings to the general population; the magnitude of the error of such an extrapolation is, however, difficult to estimate.

Prevalence of asthma and exercise-induced bronchoconstriction

The prevalence of asthma among the various racial and

geographical groups in South Africa is unknown, except for young Xhosa children.⁷ Reported figures thus far are based on mortality rates and reports of emergency hospital admissions due to acute asthma.^{10,11} It has been roughly estimated that approximately 10% of whites in the northern suburbs of Cape Town have asthma,²¹ but there were no data for the coloured population.

Reported prevalence rates for exercise-induced bronchoconstriction among asthmatics vary between 63% and 81%.^{1,2,8} The only reported prevalence rates among children who were randomly selected from the general population (whites) were 7% in the USA¹ and 8,6% in Israel.⁶ These rates are higher than the reported prevalence of asthma (2 - 6%)^{2,8} and are somewhat higher than the prevalence reported in our study among the school-going population. It is not certain that this difference is significant.

Contrary to our hypothesis, we found that the prevalence of exercise-induced bronchoconstriction was significantly lower in coloured children than in white children. We suspect, however, that early school drop out of asthmatic coloured children may explain the higher prevalence of exercise-induced bronchoconstriction in the 6 - 9-year-old group and lower prevalence in the older coloured children. While the low prevalence among coloured children is similar to the finding of Van Niekerk *et al.*⁷ among 5 - 9-year-old urban Xhosa children (3,17%), it is in disagreement with hospital data, which suggests that more coloured children are being treated for asthma in hospital than white children.¹⁰ However, it is also possible that published hospital reports are merely a reflection of the fact that whites have more ready access to private medical services, while coloureds use mainly provincial hospital services from which the hospital-based studies are reported.

Pulmonary function and exercise-induced bronchoconstriction

It seems from this and other studies^{1,8} that there are some apparently healthy children who develop bronchoconstriction after exercise, although they are not clinically diagnosed or even symptomatic asthmatics: the 3% of the schoolchildren in our study who developed bronchoconstriction after exercise had no history of asthma or other respiratory complaints and were considered to be healthy. In comparison with a reference group, these children did not present with abnormal pre-exercise pulmonary function. On the other hand, approximately 32% of children who had a history of asthma developed exercise-induced bronchoconstriction and this group had pre-exercise pulmonary function that was significantly worse than in the reference group. The asymptomatic children may thus be a subclinical fringe group of 'bronchial hyper-responders'. In a future study, other tests of bronchial hyper-reactivity in this group of children would provide evidence to test this hypothesis.

The reported frequency of smoking in children with exercise-induced bronchoconstriction and the reference group was minimal. The frequency rates were much lower than those reported by Benatar²² and we suspect that the response of the children to the questionnaire is not an accurate reflection of the prevalence of smoking. We were therefore unable to reach any conclusions with regard to the influence of smoking on exercise-induced bronchoconstriction or on lung function.

Exercise-induced bronchoconstriction as a predictor for asthma

Although the specificity of the exercise test in this study was 0,97, the sensitivity of the exercise test was only 0,31. We contend that the previously reported high sensitivity of exercise

testing (0,78 and 0,99^{1,23}) reflects the severity of asthma in children attending hospital-based clinics and that the sensitivity in the general population is much lower. Another factor that might influence our results is the accuracy of the diagnosis of asthma. It is possible that reliance on sections of the ATS questionnaire resulted in an inaccurate estimate of the true prevalence of asthma. On the other hand, the rates reported here are not very different from those reported elsewhere;¹⁻⁴ furthermore, the children in our study with exercise-induced bronchoconstriction and a history of asthma had lower FEV₁ and FEV₁/FVC values than a reference group of children with no history of asthma.

According to Fourie and Joubert,²⁴ 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. In the testing of individual patients in the clinical setting, it should be remembered that only one-half to one-third of asthmatics from the school-going population have a positive exercise test. Therefore, although a positive result may suggest the presence of asthma, a negative result does not entirely exclude asthma, because it may indicate a patient falling in the mild-to-slight range of severity. It seems, then, that exercise testing is not a useful screening test for identifying asthmatics in epidemiological studies. Furthermore, exercise is unlikely to confirm the diagnosis of asthma when the clinical suspicion is low; it is probably useful as a test in the individual patient when the likelihood of the disease is high.

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