Prevalence of exercise-induced bronchospasm in Thokoza schoolchildren

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Background. Asthma is a common childhood illness, with a prevalence of 1 in 10 children. Exercise-induced bronchospasm (EIB) is a common feature of asthma and is found more often in children than in adults.

Objective. To determine the prevalence and potential impact of various factors on the prevalence of EIB in Thokoza schoolchildren.

Methods. Data were collected on respiratory health and the home environment of children living in Thokoza, Gauteng. A total of 475 9- and 10-year-old children performed the free-running asthma screening test (FRAST). An abnormal response to FRAST was defined as a reduction in the post-exercise peak flow of more than 15% of the pre-exercise value, at 3- and 10-minute intervals. All children who had a fall in post-exercise flow rate (PEFR) of more than 15% on 2 occasions after FRAST were classified as having EIB.

Results. Using the above criteria to diagnose EIB, an overall prevalence rate of 7.26% (95% confidence interval (CI): 4.5 - 10.3%) was recorded. A less rigorous definition of EIB is a fall in PEFR of more than 10% on 2 occasions after FRAST, and if this was used then the prevalence of EIB was 15.69% (95% CI: 10.6 - 20.8%). Difficulty breathing and a tight chest were the most prevalent respiratory symptoms in children with EIB (odds ratio (OR): 1.79, 95% CI: 0.49 - 6.49 and OR 1.69, 95% CI: 0.72 - 3.99, respectively). The use of gas and electricity as domestic fuels was the strongest risk factor associated with EIB, as shown by logistical regression analysis using an adjusted OR in a reduced model (OR 2.44, 95% CI: 0.71 - 8.44 and OR 2.33, 95% CI: 0.59 - 9.24, respectively).

Conclusion. The prevalence of EIB reported in this study is higher than that reported in studies from other African countries, with the exception of a study from Kenya. Findings of the present study suggest that there may be a trend towards increasing prevalence of EIB in South African urban areas.

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The prevalence of childhood asthma has increased in the past 2 decades and asthma has become a common problem in industrialised countries.[1-3] Studies from Africa have shown that the prevalence rates are higher in urban than rural areas, and the change from a traditional to a Western lifestyle has been implicated as a possible cause.[3-6] Earlier prevalence studies[5,6] suggested that exercise-induced bronchospasm (EIB) may be underdiagnosed and underreported. The aims of this study were therefore to establish the prevalence of EIB in children in urban industrialised areas and to determine possible associated factors.

Methods

Study sites

A cross-sectional survey was undertaken of 9- and 10-year-old children in the Thokoza area. Thokoza is situated on the East Rand in Gauteng, 30 km south-east of Johannesburg, with an altitude of approximately 1 700 m above sea level. It is a poor urban area, surrounded by industries, which may contribute to high pollution levels. Approximately half of Thokoza consists of informal settlements with no electricity, hence open fires and paraffin stoves are used for cooking. This practice and considerable motor vehicle pollution in the area exacerbate the pollution levels. There are 39 primary schools in Thokoza. Eleven of the 39 schools were selected for this study, using a stratified random sampling technique to represent each part of Thokoza. The random numbers were generated by a computer, using the SPSS 10.0 for Windows programme.

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Subjects

Permission to conduct the study was obtained from the CRHS of the University of the Witwatersrand. Headmasters from the selected schools were provided with informed consent forms; these were distributed to the children by their class teachers. The informed consent forms explained the nature and aims of the study, the possibility of precipitating bronchospasm and how bronchospasm is managed, and requested parental permission for children to be included in the study.

Systematic random sampling was used to select 9- and 10-year-old children from each participating school in the Thokoza area. A total of 506 primary school children in grades 3 and 4 were selected. Children who attended schools for physically or mentally handicapped children were not included. All 9 - 10-year-old children at 11 schools were grouped. Every second child was then systematically sampled for inclusion in the study.

Inclusion criteria

All 9- and 10-year-old children with signed consent forms were included in the study.

Exclusion criteria

Children were not included in the study if: (*i*) they were unable to complete the free-running asthma screening test (FRAST); (*ii*) they had current symptoms of an acute asthma attack (post-exercise flow rate (PEFR) < 60% predicted for height); (*iii*) they had had an upper respiratory tract infection during the month before the study; or (*iv*) there was no parental consent.

Procedure

The selected children were assigned numbers that they used throughout the study. The child presented his/her number at each of the following stations.

Station 1

Here each child was interviewed using a validated and reliable data collection sheet. Questions about the child's history of respiratory symptoms, personal characteristics, home environment and social history were included.

Station 2

Each child's temperature (degrees Celsius), weight (kg) and height (cm) were measured, and ear, oral and pharyngeal assessments were perfomed. Three pre-exercise peak flow readings were recorded and the highest of the 3 readings was taken as the final reading. The highest reading was compared with age and height-predicted data and if the child presented with a PEFR < 60% of predicted, the exercise challenge test was not performed.

Station 3

Children were also encouraged to run as fast as they could for 6 minutes, to achieve a maximum heart rate of 80 - 85% corrected for age. The children's heart rates were monitored throughout the exercise challenge test using a polar heart rate monitor. If children did not run at 80 - 85% of the maximum heart rate predicted for age, the monitor alarmed and the research assistant made the appropriate adjustment to the running speed.

Station 4

PEFR was recorded at 3- and 10-minute intervals after the free FRAST. On each occasion 3 readings were taken and the highest of the three readings was recorded.

Children who presented with asthma symptoms were managed with nebulisation by primary health care nursing sisters, who then referred the children to a clinic. All children who required treatment were re-examined before they returned to class, and no child required further treatment.

Using the same 8 investigators throughout the study ensured consistency of the data collection. The tests were conducted between 08h00 and 12h00 hours for 11 days from 20 August 2001 to 5 September 2001. Relative humidity and temperature were recorded; as there was little day-to-day variation in these conditions during this period, humidity and temperature were considered to have no effect on the study. Values were obtained from the Johannesburg meteorological station on each day. To minimise the effect of temperature variation, most assessments were conducted from 09h00 to 12h00. All children who participated in the study were kept in one classroom for at least 1 hour before the study to prevent them from engaging in running games during that time, which would have tired them before engaging in the FRAST.

Statistical considerations

Because of the assumed homogeneity of the Thokoza population with regard to EIB, each of the 39 schools was viewed as a cluster, with size of the cluster equal to the number of 9- and 10-year-old children in the school for whom there was consent. The intra-class correlation was expected to be very small (assumed to be 0.05). This assumption meant that members of the cluster were poorly correlated with regard to the tendency to EIB, as opposed to members of the same family unit.

The sample size was calculated using the following formula: number of clusters to be sampled = design effect × the size of a simple random sample ÷ the number of subjects in a cluster, where design effect = 1 + (cluster size - 1) × the intra-class correlation. A 7% accuracy was used, as this enabled the study to be completed in 11 days, thus minimising the effect of seasonal temperature changes.

In a univariate analysis design, crude odds ratios (ORs) for EIB response along with their 95% confidence intervals (CIs) were determined, followed by a multivariate analysis using logistical regression to determine adjusted ORs from both a full model and a reduced model.

Results

Four hundred and seventy-five children performed the FRAST, of whom 474 completed the test. Six of the 474 children who completed the FRAST were said to be asthmatic. All the children with asthma had an abnormal response to exercise, whereas among the remaining 468 supposedly healthy children there were 34 abnormal FRASTs.

All children who had a fall in PEFR of more than 15% on 2 occasions after the FRAST were classified as having EIB. Using the above criteria to diagnose EIB, there was an overall EIB prevalence of 7.26% (95% CI: 4.5 - 10.3%) (Table I). The results for the 468 subjects were then analysed to determine how many tests would have been abnormal if a cut-off point of 10% or 20% peak flow reduction had been used. The results were 15.69% (95% CI: 10.6 - 20.8%) and 3.18% (95% CI: 1.8 - 4.6%), respectively. The results in Table I show that the prevalence rates decreased with an increase in the criteria for reduction of PEFR. The results in Table II show that the prevalence of EIB in both girls and boys did not differ significantly with age (p = 0.02), but the trend of odds was significant (p = 0.02).

In a multivariate analysis in a full model using an adjusted OR, difficulty breathing at a 10-minute interval (OR 2.03, 95% CI: 0.58 - 7.05), tight chest at a 3-minute interval (OR 2.96, 95% CI: 1.18 - 7.41) and tight chest with chest pain (OR 2.46, 95% CI: 0.78 - 7.71) were respiratory symptoms most often associated with EIB (Table III). In an adjusted OR for a reduced model, difficulty breathing at a 10-minute interval and tight chest at a 3-minute interval (OR 1.79, 95% CI: 0.49 - 6.49 and OR 1.69, 95% CI: 0.71 - 3.99) emerged as respiratory symptoms most often associated with EIB in the children in this study.

In the multivariate analysis in a full model using an adjusted OR, use of gas as a domestic fuel emerged as the strongest factor associated with EIB in children (OR 1.81, 95% CI: 0.47 - 6.90). Other significant associations were living in a brick house (OR 1.33, 95% CI: 0.54 - 3.28), the presence of smokers in the house (OR 1.42, 95% CI: 0.63 - 3.18), prolonged stay in the Thokoza area (OR 1.39, 95% CI: 0.36 - 5.24), and use of coal and electricity as domestic fuel (OR 1.39, 95% CI: 0.63 - 3.06 and OR 1.33, 95% CI: 0.19 - 8.99, respectively). Of particular interest was that living in a brick house and use of coal as a domestic fuel were significantly associated with EIB in children when studied in association with other environmental factors and changes in symptoms. However, no significant association with EIB in children was observed with living in a brick house or use of coal as a domestic fuel when each environmental factor was studied independently.

Using an adjusted OR in a reduced model, only the use of gas and electricity as a domestic fuel emerged as strong factors associated with EIB in children in this study.

Table I. Prevalence of EIB with peak flow reductions of 10%, 15% and 20%

Fall in PEFR (%)	Prevalence of EIB (% (*N*))	95% confidence interval (%)
10	15.69 (73/468)	10.6 - 20.8
15	7.26 (34/468)	4.5 - 10.3
20	3.18 (14/468)	1.8 - 4.6

Table II. Prevalence of exercise-induced bronchospasm by both age and gender at 15% reduction in PEFR

Gender	Age (yrs)	Number of children	Odds ratio*	Prevalence of EIB† (% (*N*))
Female	9	191	0.110	9.94 (19/191)
Female	10	84	0.073	6.80 (7/103)
Male	9	103	0.077	7.14 (6/84)
Male	10	88	0.02	2.2 (2/88)

*p = 0.02 (trend).
†p = 0.22 (difference).

Discussion and conclusion

The main findings in this study are the high prevalence rates of EIB in Thokoza school children, rates higher than those reported for children in Cape Town.[4] In the latter study children were from Guguletu, an area similar to Thokoza. In the Cape Town study, Van Niekerk[4] used a 15% decrease in PEFR to define EIB, and found a 3.17% EIB prevalence rate.

Table III. Comparison of EIB with regard to risk factors in a full and reduced model using logistical regression

Risk factor/ symptom	Adjusted OR full model (DB)	95% CI for adjusted OR (full)	Adjusted OR reduced model	95% CI for OR (reduced model)
Smokers in the home	1.42	(0.63 - 3.18)		
Animals in the home	0.94	(0.53 - 1.68)		
Brick house	1.33	(0.54 - 3.28)		
Windows in the house	0.85	(0.08 - 8.19)		
Domestic use of paraffin	0.47	(0.79 - 2.80)		
Domestic use of coal	1.39	(0.63 - 3.06)		
Domestic use of gas	1.81	(0.47 - 6.90)	2.44	(0.70 - 8.43)
Domestic use of electricity	1.33	(0.19 - 8.99)	2.33	(0.59 - 9.23)
Prolonged stay in area	1.39	(0.36 - 5.24)		
Cough 03	0.28	(0.02 - 3.0)		
Cough 010	1.12	(0.32 - 3.87)		
Difficulty breathing 03	0.60	(0.19 - 1.89)		
Difficulty breathing 010	2.03	(0.58 - 7.05)	1.79	(0.49 - 6.49)
Tight chest 03	2.96	(1.18 - 7.41)	1.69	(0.71 - 3.99)
Tight chest 010	0.75	(0.29 - 1.91)		
Pain 03	0.24	(0.08 - 0.68)		
Pain 010	2.46	(0.78 - 7.71)		

03 = 3 min after exercise; 010 = 10 min after exercise; DB = design-based.

The criterion of a 15% drop in PEFR arose from the need to balance the specificity and sensitivity of the exercise challenge test in the detection of bronchial hyper-responsiveness in asthmatic patients, which is widely used in clinical practice and in the literature.[7] If a less rigorous definition had been used in this study, such as a 10% decrease in PEFR to define EIB, prevalence rates would have been more than double, i.e. 15.69% at 95% CI (10.6 - 20.8%). This study showed high prevalence rates compared with finding from other African countries, with the exception of Kenya.[3-6]

Eighty-four per cent of children diagnosed with EIB in this study had lived in the Thokoza area from birth. The high prevalence rate may be explained as being the result of prolonged exposure to high pollution from industrial and motor-vehicle emission.

Seventy to 90% of children who have asthma have EIB.[8] In this study the reason for including children with asthma was to provide an indication of the quality control of the testing. Six children had asthma and had an abnormal response to the FRAST. If their results had been included in the final results the prevalence of EIB would have been 9% instead of 7.26%. All the children with asthma managed to complete the exercise challenge test, which suggests that their disease was controlled. Only 1 child required nebulisation after the exercise challenge test because of wheezing.

An association was demonstrated between EIB and difficulty breathing, chest tightness, and tight chest with chest pain. However, the strongest associations with EIB were difficulty breathing and chest tightness. This finding is similar to that of other studies.[9-11]

This study strongly supports the suggestion that environmental factors are of importance in determining the prevalence of EIB in a given population. The prevalence of EIB in children, exposed to gas cookers was 64.71%. Children who are exposed to high hourly peak nitrogen oxide levels have an increased risk of developing asthma-like symptoms.[12] The above findings can be explained by sustained exposure to high levels of nitrogen oxide in association with greater time spent indoors.[12] The higher prevalence of EIB in girls than boys in this study may be explained by girls being exposed to higher concentrations of nitrogen oxide from gas cookers while assisting their mothers.

Use of gas or electricity as a domestic fuel is strongly associated with childhood EIB. Brick houses usually have electricity and the prevalence of EIB was observed to be higher in brick houses with electricity than that in shacks. More children in this study lived in brick houses than in shacks and most houses had windows. Having windows in the house was also associated with EIB, as shown by an OR of 0.49 (95% CI: 0 - 2.95). Of the 26 households without windows, 24 were shacks. The children living in shacks, where there was overcrowding, poor sanitation and a high incidence of infections, showed no association with EIB. This fact supports the notion that exposure to infection alters the immune response, suppressing immunoglobulin E (IgE) response to environmental stimuli. This means that activation of the Th1 (non-asthmatic) responses by bacteria could reduce the Th2 (asthmatic) response.[13,14]

The results are not clear-cut, and these findings should be explored further.

The prevalence of EIB in Thokoza is higher than previously observed in other studies. This might suggest a trend towards increasing prevalence of EIB in South Africa

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