

REGULAR ARTICLE

Prevalence of asthma and bronchial hyperreactivity in Danish schoolchildren: no change over 10 years

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ABSTRACT

Aim: To describe the point prevalence of current physician-diagnosed asthma and bronchial hyperreactivity (BHR) in 2001 among unselected Danish schoolchildren aged 6–17 years, compared with the prevalence from a similar study from 1990 to 1991.

Methods: Cross-sectional study using parental questionnaire on asthma and respiratory symptoms combined with a 6-min free running test with peak expiratory flow rate (PEFR) measurement ($n = 1051$, response rate 89.3%). Results were compared with those of a similar study in the same area from 1990 to 1991. Main outcome measures were current physician-diagnosed asthma or BHR in children without physician-diagnosed asthma measured by either a decrease in lung function after standardized running test and/or variability in PEFR on home monitoring.

Results: The prevalence of current physician-diagnosed asthma was 4.0% [95% confidence interval (CI) 2.7–5.3%] in 1990–1991 and 3.6% (95% CI 2.4–4.8%) in 2001. The prevalence of BHR was 3.2% (95% CI 2.0–4.4%) in 1990–1991 and 2.0% (95% CI 1.1–2.9%) in 2001. The combined prevalence was 7.2% (95% CI 5.4–8.9%) in 1990–1991 and 5.6% (95% CI 4.2–7.1%) in 2001.

Conclusion: The point prevalence of current physician-diagnosed asthma and BHR among unselected Danish schoolchildren aged 6–17 years was unchanged over 10 years between 1990–1991 and 2001.

INTRODUCTION

With repeated phases one and three questionnaire-based studies, the International Study of Asthma and Allergies in Childhood (ISAAC) has revealed a great deal of information about the prevalence and time trend of childhood asthma around the world (1). Danish schoolchildren, however, have not participated in the ISAAC studies. In Denmark, there have been only a limited number of studies on the prevalence and trend of asthma in schoolchildren using similar methods at different time points (2). Both internationally and in Denmark, only a few of the cross-sectional studies on asthma in schoolchildren that have been repeated over time have included objective measures such as lung function and bronchial hyperreactivity (BHR) tests (3–11).

During the period 1990–1991, a cross-sectional study (12) was carried out in Nordborg, a rural municipality in Denmark, to evaluate the point prevalence of physician-diagnosed asthma and BHR in an unselected population of Danish schoolchildren aged 6–17 years. The study used parental questionnaires, a 6-min free running test (F-RT) and follow-up of children with a positive F-RT and without

physician-diagnosed asthma. We used an identical method in exactly the same geographical area approximately 10 years later, to evaluate whether there had been a change in the point prevalence of physician-diagnosed asthma and BHR in Danish schoolchildren between 1990–1991 and 2001.

METHODS

This study included all 1051 children (541 boys and 510 girls; age 6–17 years) who attended the same three schools in Nordborg municipality that were included in the previous study (12). The parents of all the children were asked to complete a questionnaire concerning history of physician-diagnosed asthma, current physician-diagnosed asthma (asthma symptoms within the last 12 months), recurrent wheezy bronchitis (RWB) (previously and within the last 12 months), use of asthma medication, lung infection within the previous month and parental tobacco smoking. The children themselves were also asked whether they were smokers. These questions were identical to the questions in the previous study (12). In addition, the parents were asked

whether their child had experienced symptoms such as coughing, wheezing or shortness of breath when exercising, or decreased activity or difficulty in keeping up with children of the same age during sports. On the day of the F-RT, the children with asthma had been asked to take their usual asthma medication except for beta2 agonists.

Free running test

Free running tests were carried out at the schools in the autumn of 2001 by the sports teachers and supervised by the authors. Lung function was measured with mini-Wright peak flow metres as in the previous study (12), and the best value of three was registered. The peak expiratory flow rate (PEFR) values were measured before and 2–5 min after the 6-min continuous run. As a supplement to the previous study, a third PEFR was measured after 10 min to identify children with a later decrease in lung function. A positive F-RT was defined as a decrease in PEFR $\geq 15\%$. All children without physician-diagnosed asthma and with a positive F-RT were offered follow-up with further investigations at the outpatient clinic at the Department of Pediatrics, Sønderborg Hospital (Table 1). When comparing the point prevalence of asthma and BHR within the two studies, only children with a positive F-RT after 2–5 min were included (Group A), as this was the only group with possible BHR that was examined further in the previous study.

Follow-up of children at the outpatient clinic

A careful case history was taken by one of the authors with particular regard to previous asthmatic and atopic symptoms and allergy disposition. The children underwent a physical examination and a standardized running test (S-RT) on a treadmill for 6 min with an 8% incline; heart rate increased to at least 170–180 beats per minute. PEFR and forced expiratory volume in 1 min (FEV1) were measured before and repeatedly for up to 10 min after running. A positive S-RT was defined as a decrease in PEFR $\geq 15\%$ and/or a decrease in FEV1 $\geq 10\%$. Afterwards, a reversibility test was carried out with inhalation of 1.0 mg beta2 agonist (terbutaline) and PEFR and FEV1 were recorded after 10 min. A positive reversibility test was defined as an increase in PEFR $\geq 15\%$ and/or an increase in FEV1 $\geq 10\%$. Following the examination, patients monitored PEFR at home in the morning and evening for 3 weeks. Variability

in the morning-to-evening PEFR or day-to-day PEFR $\geq 15\%$ was defined as a positive test. BHR was defined as either a positive S-RT, a positive reversibility test, or variability in home-monitored PEFR $\geq 15\%$.

Statistical analysis

We used the chi-square test for contingency tables and the z-test for differences between two proportions as appropriate.

Ethical approval

The project was approved by the ethics committee for the local county (protocol number 2315-01). Informed consent was obtained from the parents and the children. The project was registered at The Danish Data Protection Agency.

RESULTS

Completed questionnaires, F-RTs and lung function measures were available for 89.3% (939/1051) of the children. These 939 children (466 boys and 473 girls) comprised the final population. [In 45 children, the questionnaires and parental consent forms were completed, but the children refused to participate in the F-RTs and were therefore not included in the study. Of these, seven children (15.6%) had a history of physician-diagnosed asthma. Five children (11.1%) had current physician-diagnosed asthma, which was a significantly higher proportion than in the group of children who participated in the F-RTs ($p < 0.025$)].

Children with physician-diagnosed asthma

According to the parental questionnaire, 88 children (9.4%) had a history of physician-diagnosed asthma [48 boys and 40 girls ($p = 0.33$)]. Thirty-four children (3.6%) had current physician-diagnosed asthma [20 boys and 14 girls ($p = 0.27$)]. Eleven children with a history of asthma (12.5%) ($p < 0.05$) and seven children with current asthma (20.6%) ($p < 0.01$) had a positive F-RT, which was significantly higher than in children without previously known asthma (54/851, 6.3%).

Children without physician-diagnosed asthma

Group A

Thirty-eight children (18 boys and 20 girls) without known asthma had a positive F-RT after 2–5 min. These children were all seen at the outpatient clinic for follow-up. In 19 children (7 boys and 12 girls), BHR was confirmed by the standardized tests (Table 2). In 19 children, all tests were normal at follow-up.

Group B

Sixteen children (7 boys and 9 girls) without known asthma had a positive F-RT after 10 min, but not after 2–5 min. Fifteen children were examined at follow-up (follow-up response rate 94%). In five children (two boys and three girls), BHR was confirmed by the standardized tests (Table 2). All tests were normal at follow-up in the remaining 10 children.

Table 1 Groups of children without physician-diagnosed asthma identified for follow-up with further investigations at the outpatient clinic

Group A	Children with positive F-RT with decrease in PEFR $\geq 15\%$ after 2–5 min
Group B	Children with positive F-RT with decrease in PEFR $\geq 15\%$ after 10 min, but not after 2–5 min
Group C	Children with negative F-RT but with a questionnaire that indicated RWB within the past 12 months and/or possible asthma with symptoms when exercising

F-RT = free running test; PEFR = peak expiratory flow rate; RWB = recurrent wheezy bronchitis.

Table 2 Results at follow-up of children without previous physician-diagnosed asthma. Number of children with positive tests in each of the three groups

	Group A (n = 38)	Group B (n = 15)	Group C (n = 19)
I: Positive S-RT	15	3	1*
II: Positive reversibility test	10	3	2
III: PEFR variability $\geq 15\%$ on home monitoring	12	2	6
BHR defined by either I, II or III	19	5	8

*Two children did not participate in the S-RT. One child terminated the S-RT after 3 min with no change in lung function.

†All children with a positive reversibility test in group A had either a positive S-RT and/or PEFR variability $\geq 15\%$ on home monitoring.

‡Home monitoring was not completed in two children in each group. Eleven children in total had isolated cases of PEFR variability $\geq 15\%$ on home monitoring with negative S-RT and reversibility test.

BHR = bronchial hyperreactivity; PEFR = peak expiratory flow rate; S-RT = standardized running test.

Group C

In 19 children (8 boys and 11 girls) without previously diagnosed asthma, the F-RT at the school was normal, but the answers in the questionnaire indicated symptoms of asthma. Of these 19 children, 17 had symptoms when exercising and 11 had experienced RWB within the past year. These children all attended the outpatient clinic for further examination. In eight children (two boys and six girls), BHR was confirmed by the standardized tests (Table 2), whereas all tests were normal in the remaining 11 children.

By using the same study design as in the previous study (12), we found 2.0% (19/939) of schoolchildren with BHR (Group A). By expanding the study design as described, a further 1.4% (13/939) with BHR was identified (Group B+C). Thus, the total number of schoolchildren with BHR was found to be 3.4% (32/939) with no significant difference between the genders (11 boys and 21 girls).

Point prevalence of asthma and BHR

No significant difference was found in the point prevalence of asthma and BHR in 2001 when compared to 1990–1991 (Table 3).

Previous recurrent wheezy bronchitis

A total of 253 children [26.9%, 95% confidence interval (CI) 24.1–29.8%] were found to have had previous RWB (146 boys and 107 girls) according to the questionnaire. This was significantly higher than found in 1990–1991 (8.8%, 95% CI 6.9–10.7%). Also significantly more boys

than girls with previous RWB were found in 2001 ($p < 0.005$). Significantly more children with previous RWB (11.9%, 95% CI 7.9–15.8%) than children without previous RWB (5.1%, 95% CI 3.5–6.8%) had a positive F-RT.

Smoking

In 2001, 391 children (41.6%, 95% CI 38.5–44.8%) came from homes with current parental smoking when compared to 62.9% (95% CI 59.6–66.1%) in 1990–1991. Twenty-eight children (3.0%, 95% CI 1.9–4.1%) were smokers compared to 2.4% (95% CI 1.3–3.4%) in 1990–1991. We found a significantly higher proportion of children with a history of asthma (68.2%, 60/88) ($p < 0.05$) and with current asthma (76.5%, 26/34) ($p < 0.05$) from homes with no parental tobacco smoking, compared to children without a diagnosis of asthma (57.3%, 488/851). In 1990–1991, there was no significant difference in the number of children with current asthma (41.2%) from homes with no parental tobacco smoking compared to those without a diagnosis of asthma (38.4%).

DISCUSSION

In this study, we compared the prevalence of physician-diagnosed asthma and BHR using identical methods, including objective measures in the same age group of unselected schoolchildren at the same three schools, 10 years apart. Based on parental questionnaires, the point prevalence of current physician-diagnosed asthma was not significantly different during this 10-year period up to 2001. Also, there was no significant difference in the prevalence of BHR in the two studies. In addition, we found no significant difference in the combined prevalence of physician-diagnosed asthma and BHR: 7.2% in 1990–1991 and 5.6% in 2001.

Previous studies, such as the ISAAC questionnaire-based study phases one and three (1), have not been able to elucidate the time trend of asthma prevalence in Danish schoolchildren from the mid-nineties to the beginning of this millennium. The ISAAC studies found an increase in asthma prevalence in both 6- to 7-year-old and 13- to 14-year-old children in neighbouring countries such as Germany and Poland, but no change in prevalence in 6- to 7-year-old children in Sweden (1). During the same period, other studies have shown a levelling off of the previous increase in asthma prevalence in Germany (13) and the British Isles (14). In contrast to our results, a Danish repeated cross-sectional questionnaire study found a significant increase in current asthma from 5.3% in 1986 to 11.7% in 2001 in

Table 3 Comparison of the point prevalence of asthma and BHR in the two studies

	Year 1990–1991 (n = 851)	Year 2001 (n = 939)	
Current physician-diagnosed asthma	4.0% (34/851) 95% CI: 2.7–5.3%	3.6% (34/939) 95% CI: 2.4–4.8%	$p = 0.77$
BHR in children without known asthma (Group A only)	3.2% (27/851) 95% CI: 2.0–4.4%	2.0% (19/939) 95% CI: 1.1–2.9%	$p = 0.17$
Total point prevalence of asthma/BHR	7.2% (61/851) 95% CI: 5.4–8.9%	5.6% (53/939) 95% CI: 4.2–7.1%	$p = 0.22$

BHR = bronchial hyperreactivity.

schoolchildren aged 7–17 years within the Copenhagen city area (2). This difference may be explained by different methods, as the latter was a questionnaire study in which the results may be influenced by increased awareness during the last decades. A single cross-sectional study among unselected Danish schoolchildren aged 8–10 years in the County of Copenhagen in 1992–1993 found the point prevalence of self-reported physician-diagnosed asthma to be 4.0% (15). By carrying out lung function and exercise tests among children without physician-diagnosed asthma, the authors found a further 2.6% with asthma, thus demonstrating a point prevalence of asthma of 6.6% in 1992–93. This corresponds with the findings in our reference study (12).

In the study from 1990 to 1991 (12), the PEFR was recorded before and immediately after 6 min of running in the F-RT. By adding another post-running PEFR measurement 10 min after the F-RT in the present study, a further 16 children were found to have a positive F-RT, and BHR was demonstrated at follow-up in five of these children. Thus, the prevalence of BHR might have been underestimated in the study from 1990 to 1991. In diagnosing BHR, it therefore seems important not only to measure PEFR after 2–5 min but also later, e.g. after 10 min.

The inclusion in our follow-up of 19 children without a positive F-RT but with questionnaire-based possible asthma symptoms within the past year (Group C) enabled the identification of a further eight children with BHR. Such children were not included for follow-up in the previous study, and our findings indicate that the prevalence found in 1990–1991 may have been underestimated as suggested by other authors (15–17). Screening for asthma among schoolchildren has been suggested (18) on the basis of the previously found underdiagnosis of asthma among schoolchildren (12). However, this would be very resource demanding and the long-term benefits would need to be carefully evaluated.

It has been proposed that one of the reasons for the increase in asthma in schoolchildren observed during the past decades is that parents and physicians are more aware of asthma and apply the diagnosis more readily to children with symptoms (19). Our study shows that underdiagnosis is still a problem in schoolchildren.

In contrast to the previous study, we found that children with a history of asthma and current asthma were more likely to come from non-smoking homes which could be because of increased awareness of the negative health effects of tobacco smoking and thereby changed smoking behaviour among parents of asthmatic children. We found a remarkable increase from 8.8% to 26.9% in the number of children with previous RWB. This prevalence in our study is similar to that in other studies (20–22). Among children with asthma, we found a significantly higher percentage of children with previous RWB. This is in line with studies from Finland and Sweden where many of these children develop persistent asthma later on (23,24).

Children with current asthma were less willing to participate in the F-RT than their peers without asthma, and a significantly higher number of children with current asthma

had a positive F-RT than children without diagnosed asthma. This may be because of suboptimal asthma treatment and thus symptoms when exercising, which will prevent them from taking part in sports and other physical activities.

Many of the problems with asthma prevalence studies are that the definitions of asthma and wheezing vary from study to study making comparisons difficult (19). The ISAAC study phases one and three (25) are trying to remedy this by creating a standardized questionnaire, but these studies are not using objective measurements. The ISAAC phase two studies (26), which incorporate objective markers such as bronchial responsiveness to hypertonic saline, are not based on repeated cross-sectional studies. Only a few repeated cross-sectional studies of asthma prevalence and time trend among schoolchildren have used objective measures (19,27) and these studies have used a wide variety of such measures including lung function test (7,8), exercise test (3–5), cold air challenge test (6,9) and histamine challenge test (10,11), making comparison between studies very difficult. A standard protocol on objective measures for asthma is much needed for future studies of asthma prevalence.

CONCLUSION

In conclusion, the point prevalence of current physician-diagnosed asthma and BHR in Danish schoolchildren was unchanged over a 10-year period from 1990–1991 to 2001. Using the same study design in unselected schoolchildren in the same area, we showed that the combined prevalence of asthma and BHR was 7.2% in 1990–1991 and 5.6% in 2001 with no significant change over this 10-year period. By expanding the study design in 2001 with an additional PEFR measurement, and by follow-up of children with possible asthma symptoms within the previous year, a further 1.4% of children with evidence of BHR were identified. Our findings also show that asthma is still underdiagnosed in Danish schoolchildren.

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CONFLICTS OF INTEREST

None of the authors had a conflict of interest to report.

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