

Prevalence of Aeroallergen Sensitization and Increased Exhaled Nitric Oxide Values in Schoolchildren of Different Socioeconomic Status

R Silva, L Cruz, T Vieira, A Leblanc, A Ferreira, J Fonseca, A Moreira, MG Castel-Branco

Allergy Division, Hospital S. João, EPE, Porto, Portugal

■ Abstract

Background: Screening for allergic diseases allows an early diagnosis to be made, thus reducing socioeconomic burden and enhancing quality of life. We determined the prevalence of elevated exhaled nitric oxide (eNO) levels and sensitization to common airborne allergens in schoolchildren from different socioeconomic backgrounds.

Material and Methods: The study population comprised 271 children (136 boys) aged between 8 and 12 years in whom we applied skin prick tests and determined eNO levels.

Results: Thirty-five percent of the children were identified as atopic. There was a significantly higher prevalence of atopy in boys (43% vs 27%). Among the children with a high socioeconomic status, 37% were atopic, compared with 30% of those with a low socioeconomic status. We observed a significantly lower prevalence of pollen sensitization in children of lower socioeconomic status (10% vs 20%). In the atopic group, 51% had elevated eNO levels, while in the nonatopic group this value was 4%. The mean (SD) eNO level was 33.4 (26.6) ppb in the atopic group and 11.9 (6.4) ppb in the nonatopic group. No differences were found for eNO values in terms of gender or socioeconomic status.

Conclusions: Our results emphasize the high prevalence of atopy in our population and suggest that determination of eNO levels could help to provide an early diagnosis. We also observed the following: *a)* a significant difference in mean eNO values between atopic and nonatopic children; *b)* a significantly lower prevalence of pollen sensitization in children of lower socioeconomic status; and *c)* a higher prevalence of atopy in boys.

Key words: Aeroallergens. Allergy. Children. Sensitization. Socioeconomic status. Nitric oxide.

■ Resumen

Antecedentes: El cribado de enfermedades alérgicas permite realizar un diagnóstico precoz y, en consecuencia, reducir la carga socioeconómica y mejorar la calidad de vida. En el presente estudio se determinó la prevalencia de niveles elevados de óxido nítrico exhalado (NOe) y la sensibilización a alérgenos habituales en el aire en escolares de diferentes contextos socioeconómicos.

Objetivos y métodos: La población en estudio incluyó a 271 niños (136 varones), con edades comprendidas entre los 8 y los 12 años, a quienes se realizaron pruebas de punción cutánea y se determinaron los niveles de NOe.

Resultados: Un 35% de los niños se identificaron como atópicos. Se registró una prevalencia de atopia significativamente mayor en los varones (43% frente al 27%). Un 37% de los niños con un alto estatus socioeconómico eran atópicos, comparado con un 30% de los niños con un bajo estatus socioeconómico. Se observó una prevalencia de sensibilización al polen significativamente inferior en niños con un estatus socioeconómico inferior (10% frente al 20%). En el grupo atópico, un 51% presentó niveles elevados de NOe, mientras que en el grupo no atópico este valor fue del 4%. El nivel medio (DE) de NOe fue de 33,4 (26,6) partes por mil millones (ppmm) en el grupo atópico y de 11,9 (6,4) ppmm en el grupo no atópico. En cuanto a los valores de NOe, no se hallaron diferencias entre sexos o estatus socioeconómico.

Conclusiones: Estos resultados destacan la alta prevalencia de atopia en nuestra población y sugieren que la determinación de los niveles de NOe podría ayudar a proporcionar un diagnóstico precoz. También se observó lo siguiente: 1) una diferencia significativa en los valores medios de NOe entre niños atópicos y no atópicos; 2) una prevalencia de sensibilización al polen significativamente inferior en niños con un estatus socioeconómico inferior; y 3) una mayor prevalencia de atopia en varones.

Palabras clave: Aeroalérgenos. Alergia. Niños. Sensibilización. Estatus socioeconómico. Óxido nítrico.

Introduction

An estimated 20% of the world's population has an immunoglobulin (Ig) E-mediated allergic disease, such as asthma, rhinitis, allergic conjunctivitis, or atopic dermatitis [1]. Asthma and allergic disorders are a leading cause of chronic illness in childhood and an important public health concern. There is strong evidence that the prevalence of asthma and atopy is on the rise, particularly in industrialized countries, where a very significant increase in the prevalence of allergy has been recorded in children [2,3], and several studies have also shown considerable variations in the prevalence of atopy in different parts of the world [1,3]. Many reasons for the differences in the prevalence of allergic diseases have been put forward, including environmental and lifestyle factors, diet, and socioeconomic differences [1,3].

Early diagnosis and implementation of appropriate therapy significantly reduce the socioeconomic burden of allergic diseases and enhance quality of life, whereas a lack of or delay in diagnosis can hinder the delivery of appropriate health care to patients with these conditions [4]. Screening may help to tackle this problem and increase awareness of allergic diseases in the general population. However, screening methods have not been fully standardized. Skin prick tests are often used, as they are a simple and reliable method to determine aeroallergen sensitization in epidemiological studies [5]. More recently, measurement of exhaled nitric oxide (eNO), which is produced in the epithelial cells of the bronchial wall, has been suggested as a simple, fast, reproducible, and noninvasive test for the assessment of allergic inflammation of the airways [6].

We determined the prevalence of elevated eNO levels and sensitization to common airborne allergens during screening for allergic diseases in schoolchildren from different socioeconomic backgrounds in the city of Porto, Portugal.

Material and Methods

The target population was composed of 418 children aged between 8 and 12 years attending 3 schools in Porto, Portugal. Children were excluded from participating for the following reasons: lack of parental consent, absence on the days of the study, noncooperation with test procedures, and dropout. The study population comprised 271 (65%) children (136 boys, 135 girls). Two socioeconomic groups were defined: 1) high socioeconomic status, which included children from 2 private schools located in high-income areas, with a tuition fee ranging from 1.1 to 2.2 minimum wages; 2) low socioeconomic status,

which included children from 1 public school located in a low-income area, with free tuition. Skin prick tests were performed for *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, cat dander, grass pollen mix, *Olea europaea*, and *Alternaria alternata* (Laboratorios Leti, Madrid, Spain). A histamine solution and a saline solution were used as controls. The results were considered positive if the wheal had a mean diameter ≥ 3 mm greater than that of the negative control. Atopy was defined as the presence of at least 1 positive skin prick test result. eNO level was measured using a NIOX Mino device (Aerocrine, Uppsala, Sweden), and an elevated eNO level was defined as >25 ppb [7]. The chi-square test was used to compare the frequency of sensitization between groups, and the *t* test was used to compare eNO values between atopic and nonatopic groups. A *P* value less than 0.05 was considered significant. The odds ratio and 95% confidence intervals were calculated.

The children's parents completed a self-administered questionnaire, with questions reporting allergic symptoms, asthma, physician's diagnosis of asthma, and asthma medication. According to the answers to the questionnaire, the atopic children were divided into 2 groups: a group with symptoms and/or previous diagnosis of asthma, and a group without symptoms and without previous diagnosis of asthma.

In order to promote participation, we held meetings with teachers and children and explained the importance of asthma awareness and the objectives of our study.

This study was approved by the Ethics Committee of Hospital São João, EPE (Porto, Portugal). All parents gave their written informed consent for the children to participate in the study.

Results

Out of the 271 children who participated in this study, 95 (35%) were identified as atopic and 176 (65%) as nonatopic. Atopy was significantly more prevalent in boys (58/136 cases, 43%) than in girls (37/135 cases, 27%); $P=0.01$.

Among children with a high socioeconomic status, 37% (67 out of 179) were sensitized to at least 1 allergen, compared with 30% of those (28 out of 92) with a low socioeconomic status. Elevated eNO values were observed in 55 of the 271 children (20%). In the atopic group, 51% (48/95 cases) had elevated eNO, while in the nonatopic group this value was 4% (7/176 cases); $P<0.0001$. The mean (SD) eNO level was 33.4 (26.6) ppb in the atopic group and 11.9 (6.4) ppb in the nonatopic group ($P<0.0001$). No differences were found

Table. Prevalence of Sensitization to Common Airborne Allergens and Elevated Exhaled Nitric Oxide Values

	Total (n=271)		High SES (n=179)		Low SES (n=92)		OR (95% CI)
	n	%	n	%	n	%	
Allergen sensitization							
Positive to ≥ 1 allergen	95	35	67	37	28	30	1.4 (0.8-2.3)
Mite sensitization	84	31	58	32	26	28	1.2 (0.7-2.1)
<i>Dermatophagoides pteronyssinus</i>	81	30	57	32	24	26	1.3 (0.8-2.3)
<i>Dermatophagoides farinae</i>	66	24	45	25	21	23	1.1 (0.6-2.1)
Pollen sensitization	45	17	36	20	9	10	2.3 (1.1-5.1)
Grass pollen mix ^a	42	15	35	20	7	8	3.0 (1.3-6.9)
<i>Olea europaea</i> ^b	22	8	20	11	2	2	5.6 (1.3-24.5)
Cat dander	19	7	16	9	3	3	2.9 (0.8-10.2)
<i>Alternaria alternata</i>	13	5	10	5	3	3	1.7 (0.5-6.5)
Exhaled NO							
Elevated eNO (>25 ppb)	55	20	37	21	18	20	1.1 (0.6-2.0)

Abbreviations: CI, confidence interval; eNO, exhaled nitric oxide; OR, odds ratio; SES, socioeconomic status.

^aP=0.02

^bP=0.01

regarding eNO values between genders or between the different socioeconomic groups.

The mean eNO was 40.2 (29.3) ppb in the group with symptoms and/or previous diagnosis of asthma and 27.2 (21.4) ppb in the group without symptoms and without previous diagnosis of asthma ($P=0.06$).

Discussion

We observed a lower prevalence of sensitization in children with a low socioeconomic status, although the difference only reached statistical significance for pollen (grass and *Olea europaea*). This could be due to insufficient sample size.

A significantly higher prevalence of atopy was found in boys. Similar results were found in a recent study from Govaere et al [8] of 2021 Belgian children aged between 3.4 and 14.8 years, with a significantly increased risk of atopy in the boys (odds ratio, 2.0; 98% confidence interval, 1.6-2.4). The authors suggest that the differences observed between the genders may be related to differences in hormonal environment; however, the mechanisms underlying this difference remain unknown.

We also observed a significant difference when we compared the mean value of eNO in atopic and nonatopic children: 33.4 (26.6) ppb in the atopic group and 11.9 (6.4) ppb in the nonatopic group. Our results are consistent with those of previous studies. Cibella et al [9] studied 335 schoolchildren aged 10 to 16 years from 8 schools in Palermo, Italy and reported a median eNO of 21.2 ppb in atopic and 12.6 ppb in nonatopic children, as well as an increased eNO in boys. van Amsterdam et al [10] measured eNO in a sample of schoolchildren (7-12 years old) to study the relationship between eNO and sensitization to common allergens. Regression analysis showed that eNO levels were

closely associated with different degrees of sensitization to aeroallergens, leading the authors to conclude that allergic sensitization was strongly associated with increased eNO levels.

In conclusion, we studied the prevalence of sensitization to common aeroallergens and elevated eNO values in a community population of schoolchildren aged 8 to 12 years and found that approximately 35% had evidence of allergic sensitization and 20% had elevated eNO values. Our study also revealed the following: *a*) a significant difference in the mean value of eNO between atopic and nonatopic children; *b*) a significantly lower prevalence of pollen sensitization (grass and *Olea europaea*) in children of lower socioeconomic status; and *c*) a higher prevalence of atopy in boys.

Our results underline not only the high prevalence of atopy in our population, but also the usefulness of eNO determination when attempting to establish an early diagnosis, thus reducing socioeconomic burden and enhancing quality of life. The observational and cross-sectional nature of our study means that our results should be interpreted with caution.

References

1. Prevention of Allergy and Allergic Asthma. Geneva: World Health Organization, 2003. Available from: http://www.worldallergy.org/professional/who_paa2003.pdf, accessed 22 June 2009).
2. ISAAC Steering Committee. Worldwide variation in prevalence of symptoms of asthma, allergic rhinoconjunctivitis and atopic eczema: ISAAC. *Lancet*. 1998;351:1225-32.
3. von Ehrenstein O. Asthma, allergies and respiratory health. In: Tamburlini G, von Ehrenstein O, Bertollini R (editors). *Children's health and environment: A review of evidence. A joint report from the European Environment Agency and the WHO Regional*

- Office for Europe, Copenhagen: European Environment Agency, 2002: 44-65 (available from: <http://www.euro.who.int/document/e75518.pdf>, accessed 22 June 2009).
4. Global Initiative for Asthma (GINA), National Heart, Lung and Blood Institute (NHLBI). Global strategy for asthma management and prevention 2008 (available from: <http://www.ginasthma.org/GuidelinesResources.asp?l1=2&l2=0>, accessed 22 June 2009).
 5. Dreborg S, Frew A. EAACI Position Paper: Allergen standardization and skin tests. *Allergy* 1993;48(Suppl 14):1-82.
 6. Piacentini G, Bordini A, Costella S, Vicentini L, Mazzi P, Sperandio S, Boner A. Exhaled nitric oxide and sputum eosinophil markers of inflammation in asthmatic children. *Eur Respir J*. 1999;13:1386-90.
 7. Buchvald F, Baraldi E, Carraro S, Gaston B, De Jongste J, Pijnenburg MW, Silkoff PE, Bisgaard H. Measurements of exhaled nitric oxide in healthy subjects age 4 to 17 years. *J Allergy Clin Immunol*. 2005;115(6):1130-6.
 8. Govaere E, Gysel DV, Massa G, Verhamme K, Doli E, Baets F. The influence of age and gender on sensitization to aero-allergens. *Pediatr Allergy Immunol*. 2007;18 (8):671-8.
 9. Cibella F, Cuttitta G, La Grutta S, Passalacqua G, Viegi G. Factors that influence exhaled nitric oxide in Italian schoolchildren. *Ann Allergy Asthma Immunol*. 2008;101(4):407-12.
 10. van Amsterdam JG, Janssen NA, de Meer G, Fischer PH, Nierkens S, van Loveren H, Opperhuizen A, Steerenberg PA, Brunekreef B. The relationship between exhaled nitric oxide and allergic sensitization in a random sample of school children. *Clin Exp Allergy*. 2003;33(2):187-91.
- *Manuscript received July 6, 2009; accepted for publication September 19, 2009.*
- **Rui Silva**
- Serviço de Imunoalergologia, Hospital S. João
Alameda Professor Hernâni Monteiro
4202-451 Porto, Portugal
E-mail: ruisilva@inbox.com