

Bronchial hyperresponsiveness in two populations with different prevalences of atopy

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SUMMARY

SETTING: Random population samples of young adults from Tartu, Estonia ($n = 307$) and Uppsala, Sweden ($n = 498$) in the framework of the European Community Respiratory Health Survey (ECRHS).

OBJECTIVE: To compare the prevalence and risk factors for bronchial hyperresponsiveness (BHR) to methacholine in two centres with similar climate and ethnicity but differences in the prevalence of atopy, asthma and respiratory symptoms.

DESIGN: General population-based cross-sectional survey.

RESULTS: The prevalence of BHR using the cut-off points 1.5, 1.0 and 0.5 mg was 19%, 12% and 8% in Tartu and 11%, 7% and 2%, respectively, in Uppsala. Current

smoking was a common risk factor for BHR in both centres. Female sex (odds ratio [OR] 2.9), sensitisation to cat (OR 5.9) and visible mould in the home (OR 2.4) were independent risk factors for BHR in Tartu. In Uppsala, BHR was significantly associated with total IgE levels (OR 2.0) and exposure to environmental tobacco smoke (OR 3.3).

CONCLUSION: The high prevalence of BHR can explain the high prevalence of respiratory symptoms in Tartu and indicates that causes other than asthma and atopy can be responsible for the high prevalence of BHR in a population.

KEY WORDS: bronchial hyperresponsiveness; epidemiology; methacholine; prevalence; asthma

RECENT INTERNATIONAL comparisons among children^{1–6} and adults^{7–10} consistently show that atopic sensitisation, diagnosed asthma and asthma-like symptoms are more common in Western than in Eastern Europe. However, while the prevalence of diagnosed asthma and asthma-like symptoms,^{7,9} as well as the prevalence of atopic sensitisation and respiratory allergies,¹⁰ was low among young adults in Estonia, the prevalence of respiratory symptoms in general was one of the highest in Europe.⁷ Similarly, the prevalence of diagnosed asthma was less prevalent among Estonian schoolchildren, while there was no difference in the prevalence of wheezing, and respiratory symptoms related to colds were more common than in Sweden.⁶

Comparisons of East and West Germany have shown a higher prevalence of bronchial hyperresponsiveness (BHR) in the West among both children and adults.^{2,8} In contrast, the prevalence of BHR, as measured by methacholine challenge, was high among Estonian children.¹¹

We have previously reported lower prevalence of

atopy and respiratory allergies,¹⁰ as well as lower levels of eosinophil activation,^{12,13} but higher prevalence of wheeze and nocturnal respiratory symptoms⁹ in young adults in Tartu than in Uppsala. The prevalence of BHR was compared between those two centres to characterise respiratory health in a population with a low prevalence of asthma and atopy but a high prevalence of respiratory symptoms.

MATERIAL AND METHODS

Study areas and subjects

Two areas were compared, i.e., Tartu in Estonia and Uppsala in Sweden, adhering to the protocol of the European Community Respiratory Health Survey (ECRHS).^{10,14} In the first phase of the study, a questionnaire including seven questions on asthma-related symptoms was mailed to 3000 individuals in Tartu and 3600 in Uppsala aged 20–44 years, with an equal number of each sex. The study populations were randomly selected from the civil registers. To avoid linguistic problems, only people of Estonian nationality

were selected in Tartu. From this cohort, a random sample of 800 persons in both centres was selected for further investigations, which included a structured interview and the determination of circulating immunoglobulin E (IgE) antibodies to allergens. BHR was measured by methacholine challenge. Only individuals who had responded to the mailed questionnaire ($n = 680$ in Tartu and $n = 706$ in Uppsala) were invited to participate. The study was conducted from April 1991 to February 1992 in Uppsala and from March 1994 to July 1995 in Tartu.

Methacholine challenge test

BHR to methacholine was measured using two different challenge protocols that have been validated against each other.¹⁵ In Tartu, dosimeter Spira Elektro2 (Respiratory Care Centre, Hämeenlinna, Finland) and in Uppsala, Mefar MB3 dosimeter (Mefar, Brescia, Italy) was used. Tests were stopped when the subjects' one second forced expiratory volume (FEV₁) had decreased by 20% compared with the FEV₁ post-saline or at a cumulative dose of 2 mg methacholine with the Mefar or 2.3 mg with the Spira dosimeter. The test was not performed if the post-diluent FEV₁ was reduced by more than 10% compared with the pre-diluent FEV₁. Appropriate transition equations were used to transform the Tartu data, making them comparable to those obtained in Uppsala.¹⁵ After transforming the data, the maximum cumulative dose administered using the Spira dosimeter (2.3 mg) corresponded to 1.5 mg using the Mefar dosimeter. This cut-off point was used to define BHR.

Questionnaires

The ECRHS questionnaire was used for both screening and interview.^{16,17} The interview included questions on symptoms, diagnoses, smoking history, parental smoking history, family structure, family history, early environment, education, employment, home environment, diet, use of medicines, attitudes to medicines and the use of health services.

Serum IgE levels and circulating IgE antibodies

Serum IgE levels and IgE antibodies against *Der matophagoides pteronyssinus*, timothy, birch, cat and *Cladosporium* were determined using the Pharmacia CAP™ system (Pharmacia, Uppsala, Sweden).

Definitions

Current asthma: asthma diagnosed by a doctor and asthma attack during the last 12 months or currently taking asthma medication.

Bronchial hyperresponsiveness: a 20% decline in FEV₁ compared with the post-diluent value, where the cut-off point was ≤ 1.5 mg with the Mefar method. When other limits were used, this is indicated.

Bronchial responsiveness to methacholine (slope): 100/(regression coefficient + 10), where the regres-

sion coefficient was calculated by regressing percentage fall in FEV₁ on log₁₀ (methacholine dose).^{18,19}

Atopy: presence of serum IgE antibodies >0.35 kU/l against at least one allergen.

Subjects exposed to environmental tobacco smoke (ETS): non-smokers who reported exposure to ETS on most days or nights during the last 12 months.

Visible mould: affirmative answer to the question 'Has there been mould or mildew on any surface, other than food, inside the home in the last 12 months?'

Ethical considerations

All participants gave their informed consent. The respective local ethics committees approved the study.

Statistical analysis

The statistical analysis was performed on a Hewlett Packard PC using the SAS System for Windows 6.11 software package (SAS Institute Inc, Cary, NC, USA). The χ^2 test was used to analyse differences between groups. Odds ratios (OR) with 95% confidence intervals (CI) were determined. Logistic regression analysis was performed to estimate adjusted ORs when taking into account several variables. Risk factors were first estimated in univariate analyses. All risk factors of at least borderline significance ($P < 0.1$) in the univariate analysis were included in the logistic regression. All multivariable estimates were adjusted for age, sex and baseline lung function (FEV₁ as % of the predicted value). Two-tailed tests were used. A P value <0.05 was regarded as statistically significant.

RESULTS

Study participation

The response rates to the postal questionnaire were similar in Tartu and Uppsala (82% vs. 87%), while participation in BHR testing in the clinical phase of the study was lower in Tartu (45% vs. 71%). In

Table 1 Characteristics of the study groups who completed bronchial challenge testing in Tartu and Uppsala

Centre	Tartu $n = 307$	Uppsala $n = 498$
Female	56	48*
Mean age, years	32	32
Mean BMI in females	23.3	22.6
Mean BMI in males	24.3	23.8
Atopy	19	32†
Current smokers	30	25
Passive smokers	27	17†
Ex-smokers	21	24
Visible mould	20	21
Parental asthma	4	16†
Self-reported asthma	1	8†
Asthma treatment	1	3*

Except for age and body mass index (BMI), proportions are shown as percentage values.

* $P < 0.05$.

† $P < 0.005$.

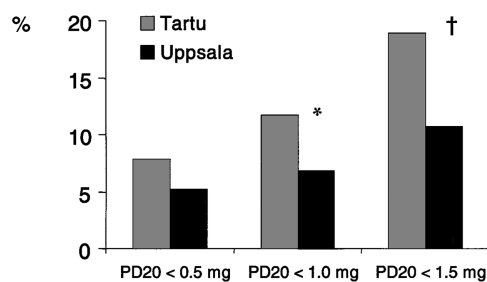


Figure 1 Prevalence (%) of BHR with different cut-off points. * $P < 0.05$. † $P < 0.005$. BHR = bronchial hyperresponsiveness.

Tartu, the prevalence of waking with chest tightness was 11% among the participants and 16% among non-participants in the clinical phase of the study ($P < 0.05$), while in Uppsala wheeze was more prevalent among participants than non-participants (27% vs. 15%, $P < 0.05$). Responses to the other questions on symptoms in the postal questionnaire were similar among those participating and not participating in the clinical phase. The prevalence of smoking was also similar in the two groups. The study populations are described in Table 1.

Prevalence of BHR

The prevalence of BHR was 19% in Tartu and 11% in Uppsala ($P < 0.001$) using the 1.5 mg cut-off point; the mean slope was 7.2 and 7.8, respectively ($P < 0.001$). The prevalence of BHR was higher in Tartu regardless of how BHR was defined (Figure 1). The prevalence of current asthma in subjects with BHR was 7% in Tartu and 23% in Uppsala ($P < 0.05$).

Factors influencing BHR

The results of the univariate analysis of risk factors of BHR are presented in Table 2 and Figure 2. Univariate analyses revealed no age or gender differences in the prevalence of BHR in either of the centres. The presence of serum IgE antibodies against cat was the only significant risk factor for BHR in Tartu, while in Uppsala sensitisation to cat, mites or grass pollen was significantly associated with BHR. In Tartu,

Table 2 Univariate analyses for the prevalence of BHR (%) as a dependent variable

	Tartu		Uppsala	
	Yes	No	Yes	No
Women	22	15	11	10
Sensitisation	27	17	20	8*
IgE against mite	29	18	29	10*
IgE against cat	54	17*	26	9*
IgE against grass pollen	35	18	24	9*
IgE against birch pollen	29	18	16	11
Visible mould	27	16	11	10
Parental asthma	13	19	14	10

* $P < 0.005$.

BHR = bronchial hyperresponsiveness; IgE = immunoglobulin E.

the prevalence of BHR among current smokers was significantly higher only compared to lifelong non-smokers who were not exposed to ETS, while in Uppsala prevalence of BHR was higher among passive smokers than in individuals not exposed to ETS (Figure 2). None of several other environmental factors, e.g., use of gas and open fire, age of the dwelling, water damage, childhood environmental factors such as parental smoking, number of siblings and severe respiratory infection before 5 years of age, and social class, were significantly associated with BHR in the univariate analyses.

Female sex and sensitisation to cat in Tartu and serum IgE levels in Uppsala were significantly associated with BHR after controlling for confounding in multiple regression analyses (Table 3). Current smoking was an independent risk factor for BHR in both centres, while this was the case for passive smoking only in Uppsala. Visible mould or mildew on any surface inside the home during the last 12 months was an independent risk factor for BHR in Tartu. Atopic sensitisation was a significant risk factor for BHR in Uppsala (OR 3.3; 95%CI 1.7–6.5), but not in Tartu (OR 2.2; 95%CI 0.99–4.6), when atopic sensitisation instead of sensitisation to individual allergens was included into the regression model. When the two populations were combined, living in Tartu was an independent risk factor for BHR (OR 1.8; 95%CI 1.15–3.0).

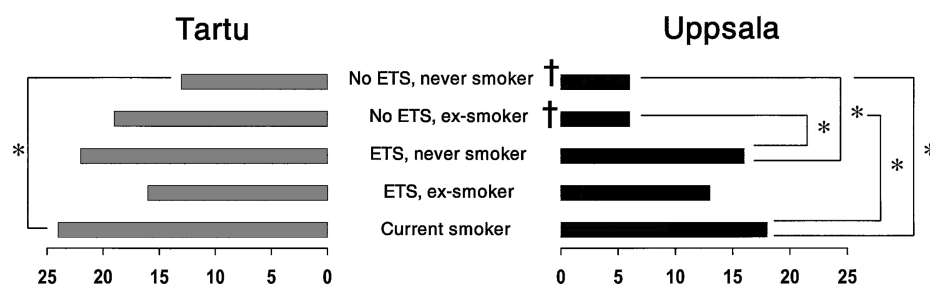


Figure 2 Prevalence (%) of BHR in groups with different exposure to cigarette smoke and environmental tobacco smoke (ETS). * $P < 0.05$. † $P < 0.05$ difference between centres. BHR = bronchial hyperresponsiveness.

Table 3 Risk factors for BHR

	Tartu 51/229		Uppsala 49/363	
	aOR	95%CI	aOR	95%CI
Female	2.94	1.36–6.4	1.54	0.77–3.1
Serum IgE level	1.60	0.90–2.9	2.00	1.01–4.0
Sensitisation to mite	0.97	0.31–3.1	1.64	0.56–4.8
Sensitisation to cat	5.85	1.33–5.6	2.37	0.97–5.8
Sensitisation to grass pollen	0.87	0.21–3.6	2.47	0.95–6.4
Sensitisation to birch pollen	0.84	0.16–4.3	0.34	0.11–1.0
Parental asthma	0.58	0.14–2.4	1.18	0.52–2.7
Current smoking	2.57	1.05–6.3	3.18	1.38–7.3
Passive smoking	1.69	0.72–4.0	3.29	1.36–8.0
Ex-smoking	1.12	0.44–2.8	0.95	0.36–2.5
Visible mould at home	2.43	1.11–5.3	1.07	0.49–2.3

In addition to factors listed in the table, pre-challenge FEV₁ as % predicted and age was included in the multiple logistic regression model.

BHR = bronchial hyperresponsiveness; aOR = adjusted odds ratios; CI = confidence interval; FEV₁ = one second forced expiratory volume.

DISCUSSION

The higher prevalence of BHR in Tartu compared to Uppsala is in accordance with a previously reported high prevalence of respiratory symptoms in Tartu.^{7,10} Atopy was less associated with BHR in Tartu than in Uppsala, indicating that environmental factors are more important for BHR in Tartu.

Our results concord also with a previously reported high prevalence of BHR, as measured by methacholine challenge, among 10–12-year-old schoolchildren in Estonia.¹¹ In contrast to our results, the prevalence of BHR among adults, as measured by methacholine challenge, was lower in Erfurt in East Germany than in Hamburg in West Germany (25% vs. 19%, $P < 0.05$).⁸ All respiratory symptoms were also considerably lower in Erfurt.

Several studies in children have shown a lower prevalence of atopic sensitisation and hay fever in previously socialist countries than in countries with a market economy, while in the former the prevalence of respiratory symptoms, including wheeze, was higher.^{2–5} Recent analyses of the subset of the International Study of Asthma and Allergies in Childhood (ISAAC) phase 2 data,⁶ comparing Tallinn in Estonia with Linköping and Östersund in Sweden, showed a similar prevalence of wheeze. Respiratory symptoms associated with colds were, however, higher in Estonia. Studies in children have reported a low prevalence of BHR in Eastern Europe. This does not necessarily contradict our results, as in the previous studies indirect stimuli, such as cold air² or hypertonic saline,²⁰ were used. Such stimuli correlate better with atopy than direct stimuli such as methacholine.²¹

Smoking was significantly associated with BHR in both Tartu and Uppsala and it has been recognised as a risk factor for BHR in previous studies.^{22–24} ETS was associated with a four-fold increased BHR in Uppsala, but was not significantly associated with BHR in Tartu. This was in contrast to the results of a cross-sectional study involving 2600 schoolchildren (10–12

years) from Estonia, Poland and Sweden, where maternal smoking was related to respiratory symptoms only in the two former countries.⁴ In the current study, subjects were classified as being exposed to ETS if they reported exposure to ETS on most days or nights during the last 12 months. As, unlike in Sweden, smoking is not restricted in public places in Estonia, our questionnaire may underestimate the true exposure to ETS in Tartu. As one of the biggest indoor pollutants in Estonia is likely to be smoking, passive smoking can still be one of the main reasons for high BHR in Tartu, although we could not confirm this in our analysis. Furthermore, the lack of association between ETS and wheezing among children in Sweden may be due to a high awareness of this risk factor among Swedish parents.⁴

Domestic gas use is the only indoor risk factor related to air quality that has been found to be associated with BHR among adults with some consistency.^{25–27} Home dampness is, however, a recognised risk factor for respiratory symptoms in children.^{28–30} Visible mould can be considered as an indirect marker of humidity and bad ventilation. The association of BHR and visible mould indicates that indoor air quality has an impact on BHR in Tartu.

In our analyses, female sex was a risk factor for BHR in Tartu after controlling for baseline lung function. This is in accordance with an analysis of Leynaert et al. of the French ECRHS data set, where greater bronchial responsiveness was observed in women than in men after adjusting for several variables for airway calibre and lung size as well as for body mass index.³¹ In that study, BHR in women was more clearly related to smoking than in men. Thus, the excess BHR in women may be related to greater susceptibility to tobacco smoke. Women have also been found to be more susceptible than men to other environmental factors, as the use of gas for cooking is associated with respiratory symptoms suggestive of airways obstruction in women but not in men.^{25–27}

An association between atopic sensitisation and BHR has been found in many studies.^{22,24,32,33} Cat was the allergen most strongly related to BHR in Tartu. If sensitisation to any allergen was included in the model, the association between atopic sensitisation was statistically significant only in Uppsala, indicating that sensitisation to common allergens has less association with BHR in Tartu than in Uppsala. This is in accordance with a study among children in Estonia where BHR, current wheeze and diagnosed asthma were only weakly correlated with atopic sensitisation.¹¹

After controlling for different factors associated with BHR, living in Tartu was still an independent risk factor for BHR, indicating that some other possible risk factors, not studied in this analysis, have an impact on the high prevalence of BHR in Tartu.

Bronchial responsiveness data from Tartu were not

included in the previous analyses of ECRHS,¹⁹ as different methods for methacholine challenge were used in Estonia. To overcome this problem, a separate study was conducted to validate the methods against each other.¹⁵ People with respiratory symptoms in Tartu tended not to participate in BHR testing, while the opposite was true in Uppsala. This selection bias would not significantly alter our findings on the prevalence of BHR in the two centres, however, as the prevalence of BHR was higher in Tartu.

The high prevalence of BHR can explain the high prevalence of respiratory symptoms in Tartu and indicates that causes other than asthma and atopy may be responsible for the high prevalence of BHR in a population.

Acknowledgements

The results derive from data collected for the European Community Respiratory Health Survey. A final international comparison might use different forms of analysis.

We wish to thank Alar Haukanõmm for help in processing and analysing the data.

The study was supported by grants from Glaxo-Wellcome Estonia, Estonian Scientific Foundation grant no 4350, the Swedish Medical Research Council, the Swedish National Agency for Environmental Protection, the Swedish Association for the Prevention of Asthma and Allergies, the Swedish Heart and Lung Foundation, the Swedish Foundation for Health Care Sciences and Allergy Research, the County Council of Uppsala and Glaxo-Wellcome Ltd, United Kingdom.

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R É S U M É

CADRE : Echantillons de population de jeunes adultes, prélevé au hasard, à Tartu en Estonie ($n = 307$) et à Uppsala en Suède ($n = 498$), dans le cadre de l'enquête de la Communauté Européenne sur la santé respiratoire (ECRHS).

OBJET : Analyser la prévalence et les facteurs de risque de l'hyperréactivité bronchique (BHR) à la méthacholine dans deux centres où le climat et l'ethnicité sont similaires, mais où la prévalence de l'atopie, de l'asthme et des symptômes respiratoires est différente.

DESSIN : Enquête transversale générale basée sur la population.

RÉSULTATS : La prévalence de la BHR avec des seuils de positivité à 1,5, 1,0 et 0,5 mg a été respectivement de 19%, de 12% et de 8% à Tartu contre 11%, 7% et 2%

à Uppsala. Le fait de fumer actuellement constitue un facteur commun de risque de BHR dans les deux centres. A Tartu, les facteurs indépendants de risque ont été le sexe féminin (OR 2,9), la sensibilisation au chat (OR 5,9) et la présence de moisissures visibles au domicile (OR 2,4). A Uppsala, il y a eu une association significative entre la BHR et les niveaux d'IgE total (OR 2,0) ainsi qu'avec l'exposition à la fumée de tabac environnementale (OR 3,3).

CONCLUSION : La prévalence élevée de la BHR peut expliquer la prévalence élevée des symptômes respiratoires à Tartu et indique que des causes autres que l'asthme ou l'atopie peuvent être responsables d'une prévalence élevée de la BHR dans une population.

R E S U M E N

MARCO DE REFERENCIA : Muestras aleatorias de poblaciones de adultos jóvenes de Tartu, Estonia ($n = 307$) y de Uppsala, Suecia ($n = 498$), en el marco de la European Community Respiratory Health Survey (ECRHS).

OBJETIVO : Analizar la prevalencia y los factores de riesgo para la hiperreactividad bronquial (BHR) a la metacolina en dos centros con clima y composición étnica similares, pero con prevalencia de atopía, asma y síntomas respiratorios diferentes.

DISEÑO : Encuesta cruzada general basada sobre la población.

RESULTADOS : La prevalencia de BHR, utilizando los umbrales de positividad a 1,5, 1,0 y 0,5 mg era, respectivamente, de 19%, 12% y 8% en Tartu y de 11%, 7%

y 2% en Uppsala. El tabaquismo actual era un factor de riesgo común para BHR en los dos centros. En Tartu, el sexo femenino (OR 2,9), la sensibilización a los gatos (OR 5,9) y la presencia de mohos visibles en el domicilio (OR 2,4) eran factores de riesgo independientes para BHR. En Uppsala, BHR estaba asociada significativamente con los niveles totales de IgE (OR 2,0) y con la exposición al humo de tabaco ambiental (OR 3,3).

CONCLUSION : La prevalencia elevada de BHR puede explicar la alta prevalencia de síntomas respiratorios en Tartu e indican que otras causas, fuera del asma y la atopía, pueden ser responsables de la alta prevalencia de BHR en la población.