Respiratory Medicine (2005) **99**, 1010–1014

respiratoryMEDICINE

Body mass index, asthma and allergic rhinoconjunctivitis in Swedish conscripts—a national cohort study over three decades

Lennart Bråbäck[a], Anders Hjern[b,c], Finn Rasmussen[d,*]

[a]*Department of Public Health and Research, Sundsvall Hospital, Sweden*
[b]*Unit of Paediatrics, Department of Women's and Children's Health, Uppsala University, Sweden*
[c]*Centre for Epidemiology, Swedish National Board of Health and Welfare, Sweden*
[d]*Child and Adolescent Public Health Epidemiology Group, Department of Public Health Sciences, Epidemiology Research Unit, Karolinska Institutet, Norrbacka, SE-17176 Stockholm, Sweden*

Received 17 June 2004

KEYWORDS
Asthma;
Allergic rhinoconjunctivitis;
Body mass index;
Time trend;
Birth cohort

Summary Obesity and overweight have been associated with an increased risk of asthma in children as well as adults. The association between atopy and body mass index (BMI) is less clear. It has also been suggested that the link between a high BMI and asthma could be a recent phenomenon. The objective of this study was to assess whether the association with BMI differed between allergic rhinoconjunctivitis and asthma and if these associations have changed over time.

The Swedish Military Service Conscription Register was linked to the Register of the Total Population and the Population and Housing Censuses. Asthma (with and without allergic rhinoconjunctivitis) and allergic rhinoconjunctivitis at conscription were analysed in relation to BMI for 1,247,038 male conscripts in successive cohorts born between 1952 and 1977. Obesity was associated with asthma without allergic rhinoconjunctivitis, adjusted OR 1.53 (95% CI 1.43–1.63), and with asthma with allergic rhinoconjunctivitis, adjusted OR 1.34 (95% CI 1.20–1.50), but not with allergic rhinoconjunctivitis, OR 1.00 (95% CI 0.97–1.03) after multivariate analyses with adjustments for confounders. The odds ratios were similar in three successive cohorts (conscripts born in 1952–1961, 1962–1971 and 1972–1977). Underweight was associated with a slightly increased risk for all three conditions. The increased risk of asthma in young Swedish men with obesity has remained unchanged over a period of three decades.

*Corresponding author. Tel.: +46 8 51776592; fax: +46 8 51776529.
E-mail address: finn.rasmussen@phs.ki.se (F. Rasmussen).

0954-6111/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.rmed.2005.02.004

Introduction

An increasing trend in body mass index (BMI) in affluent countries[1] has been paralleled by an increase in asthma and atopic disorders.[2] It is questionable whether atopy per se has any association with overweight and obesity.[3] It has also been suggested that the link between a high BMI and asthma could be a recent phenomenon.[4] Numerous studies have demonstrated a close relationship between a high BMI and asthma during the last decade,[3] whereas previous studies from the 1970s and 1980s focused on the increased risk of underweight in asthmatic children.[5,6]

Substantial changes in lifestyle, dietary habits and standard of living have taken place in Sweden over the last forty to fifty years. In this study, we have used the annual Swedish military service examinations to investigate the secular trend in BMI, allergic rhinoconjunctivitis and asthma (with and without allergic rhinoconjunctivitis) in young Swedish men. We have evaluated whether the association with BMI differed between allergic rhinoconjunctivitis and asthma. We have also evaluated whether these associations have changed over a period of three decades.

Method

Sweden has a long tradition of national registers with high-quality data relating to socio-economic and health indicators for the entire Swedish population. The key to these registers is the unique personal identification number, which accompanies each Swedish resident from the cradle to the grave. In this study, we used the Swedish Military Service Conscription Register (MSCR, 1968–1996), the Register of the Total Population (RTP; 1967–1996) and the Population and Housing Censuses (PHC; 1970, 1975, 1980, 1985, 1990). Statistics Sweden keeps the Multi-Generation Register (MGR) with records of the unique personal ID numbers of the mothers and fathers of almost all the individuals born after 1932, who were alive and resident in Sweden in 1961. The parents of the study subjects were identified by record linkage to this register.

Study population

All Swedish-born males born between 1952 and 1977 were identified at 17 years of age—using their unique personal ID number—in the RTP. All the individuals recorded as living in Sweden are included in these registers. Of the young men born in 1952–1959 and 1961–1977 who were thus identified, the 90.9% (1,239,705) who were recorded in the MSCR as having participated in the military service conscription examination at the age of 17–20 were included in the study population. Of the cohort born in 1960, only 14.6% (7333) participated in a military service conscription examination due to administrative changes to the entire conscription system in Sweden. These subjects were added to the study population. The Swedish military service conscription examination is required by law. Foreign citizenship or a severe chronic medical condition or handicap documented in a medical certificate are the only reasons that are accepted for non-participation according to Swedish law.

Asthma and allergic rhinoconjunctivitis

The examination of the conscripts consists of a health questionnaire, a personal interview by a medical doctor and a comprehensive physical and psychological examination that includes a physical exercise test. The health questionnaire is sent to the conscripts prior to the examination and contains specific questions about itchy or watery eyes, congested nose/allergic rhinoconjunctivitis, wheezing, asthma and eczema. The examining doctor makes a registration of diagnoses on a practical clinical basis, with the emphasis on conditions that may affect the young man's performance in the military service. The diagnostic codes were based on the ICD-8 and ICD-9 (eighth and ninth revision of the International Classification of Diseases) in 1968–1986: 493 (asthma) and 477 (allergic rhinoconjunctivitis). The diagnostic procedure has changed very little over the years, with the exception of the health questionnaire, which has been changed several times. Asthma with and without allergic rhinoconjunctivitis were used as proxies for atopic and non-atopic asthma in our analyses.

BMI

Weight and height measurements at the military conscription examination were used to calculate BMI. Four BMI categories were created according to WHO criteria[7]: 30.00 and above (obese), 25.00–29.99 (overweight), 18.50–24.99 (reference), 18.49 and lower (low).

Socio-demographic confounders

Information from the PHC nearest in time to the military conscription and the geographical location of the home in the RTP at 17 years of age were used to create a dichotomous *rural/urban* variable. In the PHC, urban is defined as a home located in a settlement with at least 200 inhabitants. Parental occupation from the PHC nearest in time to the military conscription was used to create a dichotomous "*farmer*" variable. *County of residence* was identified in the RTP at 17 years of age and classified into six categories, one for southern Sweden and five for northern Sweden. *Maternal age* at the birth of the conscript was calculated using information relating to the year of birth of the mother and the conscript from the RTP. Variables of *family size* and *overcrowding* (defined as more than two people per room excluding the kitchen and one more room) were created using data from the PHC nearest to the conscription examination. A variable of being the *first-born boy in the family,* as a proxy to first-born child in the absence of data on sisters, was created by linkage to the multigenerational register of the conscripts in the study. *Socio-economic status* (SES) was defined according to the categorisation of the head of the household in the PHC nearest to the military conscription examination made by Statistics Sweden.[8]

Statistical analyses

Asthma with allergic rhinoconjunctivitis, asthma without allergic rhino-conjunctivitis and allergic rhinoconjunctivitis were used as dependent variables in logistic regression models. These models included a four-category BMI variable as defined above and dichotomous confounders. Missing was included in the models as a third category for confounders. Year of birth was entered as a continuous variable in all the models. Logistic regression models that contained all the variables described above were used to calculate the interaction of time (year of birth) with other independent variables. 95% confidence intervals were calculated using the test-based method. Statistical analyses were carried out using the SPSS 11.0 software package for Windows.

Results

Information on BMI was available for 1,247,038 male conscripts and 35.4% were born in 1952–1961, 41.9% in 1962–1971 and 22.7% in 1972–1977. The percentage of conscripts with a low BMI was 8.5%, whereas 81.8% had a normal BMI, 8.1% were overweight and 1.7% were obese. Additional socio-demographic characteristics have been presented in a previous paper.[9]

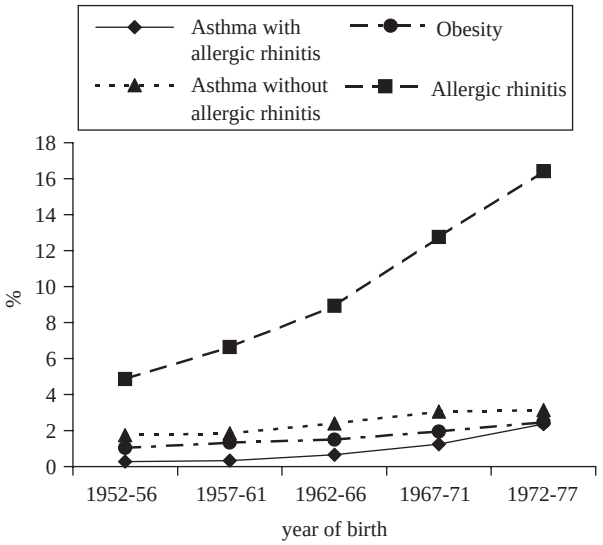

Figure 1 The time trend for asthma with allergic rhinitis, asthma without allergic rhinitis, allergic rhinitis and obesity in 1952–1977.

The prevalence of asthma with and without allergic rhinoconjunctivitis, allergic rhinoconjunctivitis and obesity increased continuously with year of birth during the entire study period (Fig. 1). Adding the four-category BMI variable to a logistic regression model with year of birth and confounders did not change the estimates of the effect of year of birth for any of the three allergic conditions.

Obesity was associated with asthma without allergic rhinoconjunctivitis, OR 1.53 (95% CI 1.43–1.63), and with asthma with allergic rhinoconjunctivitis, OR 1.34 (95% CI 1.20–1.50), but not with allergic rhinoconjunctivitis, OR 1.00 (95% CI 0.97–1.03), after multivariate analyses comprising all the conscripts born in 1952–1977 with adjustments for county of residence, rural living, year of birth, SES, overcrowding and being the first-born boy. The corresponding odds ratios for overweight were 1.23 (95% CI 1.18–1.28), 1.12 (95%CI 1.05–1.19) and 0.99 (95% CI 0.97–1.03) respectively. Underweight was associated with a slightly increased risk for all three conditions. The adjusted odds ratios were 1.16 (95% CI 1.11–1.21), 1.20 (95% CI 1.13–1.28) and 1.18 (95% CI 1.15–1.20), respectively.

We have also assessed whether the odds ratios changed over time (Table 1). Year of birth did not

Table 1 The association between body mass index (BMI) and asthma without allergic rhinitis (A), asthma with allergic rhinitis (B) and allergic rhinitis (C). OR (95% CI) after multivariate analyses of different birth cohorts born in 1952–1961, 1962–1971 and 1972–1977 adjusting for social class, county of residence, rural living, overcrowding and being the first-born boy.

BMI	1952–1961	1962–1971	1972–1977
(A) Asthma without allergic rhinitis adjusted OR (95% CI)			
30 or more	1.62 (1.37–1.92)	1.42 (1.27–1.59)	1.61 (1.45–1.84)
25–29	1.20 (1.10–1.31)	1.27 (1.20–1.35)	1.24 (1.15–1.33)
18.5–24.99	1	1	1
18.49 or less	1.23 (1.15–1.31)	1.16 (1.08–1.24)	1.05 (0.95–1.15)
(B) Asthma with allergic rhinitis adjusted OR (95% CI)			
30 or more	1.38 (0.89–2.16)	1.27 (1.05–1.44)	1.36 (1.17–1.58)
25–29	0.91(0.72–1.15)	1.00 (0.90–1.11)	1.24 (1.14–1.34)
18.5–24.99	1	1	1
18.49 or less	1.30 (1.10–1.52)	1.27 (1.15–1.40)	1.09 (0.98–1.21)
(C) Allergic rhinitis adjusted OR (95% CI)			
30 or more	0.93 (0.88–1.00)	0.99 (0.93–1.06)	1.01 (0.97–1.06)
25–29	0.96 (0.92–0.98)	0.97 (0.94–1.00)	1.01 (0.99–1.04)
18.5–24.99	1	1	1
18.49 or less	1.18 (1.15–1.21)	1.19 (1.15–1.23)	1.13 (1.10–1.17)

affect the association between BMI and asthma. The odds ratios for asthma in obesity were relatively unchanged during the three decades of the study. An association between overweight and asthma without allergic rhinoconjunctivitis was demonstrated in all three birth cohorts, whereas asthma with allergic rhinoconjunctivitis was only associated with overweight in the most recent birth cohort.

Discussion

Overweight and obesity had a close association with asthma and the associations were stronger for asthma without allergic rhinoconjunctivitis. In contrast, allergic rhinoconjunctivitis per se had no relationship with overweight or obesity. Recent longitudinal studies indicate that a high BMI precedes the development of asthma.[10,11] As a result, overweight and obesity per se may cause asthma. An alternative explanation could be that overweight and asthma have common risk factors related to lifestyle, such as dietary changes or a low level of physical activity. It has been argued that the association between asthma and a high BMI is of recent origin in children and this would contradict a causal relationship.[4] However, our findings do not support this hypothesis. The increased risk of asthma in obese conscripts has been unchanged over three decades in Sweden, even after adjustment for socio-economic status, rural living and family size. Less overweight and obesity in the population, insufficient study size and failure to make a distinction between atopic and non-atopic asthma in the analyses may have contributed to the failure to detect a relationship between a high BMI and asthma in studies from the 1970s or before. It is, however, important to underline that we have analysed the trend in 18-year-old men. We have no information about the age at which the asthma symptoms started. Furthermore, the increase in asthma (with and without allergic rhinoconjunctivitis) was largely independent of changes in BMI. A similar increase was demonstrated in all BMI classes.

We have no explanation for the slightly increased risk of allergic rhino-conjunctivitis and asthma in underweight conscripts. The association between asthma and underweight appeared to be independent of allergic rhinoconjunctivitis and was weak in the most recent birth cohorts (born in 1972–1977). In some other studies, underweight has been linked to an increased risk of lower respiratory illness and bronchial hyper-responsiveness.[12–14] Undernourishment may have detrimental effects on lung function.[13] A recent American study of adults of all ages only observed an association between underweight and asthma in men.[15] It has also been suggested that underweight was related to undertreatment of asthma.[12] We have no information about the

severity of symptoms in our study. However, the association between underweight and asthma was mainly demonstrated in individuals who underwent examination for military service before inhaled steroids were in general use in Sweden.

The two most important strengths of this study are the exceptionally large study population and the consistency of the data collection. The study is further strengthened by the fact that it consists of more than 90% of all young adult men in Sweden over a period of three decades. The study has some limitations. In our analyses of asthma, we have made a distinction between individuals with and without allergic rhinoconjunctivitis. Asthma without allergic rhinoconjunctivitis does not exclude atopy, but we believe that asthma with and without allergic rhinoconjunctivitis is a reasonably good proxy for atopic and non-atopic asthma. The diagnoses of asthma or allergic rhinoconjunctivitis were made by a doctor after a personal interview. A previous validation of the conscript examinations suggested that the accuracy of the diagnosis was fairly good.[2] It is reasonable to believe, however, that some of the increase in asthma and hay fever is related to changes in the recognition or labelling of asthmatic and allergic symptoms,[16] but it is less likely that misclassification has substantially changed the association between asthma and obesity.

To summarise, linking national registers has enabled us to assess the association of BMI with asthma and allergic rhinoconjunctivitis in young Swedish men over a period of three decades. Obesity was related to an increased risk of asthma and this association has remained unchanged over time.

References

1. Rasmussen F, Johansson M, Hansen HO. Trends in overweight and obesity among 18-year-old males in Sweden between 1971 and 1995. *Acta Paediatr* 1999;**88**:431–7.
2. Åberg N. Asthma and allergic rhinitis in Swedish conscripts. *Clin Exp Allergy* 1989;**19**:59–63.
3. Chinn S. Obesity and asthma: evidence for and against a causal relation. *J Asthma* 2003;**40**:1–16.
4. Chinn S, Rona RJ. Can the increase in body mass index explain the rising trend in asthma in children? *Thorax* 2001;**56**:845–50.
5. Hauspie R, Susanne C, Alexander F. A mixed longitudinal study of the growth in height and weight in asthmatic children. *Hum Biol* 1976;**48**:271–83.
6. Kaplan B, Brush G, Mascie-Taylor C. The relationship of childhood asthma and wheezy bronchitis with height, weight and body mass index. *Hum Biol* 1987;**59**:921–31.
7. WHO. Obesity. Preventing and managing the global epidemic. Report of a WHO consultation on obesity. Geneva: World Health Organization; 1998.
8. Socio-economic classification. Stockholm: Statistics Sweden; 1982.
9. Bråbäck L, Hjern A, Rasmussen F. Trends in asthma, allergic rhinitis and eczema among Swedish conscripts from farming and non-farming environments. A nationwide study over three decades. *Clin Exp Allergy* 2004;**34**: 38–43.
10. Camargo Jr. CA, Weiss ST, Zhang S, Willett WC, Speizer FE. Prospective study of body mass index, weight change, and risk of adult-onset asthma in women. *Arch Intern Med* 1999;**159**:2582–8.
11. Huovinen E, Kaprio J, Koskenvuo M. Factors associated to lifestyle and risk of adult onset asthma. *Respir Med* 2003;**97**:273–80.
12. Schachter LM, Salome CM, Peat JK, Woolcock AJ. Obesity is a risk for asthma and wheeze but not airway hyperresponsiveness. *Thorax* 2001;**56**:4–8.
13. Litonjua AA, Sparrow D, Celedon JC, DeMolles D, Weiss ST. Association of body mass index with the development of methacholine airway hyperresponsiveness in men: the Normative aging study. *Thorax* 2002;**57**: 581–5.
14. Celedon JC, Palmer LJ, Litonjua AA, Weiss ST, Wang B, Fang Z, et al. Body mass index and asthma in adults in families of subjects with asthma in Anqing, China. *Am J Respir Crit Care Med* 2001;**164**:1835–40.
15. Luder E, Ehrlich RI, Lou WY, Melnik TA, Kattan M. Body mass index and the risk of asthma in adults. *Respir Med* 2004;**98**:29–37.
16. Magnus P, Jaakkola JJ. Secular trend in the occurrence of asthma among children and young adults: critical appraisal of repeated cross sectional surveys. *Br Med J* 1997;**314**:1795–9.