

Short communication

Is obesity a risk factor for childhood asthma?

Background: In adolescents and adults, an association between obesity and asthma was found in females. Does this sex-specific association already exist in young children?

Methods: Questionnaire data on 9357 5- and 6-year-old German children were collected in 1997 in two rural regions in Bavaria. The diagnosis of asthma, hay fever, and eczema was ascertained with the ISAAC core and other validated questions. Overweight was defined by a BMI of >90 th and ≤ 97 th percentile and obesity by a BMI of >97 th percentile.

Results: The lifetime prevalence of doctor's diagnosed asthma in girls was 3.5% (95% CI 2.9–4.1%) for normal weight, 5.8% (95% CI 3.2–8.4%) for overweight, and 10.3% (95% CI 5.3–15.2%) for obesity, whereas no relation to weight was found in boys. Hay fever and eczema were unrelated to weight in girls and boys. The adjusted odds ratio for asthma in girls was 2.12 (95% CI 1.22–3.68) for overweight and 2.33 (95% CI 1.13–4.82) for obesity.

Conclusions: A sex-specific association with doctor's diagnosed asthma was also observed in girls at school entry. Since this association was confined to doctor's diagnosed asthma in the absence of other atopic conditions, and no association with other atopic manifestations was found, we hypothesize that this association is related to factors other than atopic sensitization.

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An association between obesity and asthma has been observed in a number of studies in adults and adolescents (1–7) and school-age children (8). Interestingly, in most studies, this effect was not observed in males (3, 5, 6, 9) or the effect was stronger in women (1, 4). There have been doubts as to whether this association is causal (10). Confirmation of these findings in a population of young children might help to resolve some of the controversial issues since there is little comorbidity in this age group and additional risk factors may be ascertained more easily.

We have therefore analyzed the association between overweight/obesity and asthma in 9357 5- and 6-year-old German children at school entry. The main questions were as follows. Is there a different effect of overweight and obesity on childhood asthma in boys and girls? Are there similar effects on other atopic diseases? Is the effect of overweight and obesity on childhood asthma related to the severity of asthma?

Material and methods

Study population and data sources

The 1997 obligatory school entry health examination involved 134 577 children in Bavaria. The parents of 13 345 children seen in two rural Bavarian regions (Oberpfalz and Niederbayern) from February 1997 to August 1997 were given a questionnaire on risk

factors for atopic diseases. The consent of the Bavarian office for data confidentiality had been sought and obtained, since the main ethical issue in this anonymized cross-sectional study regarded confidentiality. The return rate for the questionnaires was 76% ($n = 10 163$). Data collected with this questionnaire were linked with the school entry health examination data. The analysis was confined to the 5- and 6-year-old children with German nationality ($n = 9357$) (11).

Height and weight were measured as part of the routine health examination. The body-mass index (BMI) was calculated as weight/height squared. The age- and sex-specific distribution of the BMI of all children with German nationality investigated during the 1997 school health examination in Bavaria was used as the reference to define overweight (BMI of >90 th and ≤ 97 th percentile) and obesity (BMI of >97 th percentile) (11).

Questionnaire

The questionnaire included the ISAAC core questions on symptoms of asthma, allergic rhinitis, and atopic eczema, which have been reported in detail elsewhere (12). In addition, parents were asked: "Did a doctor ever diagnose any of the following diseases in your child?"

- 1) asthma
- 2) asthmatic, spastic, or obstructive bronchitis
- 3) bronchitis."

Children were defined as having asthma if their parents reported that asthma had been diagnosed at least once, or that any doctor had diagnosed asthmatic, spastic, or obstructive bronchitis twice or more often (13). The prevalence of hay fever and atopic eczema was assessed by a doctor's diagnosis of the disease. Symptoms of hay

fever were assessed by asking about a runny nose without a cold being accompanied by itchy-watery eyes in the last 12 months. Current rash was assessed by asking about an itchy rash coming or going in specified skin areas for at least 6 months in the past 12 months (14). The severity of asthma was assessed by the number of wheezing attacks in the last 12 months (0 vs 1, 1–3, 4–12, or more than 12), waking up at night because of wheezing (never, fewer than one night per week, or one or more nights per week in the previous 12 months), and having to breathe after one or two words when attempting to speak during an asthma attack (never vs ever in the previous 12 months).

The main explanatory variables considered were overweight and obesity. Potential confounding of the association between overweight/obesity and atopic diseases by family history of atopic disease, indoor dampness, smoking at home (number of cigarettes smoked in the house in the third year of life), low birth weight or premature birth, breast-feeding, number of febrile episodes in the first year of life, living on a farm, consumption of full-fat milk, and parental education was considered.

Statistical analyses

Chi-square testing was used to assess significant differences in the prevalence of atopic disease in overweight and obese compared to normal weight children, and to assess the association between potential confounders and these variables. For variables which were significantly ($P < 0.05$) associated with both atopic disease and overweight/obesity, their impact on the association of overweight and obesity with atopic disease was tested. Confounding was assumed to be present for variables accounting for at least a 10% change of the odds ratio (OR) for overweight/obesity and atopic disease. Confounders and independent risk factors for atopic disease were included in the final logistic regression model. Adjusted odds ratios were calculated by logistic regression analysis. All calculations were carried out with the software package SAS, Version 6.12.

Results

Information on BMI was available for 9317 of the 9357 German children aged 5 and 6 years. In boys and girls combined, the prevalence of hay fever and atopic dermatitis was unrelated to overweight and obesity, whereas a clear dose effect of overweight and obesity on doctor's diagnosed asthma was observed with a prevalence of 5.7% (95% CI 5.2–6.2%) in children with a BMI of <90th percentile, increasing to 6.5% (95% CI: 4.6–8.4%) in overweight children and further increasing to 9.9% (95% CI: 6.6–13.2%) in obese children. The data stratified by sex are shown in Tables 1A and 1B. The effect of overweight and obesity on asthma was almost confined to girls (Table 1A),

whereas no significant relation to any atopic condition was found in boys (Table 1B). In girls, the effect of overweight and obesity on asthma reached significance for doctor's diagnosis of asthma. For wheeze in the past 12 months, a similar trend was observed. There was no effect of overweight and obesity on hay fever or atopic dermatitis in girls. We have also looked at the effect of increasing BMI in girls on doctor's diagnosis of asthma by quartiles of the BMI distribution in the girls enrolled in this study. There was an increase of the asthma prevalence in the order of 3–3.1% to 4–5.4% from below the first to above the third quartile ($P = 0.003$, Mantel-Haenszel chi-square test for trend).

The effect of overweight and obesity on the risk of asthma in girls could not be explained by confounding due to the known risk or protective factors family history of atopic disease, indoor dampness, smoking in the house, farming environment, breast-feeding, low birth weight or premature birth, and social class indicated by parental education, whereas a frequent consumption of full-fat milk reduced the odds ratio by more than 10%. Confounders and independent risk factors in the final logistic regression model are shown in Table 2. The adjusted odds ratios indicate a greater than twofold risk of doctor's diagnosed asthma by overweight. After adjustment, the dose effect (obesity vs overweight) becomes less clear. Other independent risk (protective) factors in the final logistic regression model were family history of atopic disease, low birth weight, frequent consumption of full-fat milk, and ≥ 3 febrile episodes in the first year of life.

The effect of overweight and obesity on doctor's diagnosed asthma was almost identical for those asthma patients who had no wheezing attack in the last 12 months (adjusted odds ratios: 2.1 [95% CI 0.98–4.5] for overweight and 2.5 [95% CI 0.97–6.5] for obesity) and those with one or more wheezing attacks in the last 12 months (adjusted odds ratios: 2.2 [95% CI 1.0–4.7] for overweight and 2.2 [95% CI 0.8–6.4] for obesity).

Discussion

There have been few studies looking at interdependencies between overweight/obesity and asthma in young children (15), and the question of whether

Table 1A. Prevalence of atopic diseases by BMI in 5- and 6-year-old German girls

BMI category	Lifetime doctor's diagnosis of asthma (%)	Wheeze in past 12 months (%)	Lifetime doctor's diagnosis of hay fever (%)	Runny nose and itchy eyes in past 12 months (%)	Lifetime doctor's diagnosis of eczema (%)	Itchy rash in past 12 months (%)
≤ 90 th percentile $n = 4015$	3.5 (2.9–4.1)	5.9 (5.2–6.6)	3.0 (2.5–3.6)	3.6 (3.0–4.2)	16.4 (15.3–17.6)	8.2 (7.3–9.1)
> 90th and ≤ 97 th percentiles $n = 324$	5.8 (3.2–8.4)	8.0 (5.0–11.0)	2.5 (0.8–4.2)	3.2 (1.2–5.0)	14.5 (10.6–18.4)	8.9 (5.8–12.1)
> 97th percentile $n = 156$	10.3 (5.3–15.2)	7.8 (3.6–12.1)	1.3 (0–3.1)	2.0 (0–4.1)	15.5 (9.8–21.2)	7.6 (3.3–11.9)

Table 1B. Prevalence of atopic diseases in 5- and 6-year-old German boys by BMI

BMI category	Lifetime doctor's diagnosis of asthma (%)	Wheeze in past 12 months (%)	Lifetime doctor's diagnosis of hay fever (%)	Runny nose and itchy eyes in past 12 months (%)	Lifetime doctor's diagnosis of eczema (%)	Itchy rash in past 12 months (%)
≤90th percentile <i>n</i> =4303	7.8 (7.0–8.6)	9.1 (8.2–10.0)	5.9 (5.2–6.6)	6.3 (5.6–7.0)	14.3 (13.2–15.3)	5.7 (5.0–6.4)
>90th and ≤97th percentile <i>n</i> =344	7.3 (4.5–10.0)	11.1 (7.7–14.5)	5.9 (3.4–8.4)	7.7 (4.8–10.5)	15.1 (11.3–18.9)	10.2 (7.0–13.5)
>97th percentile <i>n</i> =171	9.5 (5.1–14.0)	7.3 (3.3–11.3)	4.2 (1.2–7.3)	6.0 (2.4–9.6)	14.6 (9.2–19.9)	5.6 (2.0–9.1)

there are different effects in boys and girls has never been addressed. Our main finding is a strong association between overweight/obesity and doctor's diagnosed asthma in 5- and 6-year-old children that was confined to girls. Similar studies in adults and adolescents have also shown an association between overweight/obesity and asthma in females only (3, 5, 6). Our observations suggest that sex-specific overweight/obesity-related mechanisms accounting for an increased risk of asthma in females might be operative early in life already.

The association could be explained neither by confounding due to parental education, family history of asthma, low birthweight, smoking in the house, and number of older siblings (8, 15), nor by the recently identified protective factors, such as living on a farm or frequent consumption of full-fat milk (14).

This association was significant for doctor's diagnosed asthma only. For recent symptoms of asthma (wheeze in past 12 months) or wheezing at any time (data not shown), only a trend was observed. The absence of significant associations between overweight/obesity and wheezing might partially be explained by the German language: there is no generally accepted and unequivocally understood translation for *wheezing* in German (16). Doctor's diagnosed asthma also appears to reflect the more severe asthma cases (13). There might, however, also be a diagnostic bias for doctor's diagnosed asthma due to a possibly higher rate of dyspnea and "asthma-like symptoms" in obese children. Although diagnostic bias cannot be excluded, this does not appear very likely, since it would be difficult to explain why such a bias should be operative in girls only. There is a possibility, however, that obese girls might differ from obese boys in other aspects relevant to dyspnea and "asthma-like symptoms", such as physical activity.

There is, however, in addition, an issue regarding reverse causation: children might become overweight/obese as a result of a switch to less physical activities after the diagnosis of asthma or as a consequence of asthma therapy (17, 18). This, however, does not appear likely from the results of the subgroup analyses: similar relations of overweight/obesity and

doctor's diagnosed asthma were seen in children with or without any attacks of wheeze in the previous 12 months.

In our study, the association between overweight/obesity and asthma was not related to the severity of asthma (18). We also looked at subgroups with severe symptomatic asthma in the previous year, as indicated, for example, by waking up at night because of wheezing (never vs ever) and having to breathe after one or two words when attempting to speak during an asthma attack (never vs ever). For neither of these subgroups was overweight or obesity associated with a higher asthma risk than in children with less severe asthma (data not shown). Since the total numbers of girls with severe asthma were low (asthma plus at least one episode in the last 12 months [*n*=214], asthma plus waking at night because of wheezing at least once in the previous months [*n*=140], and having to breathe after one or two words when attempting to speak during an asthma attack ever in the previous 12 months [*n*=42]), this study did not have much power to detect different effects of overweight and obesity on different degrees of severity of asthma in girls.

The effect is unlikely to be related to atopy, since, as in other studies (4, 6), no similar association between overweight/obesity and other atopic conditions was observed. There is only one study reporting an association between asthma/obesity and the prevalence of atopy and rhinitis symptoms in

Table 2. Impact of overweight and obesity on risk of asthma (lifetime doctor's diagnosis) in girls at school entry (final logistic regression model including confounders and other independent risk factors)

	Odds ratio	95% CI
BMI >90th percentile and ≤97th percentile	2.12	1.22–3.68
BMI >97th percentile	2.33	1.13–4.82
At least one family member with atopic disease	2.29	1.59–3.30
Full-fat milk ≥3 times weekly*	0.76	0.54–1.08
Birth weight ≤2500 g	2.21	1.37–3.55
Fever above 38.5°C ≥3 times in first year	1.99	1.41–2.82

* Confounder (>than 10% change of odds ratio).

adolescent girls (5). In our data, we also looked at the impact of overweight and obesity on the risk of asthma in girls with a history of other atopic manifestations and those without. These analyses showed the effect in the group of girls with asthma and absence of a lifetime diagnosis of hay fever or eczema, whereas no such effect was shown for asthma plus a lifetime diagnosis of hay fever or eczema (data not shown), further suggesting that the effect of overweight and obesity on asthma is unrelated to differences in atopic sensitization.

Overweight and obese children appear to experience more acute respiratory tract infections than children with normal weight (19, 20). Although many of the asthma patients might have infection-associated asthma, and not atopic asthma, this could only explain the apparently different effects in boys and girls if the higher rates of acute respiratory tract infections in overweight and obese children were also found in girls. However, the rates for cough and bronchitis appear to be higher in overweight and obese boys (8, 20).

There are preliminary data on a higher susceptibility to exercise-induced bronchospasm in nonallergic overweight children (21). Overweight and obesity might be associated with a reduced airways caliber as a result of chest-wall restriction. Interestingly, overweight in asthmatic children was associated with a peak flow rate of $\leq 60\%$ of the predicted value (18).

Studies on the ratio of fat to body mass determined by dual-energy x-ray absorptiometry have shown that

boys and girls differ substantially in body fatness, given a similar BMI. Girls have a greater total body fat than boys at the same level of BMI (22). Moreover, the 90th percentile for 5- or 6-year-old girls was higher than in boys (17.39 and 17.70 vs 17.24 and 17.53) in the reference population of all Bavarian children. The respective values for the 97th percentile were 19.39 and 19.93 in girls and 19.22 and 19.77 in boys. Therefore, if overweight and obesity are defined by BMI values above the sex- and age-specific percentiles, a sex-specific effect of overweight/obesity on asthma might be caused by a higher percentage of total body fat in girls than in boys in the same BMI categories.

Cross-sectional data on 5- and 6-year-old German children showed a 1.7- and 2.9-fold higher prevalence of doctor's diagnosed asthma in overweight and obese girls, respectively, but not in boys. This does not appear to be related to a higher risk of atopic asthma but rather to higher rates of dyspnea and "asthma-like symptoms" in obese girls. The causes of this association are unclear. From the data of other studies, we hypothesize that this association might be related to reduced airways caliber as a result of the specific fat deposition in girls.

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