

Body mass index in Belgian schoolchildren and its relationship with sensitization and allergic symptoms

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Results of studies of the influence of body mass index (BMI) on the allergic status are controversial. As a part of the Aalst Allergy Study, we assessed the prevalence of the different BMI categories (underweight, normal weight, overweight, and obesity) and a possible association between BMI and atopy in 1576 unselected Belgian schoolchildren, aged from 3.4 to 14.8 yr. BMI was used to determine weight status. Skin prick testing with the most common aeroallergens was performed. A parental questionnaire documented data on respiratory and allergic disorders, demographic characteristics and other potential risk factors for sensitization. Among the total children, 4.1% of the children were underweight, 14.5% were overweight, and 7.4% were obese. More girls than boys were overweight ($p = 0.015$). In the group of children older than 12 yr, we found more overweight ($p = 0.03$) and obese ($p = 0.004$) girls, and more obese boys ($p = 0.004$) than in the younger age groups. In contrast with reports in the literature, an increased prevalence of allergic sensitization in underweight girls only [adjusted odd ratio (OR_{adj}) = 2.9, 95% confidence interval (CI): 1.3–6.4] was documented. A strong association between obesity and exercise-induced respiratory symptoms was found in both boys ($OR_{adj} = 14.5$, 95% CI: 2.9–73.3) and girls ($OR_{adj} = 4.9$, 95% CI: 1.3–17.4). No correlations with allergic respiratory symptoms, eczema, or rhinoconjunctivitis could be documented.

**D. Van Gysel¹, E. Govaere¹,
K. Verhamme², E. Doli¹ and F. De Baets³**

Departments of ¹Pediatrics and ²Epidemiology,
O.L.Vrouw Hospital, Aalst, Belgium, ³Department of
Pediatric Pulmonology, University of Ghent, Ghent,
Belgium

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Elke Govaere, Department of Pediatrics, O.L.Vrouw
Hospital, Moorselbaan 164, B-9300 Aalst, Belgium
Tel.: +32-53-724155
Fax: +32-53-724645
E-mail: elke.govaere@olvz-aalst.be

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In literature, there are conflicting reports about the influence of body mass index (BMI) on the allergic status. Several studies about children have evaluated the association between obesity and allergy, mostly focusing on asthma and asthma-like symptoms, with variable results. Some studies did find an association between high BMI and asthma (1–4) while others did not (5–7). Some authors reported the importance of gender as high BMI and asthma was only observed in girls (2, 8–12) or boys (13, 14).

When considering high BMI with atopy, here as well, contradictory results have been published. Xu et al. (15) and Hancox et al. (12) did find an association of a high BMI with atopy,

while others did not (1, 2, 16, 17) or found an association in girls only (5, 18).

The objective of this study, as a part of the Aalst Allergy Study (AAS), was to study the association between the different BMI categories (underweight, normal weight, overweight, and obesity) and allergy in an unbiased population of Belgian children aged 3.4–14.8 yr.

Materials and methods

Study population

The subjects were drawn from the AAS. This study was performed from January 2004 to June

2005 in an unselected sample of children aged 3.4–14.8 yr (mean age: 9.3 yr) attending randomly selected nursery, primary, and secondary schools in the city of Aalst and the surrounding area. Aalst is a Flemish-speaking Belgian municipality situated 19 miles northwest from Brussels. It has a total population of 76,852 for a total area of 78.12 km², giving a population density of 983.83 inhabitants/km².

The parents of all 2674 children in the 2nd grade of nursery school, the 1st, 3rd, and 5th grade of primary school, and the 1st grade of secondary school were contacted, provided with a questionnaire (see next), and invited to participate in this study. The parents of 2021 children (75%) returned a completed questionnaire and provided written consent for skin prick testing to be performed in their child (see next). In 1576 of these 2021 children, data on height and weight were available. Height was measured to the nearest 0.5 cm with a wall-mounted stadiometer and weight (with the children wearing underwear only) to the nearest 0.1 kg with standardized scales, at the time of skin prick testing. The baseline characteristics of this group of children matched completely with the baseline characteristics of the whole study population of the AAS (19–21). BMI was calculated by dividing the weight in kilograms by the square of the height in m². BMI was analyzed as a continuous variable and as a categorical variable divided into four categories (underweight, normal weight, overweight, and obese). For overweight and obesity, age-dependent cut-off values, with the cut-off points being sex-specific centiles corresponding to a BMI of, respectively, 25 and 30 kg/m² at age 18 yr averaged across six populations (22), were used. For underweight, there are no uniform international criteria. In adults, a BMI value of less than 18.5 kg/m² is most often used (23). For defining underweight in our study population, we used – by analogy with the internationally accepted criteria for overweight and obesity in children – age-dependent cut-off values, with the cut-off points being sex-specific centiles corresponding to a BMI of 18.5 kg/m² at age 18 yr, as others have done before (24).

Questionnaire

Parental questionnaires were distributed through the school doctors of the participating schools. The questions addressing respiratory and allergic disorders, i.e., rhinoconjunctivitis, asthma, and eczema, were adapted from the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire (25) and also covered the

items of the Brief Pediatric Asthma Screen Plus (BPAS+) (26) (the scoring for the asthma component of the BPAS+ is a positive response to any one of the following four items: wheeze, persistent cough, night cough, and response to change in air temperature). The questionnaire also included questions about demographic characteristics (age, gender, nationality, maternal, and paternal profession), tobacco smoke exposure (prenatal and postnatal), and other potential risk factors for sensitization, such as prematurity, birth weight, feeding practices in the neonatal period, family history of allergy, number of siblings, frequency of childhood infections, vaccinations, place of residence (urban or rural), animal contacts, and housing characteristics (age of building, heating, dampness, bedroom conditions, etc.).

Skin prick tests

Skin prick testing with the most common aero-allergens was performed by the same two trained pediatricians to ensure uniformity in testing technique and interpretation. The allergen panel consisted of *Dermatophagoides pteronyssinus*, *Alternaria tenuis*, cat, dog, mixed grass pollens (orchardgrass, Kentucky bluegrass, perennial ryegrass, gramineae, and timothy), tree pollens (common alder, common birch, hazel, and European hornbeam), and *Blattella germanica* (cockroach); allergen extracts were used at a concentration of 100 index reactivity (IR) units per milliliter (Stallergenes, Waterloo, Belgium). Histamine solution (10 mg/ml in distilled water) was used as a positive control and saline as a negative control. Each child was tested on the volar surface of the forearm using 1-mm prick lancets (Stallergenes). The skin reaction was recorded after 15 min by evaluating the skin response rate to inoculation of each allergen extract in comparison with the wheal given by the positive and the negative control. The size of each wheal was documented as the mean of the longest diameter and the diameter perpendicular to it. A positive test was defined as a mean wheal size, after subtraction of the negative control, of at least 3 mm. Use of H1 antihistamines was suspended at least 7 days before the skin prick test.

Atopy was defined as at least one positive skin test to any of the seven allergens tested (27).

Statistical analysis

Descriptive statistical analysis methods were used to study the BMI categories and the prevalence of sensitization according to the different age

groups and gender. To extrapolate the prevalence results to the general Flemish population, the overall prevalence was age-standardized using the age distribution of children in the north of Belgium (<http://www.wvc.vlaanderen.be/statistieken.htm>). Chi-squared test or Fisher's exact test was used to study the differences for the different age categories and between genders.

Differences in mean BMI for the different age categories were tested by means of an ANOVA. A *post hoc* Tukey analysis was performed to test pairwise differences in mean BMI.

Logistic regression analysis was used to study the association between BMI, the covariates, and the outcome (sensitized or non-sensitized). In a univariate analysis, the association between each covariate and sensitization was studied. We then performed stepwise addition of all risk factors for sensitization into the model. Risk factors were included in the final model if they changed the estimate by more than 5%.

A p-value of less than 0.05 was considered statistically significant. All analysis was performed using the statistical package SPSS for Windows version 13.0.

Results

A total of 1576 children (48.8% boys), aged 3.4–14.8 yr old, were included.

Table 1 shows the baseline characteristics of the study population. A total of 1174 (74.5%) among all the study children had negative skin prick tests and 402 (25.5%) had at least one positive skin prick test.

Table 2 shows the absolute numbers and percentages of boys, girls, and the total group of children, subdivided into different BMI and age categories.

Among the children, 4.1% (4.2% of the boys and 4.0% of the girls) were underweight, 14.5% (11.7% of the boys and 17.1% of the girls) were overweight, and 7.4% (6.9% of the boys and 7.8% of the girls) were obese. The age standardized prevalence rate for underweight, overweight, and obesity were 4.1% (4.0% of the boys and 4.2% of the girls), 14.4% (11.4% of the boys and 17.3% of the girls), and 7.5% (7.4% of the boys and 7.7% of the girls), respectively. Overweight was significantly more present in girls than in boys ($p = 0.015$).

The prevalence of overweight (20.1%) and obese children (13.6%) was much higher in the group of children older than 12 yr compared with the youngest age category (13.0% and 4.9%, respectively). This difference was statistically significant. No significant difference in

Table 1. Baseline characteristics of the study population

	Study population (n = 1576)		
	Not sensitized, n = 1174 (%)	Sensitized, n = 402 (%)	Odds ratio [95% CI]
Age (in yr)	3.4–14.8 (mean: 9.4 ± 2.9)	3.9–14.0 (mean: 10.2 ± 2.6)	
3.4–< 6 y:	237 (20.2%)	47 (11.7%)	1
6–<8 y:	119 (10.1%)	28 (7.0%)	1.2 [0.7–2.0]
8–<10 y:	128 (10.9%)	32 (8.0%)	1.3 [0.8–2.1]
10–<12 y:	417 (35.5%)	170 (42.3%)	2.1 [1.4–2.9]
12–14.8 y:	273 (23.3%)	125 (31.1%)	2.3 [1.6–3.4]
Gender			
Male	532 (45.3%)	237 (59.0%)	1
Female	642 (54.7%)	165 (41.0%)	0.6 [0.5–0.7]
Animal exposure at birth			
No	617 (52.6%)	242 (60.2%)	1
Yes	528 (45.0%)	157 (39.1%)	0.8 [0.6–0.956]
Missing	29 (2.5%)	3 (0.7%)	
Current animal exposure			
No	366 (31.2%)	138 (34.3%)	1
Yes	805 (68.6%)	262 (65.2%)	0.9 [0.7–1.1]
Missing	3 (0.3%)	2 (0.5%)	
Passive smoke exposure			
No	664 (56.6%)	251 (62.4%)	1
Yes	493 (42.0%)	147 (36.6%)	0.8 [0.6–0.997]
Missing	17 (1.4%)	4 (1.0%)	
Maternal smoking during pregnancy			
No	959 (81.7%)	332 (82.6%)	1
Yes	178 (15.2%)	57 (14.2%)	0.9 [0.7–1.3]
Missing	37 (3.2%)	13 (3.2%)	
Prematurity			
No	1075 (91.6%)	379 (94.3%)	1
Yes	74 (6.3%)	18 (4.5%)	0.7 [0.4–1.2]
Missing	25 (2.1%)	5 (1.2%)	
Breastfeeding			
No	640 (54.5%)	224 (55.7%)	1
Yes	497 (42.3%)	168 (41.8%)	1.0 [0.8–1.2]
Missing	37 (3.2%)	10 (2.5%)	
Daycare attendance			
No	688 (58.6%)	249 (61.9%)	1
Yes	450 (38.3%)	145 (36.1%)	0.9 [0.7–1.1]
Missing	29 (2.5%)	8 (2.0%)	
Eczema			
No	925 (78.8%)	266 (66.2%)	1
Yes	235 (20.0%)	128 (31.8%)	1.9 [1.5–2.4]
Missing	14 (1.2%)	8 (2.0%)	
Respiratory symptoms			
Coughing			
No	868 (73.9%)	269 (66.9%)	1
Yes	290 (24.7%)	125 (31.1%)	1.4 [1.1–1.8]
Missing	16 (1.4%)	8 (2.0%)	
Viral-induced coughing			
No	887 (75.6%)	285 (70.9%)	1
Yes	271 (23.1%)	109 (27.1%)	1.3 [0.966–1.6]
Missing	16 (1.4%)	8 (2.0%)	
Non-infectious coughing			
No	1127 (96.0%)	369 (91.8%)	1
Yes	31 (2.6%)	25 (6.2%)	2.5 [1.4–4.2]
Missing	16 (1.4%)	8 (2.0%)	
Wheezing			
No	946 (80.6%)	269 (66.9%)	1
Yes	190 (16.2%)	121 (30.1%)	2.2 [1.7–2.9]
Missing	38 (3.2%)	12 (3.0%)	

Table 1. (Continued)

	Study population (n = 1576)		
	Not sensitized, n = 1174 (%)	Sensitized, n = 402 (%)	Odds ratio [95% CI]
Dyspnea			
No	1030 (87.7%)	313 (77.9%)	1
Yes	108 (9.2%)	79 (19.7%)	2.4 [1.8–3.3]
Missing	36 (3.1%)	10 (2.5%)	
Exercise-induced			
No	1071 (91.2%)	334 (83.1%)	1
Yes	81 (6.9%)	59 (14.7%)	2.3 [1.6–3.3]
Missing	22 (1.9%)	9 (2.2%)	
Laughing-induced			
No	1119 (95.3%)	366 (91.0%)	1
Yes	27 (2.3%)	21 (5.2%)	2.4 [1.3–4.3]
Missing	28 (2.4%)	15 (3.7%)	
Weather-induced			
No	1064 (90.6%)	335 (83.3%)	1
Yes	82 (7.0%)	55 (13.7%)	2.1 [1.5–3.1]
Missing	28 (2.4%)	12 (3.0%)	
Rhinitis			
No	965 (82.2%)	227 (56.5%)	1
Yes	172 (14.7%)	161 (40.0%)	4.0 [3.1–5.2]
Missing	37 (3.2%)	14 (3.5%)	
Conjunctivitis			
No	1080 (92.0%)	280 (69.7%)	1
Yes	60 (5.1%)	109 (27.1%)	7.0 [5.0–9.9]
Missing	34 (2.9%)	13 (3.2%)	
Family history of allergy			
No	390 (33.2%)	98 (24.4%)	1
Yes	528 (45.0%)	229 (57.0%)	1.7 [1.3–2.3]
Missing	256 (21.8%)	75 (18.7%)	
Bedroom conditions			
Stuffed toys			
No	70 (6.0%)	40 (10.0%)	1
1–5	476 (40.5%)	192 (47.8%)	0.7 [0.5–1.1]
>5	565 (48.1%)	160 (39.8%)	0.5 [0.3–0.8]
Missing	63 (5.4%)	10 (2.5%)	
Bedding material			
Synthetic	759 (64.7%)	292 (72.6%)	1
Duvet or non-synthetic bedding material	315 (26.8%)	82 (20.4%)	0.7 [0.5–0.9]
Missing	100 (8.5%)	28 (7.0%)	
Floor			
Wood or fitted carpet	991 (84.4%)	345 (85.8%)	1
Rest	148 (12.6%)	40 (10.0%)	0.8 [0.5–1.1]
Missing	36 (3.1%)	17 (4.2%)	

prevalence of overweight and obese children was found between the other age groups and the youngest age category. After stratification by gender, we found significantly more overweight (22.9%) and obese (13.8%) girls in the oldest age category ($p = 0.03$ and $p = 0.004$, respectively). Boys older than 12 yr showed only a tendency toward overweight (16.7%) and showed significantly more obesity (13.3%) ($p = 0.06$ and $p = 0.004$, respectively).

The prevalence of underweight was lowest in the youngest (1.1%) and eldest age category (1.3%) compared with the other age categories; this difference in prevalence was statistically

Table 2. Numbers (and percentages) of children in each BMI category for each age group, for the whole study population, and for boys and girls, respectively

	Underweight	Normal weight	Overweight	Obese	Total
Total study population					
3–6 yr	3 (1.1)	230 (81.0)	37 (13.0)	14 (4.9)	284 (100)
6–8 yr	15 (10.2)	118 (80.3)	9 (6.1)	5 (3.4)	147 (100)
8–10 yr	13 (8.1)	118 (73.8)	22 (13.8)	7 (4.4)	160 (100)
10–12 yr	28 (4.8)	443 (75.5)	80 (13.6)	36 (6.1)	587 (100)
>12 yr	5 (1.3)	259 (65.1)	80 (20.1)	54 (13.6)	398 (100)
All children	64 (4.1)	1,168 (74.1)	228 (14.5)	116 (7.4)	1,576 (100)
Boys					
3–6 yr	2 (1.3)	124 (83.2)	16 (10.7)	7 (4.7)	149 (100)
6–8 yr	7 (8.4)	70 (84.3)	4 (4.8)	2 (2.4)	83 (100)
8–10 yr	7 (9.2)	59 (77.6)	5 (6.6)	5 (6.6)	76 (100)
10–12 yr	14 (5.0)	217 (77.2)	35 (12.5)	15 (5.3)	281 (100)
>12 yr	2 (1.1)	124 (68.9)	30 (16.7)	24 (13.3)	180 (100)
All boys	32 (4.2)	594 (77.2)	90 (11.7)	53 (6.9)	769 (100)
Girls					
3–6 yr	1 (0.7)	106 (78.5)	21 (15.6)	7 (5.2)	135 (100)
6–8 yr	8 (12.5)	48 (75.0)	5 (7.8)	3 (4.7)	64 (100)
8–10 yr	6 (7.1)	59 (70.2)	17 (20.2)	2 (2.4)	84 (100)
10–12 yr	14 (4.6)	226 (73.9)	45 (14.7)	21 (6.9)	306 (100)
>12 yr	3 (1.4)	135 (61.9)	50 (22.9)	30 (13.8)	218 (100)
All girls	32 (4.0)	574 (71.1)	138 (17.1)	63 (7.8)	807 (100)

Percentage is given in parenthesis.

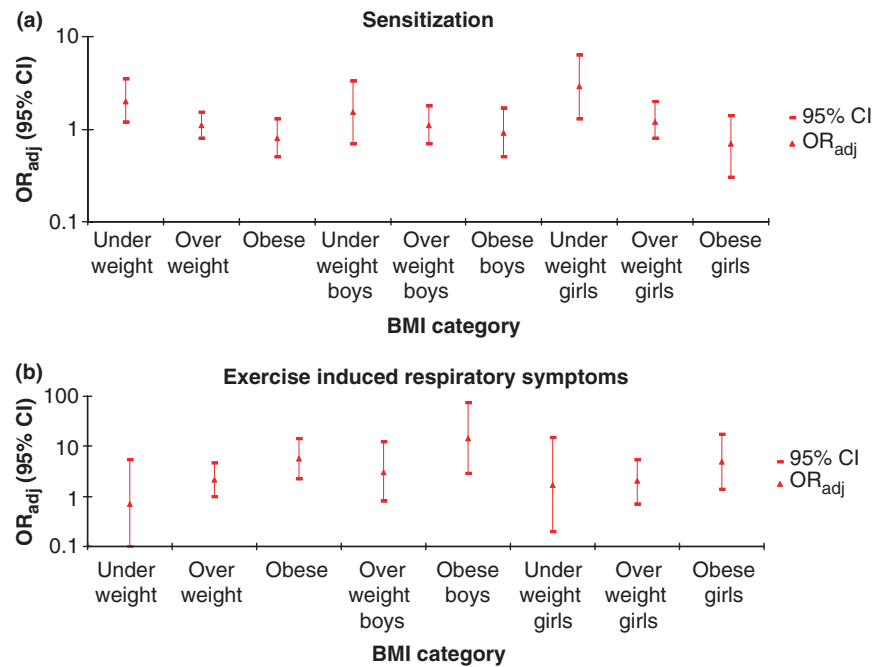
significant for the whole group, as well as for boys and girls separately ($p < 0.001$).

One thousand hundred and seventy-four (75.5%) of all 1576 children had negative skin prick tests and 402 children (24.5%) had at least one positive skin prick test. Table 2 shows the prevalence of overall sensitization in the different BMI categories for the whole group, and for boys and girls separately. Using normal weight as reference group, our data showed an association between being underweight and overall sensitization [adjusted odds ratio (OR_{adj}) = 2.0, 95% confidence interval (CI): 1.2–3.5]. As for the individual allergens (data not shown), we found an association between underweight and sensitization to mixed grass pollen (OR_{adj} = 2.0, 95% CI: 1.0–4.1), cat (OR_{adj} = 3.9, 95% CI: 1.6–4.1), and dog ($Odds_{adj}$ = 3.8, 95% CI: 1.2–12.4).

There was no statistically significant difference in overall sensitization between the normal weight group and the group of overweight (OR_{adj} = 1.1, 95% CI: 0.8–1.5) or obese children (OR_{adj} = 0.8, 95% CI: 0.5–1.3), nor for the individual allergens (data not shown).

After stratification by gender, we found that the underweight girls had almost a three-fold risk of overall sensitization compared with the normal weight girls (OR_{adj} = 2.9, 95% CI: 1.3–6.4). This association was mainly observed for *Dermatophagoides pteronyssinus* (OR_{adj} = 3.3, 95% CI: 1.2–8.9), tree pollen (OR_{adj} = 6.9, 95% CI:

Fig. 1. (a) Association with overall sensitization and (b) exercise-induced respiratory symptoms of the different BMI categories for the whole group, and for boys and girls, respectively, represented as an adjusted odds ratio (OR_{adj}) with 95% confidence intervals (CIs). OR_{adj} adjusted for all factors that changed the crude odds ratio with more than 5% (age, gender, breastfeeding, passive smoke exposure, maternal smoking during pregnancy, housing conditions, day care attendance, pets, respiratory symptoms, family history of atopy, personal history of eczema, asthma and rhinoconjunctivitis, family composition, and month of skin prick testing). No data for OR_{adj} for underweight boys available in (b) due to low number of children.



1.5–31.2), and cat ($OR_{adj} = 5.8$, 95% CI: 1.8–18.5). No difference in sensitization was seen between the underweight and normal weight boys.

Finally, we investigated the association of BMI with the presence of allergic symptoms. We found a tendency toward more exercise-induced respiratory complaints (wheezing or dyspnea induced by exercise) in the group of overweight children ($OR_{adj} = 2.1$, 95% CI: 1.0–4.6) and a significant association of obesity with exercise-induced respiratory complaints ($OR_{adj} = 5.6$, 95% CI: 2.3–14.1), which was present in both boys ($OR_{adj} = 14.5$, 95% CI: 2.9–73.3) and girls ($OR_{adj} = 4.9$, 95% CI: 1.4–17.4) (Fig. 1). We found no significant association between BMI and eczema, rhinoconjunctivitis, or other allergic respiratory symptoms (wheezing, dyspnea, chronic cough, respiratory symptoms induced by laughing or changing weather conditions) (data not shown).

Discussion

Body mass index data from different countries show quite a large variability in the literature (28). Our prevalences of overweight and obesity are in line with those from the neighboring countries (29).

For the whole study population, overweight was significantly more prominent in girls than in boys, while underweight and obesity were equally present. In the group of children older than 12 yr, we found significantly more overweight

(22.9%) and obese (13.8%) girls, and more obese boys (13.3%) than in the younger age groups. This could be explained by the increase of body fat storage at the end of childhood and beginning of adolescence (30). The higher prevalence of overweight in girls (22.9%) than in boys (16.7%) in that age group has been reported in other surveys (31). Possible explanations are the ongoing fat storage in girls even during the growth spurt, while boys probably lose fat during the fast pubertal growth (30, 31) and the increased insulin resistance that is greater in girls than in boys (32). Underweight was less prominent in the age groups of 3–6 yr and > 12 yr than in the intermediate age groups. Underweight in pre-school children depends mostly on organic diseases; therefore, it is possible that these children are less enrolled in the study as they will irregularly attend school. Children older than 12 yr have less physical activity (33) and more access to fast food (34, 35) than the children in the intermediate age groups.

In literature, there are conflicting reports about the influence of BMI on the allergic status. Chinn et al. (36), in a review confined to studies in children and adolescents on the possible association between obesity and asthma or asthma-like symptoms, concluded that no study in a Western society has found objective evidence for the association, and results might be due to increased reporting of symptoms in obese children or to diagnostic bias. Similar contradictory results were also found for BMI and atopy (1, 2, 5, 12, 15–18). Our study showed an increased

prevalence of sensitization in underweight girls only, not in underweight boys, nor in overweight or obese children. This is striking as thinner children are known to have a lower degree of skin test sensitivity (37). Underweight has been previously reported to be associated with having asthma in 2- to 11-yr-old Harlem (USA) boys (38), in Chinese adults (39), and in Swedish conscripts (40), but, to our knowledge, this is the first report in literature of an association of underweight with increased sensitization. Reasons for the association of underweight and atopy in girls are not clear. Nutritional status with nutritional deficiencies in certain nutrients or undernourishment might explain the higher degree of atopy in underweight children, as a recent study by Chatzi et al. (41) showed a potential protective effect of fruity vegetables and fish intake on childhood atopy. However, this does not explain the gender difference in the relation between underweight and atopy.

Our data showed a strong positive association between obesity and exercise-induced respiratory symptoms in both boys and girls. This effect is unlikely to be related to atopy (16), as no significant association of obesity with sensitization could be observed and no association with other allergic respiratory symptoms, eczema, or rhinoconjunctivitis was found. Mechanical properties of the respiratory system (42) and an increased occurrence of gastroesophageal reflux disease (43), all associated with obesity in literature, may possibly account for this result.

The current study has several positive attributes: data on height and weight were not based on parental report but were measured in a standardized way by qualified medical personnel, standardized skin prick testing was performed according to the international guidelines, and the study population comprised a large sample of children, representative of the general Flemish non-institutionalized pediatric population.

As described in the methods, we only included children for whom height and weight were measured in a standardized way. The baseline characteristics of this group of children matched completely with the baseline characteristics of the whole study population of the AAS (20, 21). To check whether missing values on height and weight were associated with risk factors for allergic symptoms and atopy, we conducted a logistic regression analysis with missing values as outcome. None of the risk factors for atopy or allergic symptoms were associated with the fact of having missing values for weight and height. In addition, we obtained the same study results after missing value imputation. For this reason,

we believe that the fact of having missing values for some children included in the AAS is non-differential and that our findings can be extrapolated to the whole study population.

However, as for all observational research, our data need to be interpreted with caution.

First of all, there might have been the potential of selection bias as parents were invited to participate in the study. One could imagine that parents with a family history of allergy will be more willing to provide consent for participation in a study on sensitization, meaning that our prevalence is an overestimate of the true prevalence. An argument against selection bias, however, is the fact that our response rate was quite high (75%) and the fact that our results are in line with the data on prevalence of skin sensitization that have been published in the literature (19, 44). Secondly, in contrast with the objectively documented data on sensitization, the allergic symptoms were proxy-reported and not verified by either the use of medical records, physician contact, laboratory, or technical investigations (lung function tests, assessment of bronchial hyperreactivity, etc.). We used a patient questionnaire as an instrument to obtain data on allergic symptoms and potential risk factors or confounders. Our questionnaire was based on the ISAAC questionnaire, which has been proved to be valid to study the risk factors for allergy. Finally, limitations result from the cross-sectional design, as the time sequence of events cannot be established with certainty, and reporting of early life exposures might have been affected by recall bias.

In conclusion, we report prevalences of overweight and obesity in Belgian schoolchildren. Overweight and obesity increased significantly from the age of 12 yr on, and were most pronounced in girls. In contrast with some reports in the literature, we found underweight to be associated with an increased prevalence of sensitization. Our data showed a strong association between obesity and exercise-induced respiratory symptoms, but no associations with allergic respiratory symptoms, eczema, or rhinoconjunctivitis.

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Conflict of interest statement

The sponsor of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. None of the authors had any financial or personal relationships with other people or organizations that inappropriately influence his or her actions. The corresponding author had full access to all data in the study and had final responsibility for the decision to submit for publication.

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