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Obesity – a risk factor for asthma, but not for atopic dermatitis, allergic rhinitis and sensitization

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Abstract

Objective: To analyse the relationship between obesity and overweight and the prevalence of allergic diseases and sensitization, and the impact of gender and place of residence.

Design: Questionnaire based on those used in ISAAC (International Study of Asthma and Allergies in Childhood) and ECRHS (European Community Respiratory Health Survey).

Setting: Our study involved populations of the eight largest cities and one rural region in Poland (each with over 150 000 inhabitants).

Subjects: The study included 18 617 participants (24·2 % aged 6–7 years, 25·4 % aged 13–14 years, 50·4 % adults aged 20–44 years) in eight cities and one rural area. The out-patient study involved 4783 patients (25·7 %); we performed skin prick testing with fifteen aeroallergens.

Results: Overweight was found in 16·13 % of participants (9·11 % of 6–7-year-olds, 4·90 % of 13–14-year-olds and 25·61 % of adults), obesity in 6·41 % (7·16 %, 2·45 % and 8·36 %, respectively). In adults, overweight (OR = 1·34) and obesity (OR = 1·80) increased the prevalence of asthma, especially in women (OR = 1·53, OR = 2·01). Among 13–14-year-olds the prevalence was higher only in the obese (OR = 1·76). Overweight (OR = 1·99) and obesity (OR = 2·17) affected the incidence of doctor-diagnosed asthma in 6–7-year-olds. Overweight (OR = 0·81) and obesity (OR = 0·76) reduced the prevalence of allergic rhinitis in men. There was no relationship between BMI and asthma in people from rural areas. Obesity and overweight did not affect the frequency of sensitization to aeroallergens.

Conclusions: Overweight and obesity increased the prevalence of symptomatic asthma in adults, especially in women. In 13–14-year-olds, only obesity increased the prevalence of asthma. In children, overweight was associated with increased prevalence of clinically diagnosed and declared asthma and a trend towards atopy. Higher BMI was negatively associated with the prevalence of allergic rhinitis in overweight and obese man. There was no correlation between BMI and sensitization to aeroallergens.

Key words
Obesity
Overweight
Allergic diseases
Sensitization

There have been trends worldwide of increased prevalence of both obesity and allergic disorders. Experimental models, several prospective cohort studies and meta-analysis have evaluated the association between obesity and allergy, mostly focusing on asthma, asthma-like symptoms and bronchial inflammation[1–4]. However, the association tends to be stronger in non-allergic or non-atopic individuals than in allergic or atopic individuals[5]. A similar trend was proven in bronchial hyperresponsiveness and atopic dermatitis[6–8], but obesity was negatively associated with the prevalence of allergic rhinitis or there was no relationship[8–10]. Gender is also likely to be important when examining the relationship between allergic disease and obesity in children and adults, but the evidence is inconclusive. Some data showed a relationship of obesity and asthma only in females. Among a number of studies that have been conducted among children and adults, some have demonstrated an increased risk of atopy among overweight or obese individuals[11,12], while others have found no association between adiposity and atopy[13,14].

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The objective of the present study, a part of the Epidemiology of Allergic Disorders in Poland study (ECAP), was to analyse the association between the different BMI categories (normal weight, overweight and obesity) and allergic diseases and sensitization in a population of Polish children aged 6–7 years and 13–14 years and adults aged 20–44 years.

Materials and methods

Study population

ECAP used the methodology of the International Study of Asthma and Allergies in Childhood (ISAAC) and the European Community Respiratory Health Survey (ECRHS). The study areas were selected according to the ECRHS guidelines. ECAP involved the populations of the eight largest urban agglomerations in Poland (each with over 150 000 inhabitants) and additionally one rural region, also with a population of over 150 000 inhabitants since the rural population accounts for 39 % of the entire Polish population. The study areas were chosen specifically but the study participants were selected by stratified random sampling based on the national identification number PESEL. In accordance with the ISAAC and ECRHS protocols, the study included three groups of respondents: children aged 6–7 years and 13–14 years, and adults (aged 20–44 years).

The first part of the project (a questionnaire survey) was carried out on a group of 22 703 participants with the response rate of 64·4 % and eventually 18 617 completed questionnaires were accepted. It involved two age groups of children, 6–7-year-olds and 13–14-year-olds, and adults. There were 4510 (24·2 %) 6–7-year-olds, 4721 (25·4 %) 13–14-year-olds and 9386 (50·4 %) adults. Of the respondents, 10 011 (53·8 %) were female and 8606 (46·2 %) were male. In the medical evaluation part of the study, 4783 patients (25·7 % of the respondents) were assessed on an out-patient basis, including 1329 aged 6–7 years, 1321 aged 13–14 years and 2133 adults. The study group design is shown in Table 1.

Questionnaire-based survey

The questionnaire was based on the translated and validated questionnaires used in ECRHS and ISAAC. The diagnosis of allergic diseases was based on the assumptions of these studies described in detail in previous reports[15]. Details of the definition of the diseases are shown in the Appendix.

Medical evaluation

Allergologists diagnosed asthma according to the GINA (Global Initiative for Asthma) criteria, allergic rhinitis using the ARIA (Allergic Rhinitis and its Impact on Asthma) criteria and atopic dermatitis using the Hanifin and Rajka criteria. Skin prick testing (SPT) was performed for fifteen of the most common air-borne allergens (Allergopharma, Reinbek, Germany) such as: hazel (*Corylus* spp.); alder (*Alnus* spp.); birch (*Betula* spp.); grasses/crop plants; rye (*Secale cereal*); mugwort (*Artemisia* spp.); plantain (*Plantago* spp.); *Alternaria*, *Cladosporium* and perennial allergens, including moulds I (*Alternaria tenis*, *Botrylis cinerea*, *Cladosporium herbarum*, *Culvularia lanata*, *Fusarium moniliforme*, *Helminthosporium*) and moulds II (*Aspergillus fumigatus*, *Mucor mucedo*, *Penicillium notatum*, *Rhizopus nigricans*, *Serpula lacrymans*, *Pullularia pullulans*); common species of mites (*Dermatophagoides pteronyssinus* and *Dermatophagoides farinae*); and dog and cat dander. The test was considered negative when the wheal size was <3 mm, positive when the wheal size was 3–5 mm and markedly positive when the wheal size was ≥6 mm. Positive SPT for at least one allergen indicated atopy.

Anthropometric measurements

In all participants included in the study, the anthropometric parameters were obtained by a questionnaire. Parents of 6–7-year-olds, 13–14-year-olds and adults recorded the body weight (to nearest 0·1 kg) and height (to nearest 0·5 cm). In those participating in the out-patient study, we measured weight without shoes or outer clothing (to nearest 0·1 kg) and height (to nearest 0·1 cm). BMI was calculated as weight/height^2 (kg/m^2). BMI was analysed as a categorical variable divided into three categories (normal weight, overweight and obesity). According to

Table 1 Baseline characteristics of the study population, part of the Epidemiology of Allergic Disorders in Poland study (ECAP)

	Total		6–7-year-olds		13–14-year-olds		20–44-year-olds	
	n	%	*n*	%	*n*	%	*n*	%
Questionnaire survey								
Total	18 617	100·0	4510	24·2	4721	25·4	9386	50·4
Female	10 011	53·8	2218	22·2	2275	22·7	5518	55·1
Male	8606	46·2	2292	26·6	2446	28·4	3868	44·9
Urban region	16 562	89·0	4048	24·4	4177	25·2	8337	50·3
Rural region	2055	11·0	462	22·5	544	26·5	1049	51·0
Medical evaluation								
Total	4783	100·0	1329	27·8	1321	27·6	2133	44·6
Female	2608	54·5	657	25·2	639	24·5	1312	50·3
Male	2175	45·5	672	30·9	682	31·4	821	37·7
Urban region	4242	88·7	1173	27·7	1149	27·1	1916	45·2
Rural region	545	11·4	156	28·6	172	31·6	217	39·8

the accepted definition in epidemiological studies, adult obesity was defined as BMI ≥ 30·0 kg/m^2, overweight as BMI = 25·0–29·9 kg/m^2 and normal weight as BMI = 18·5–24·9 kg/m^2[2(9,16)]. Children's BMI referred to the new Polish growth charts (OLAF Study)[17] and obesity was diagnosed when BMI was >95th percentile, overweight when BMI was >85th and <95th percentile and normal weight when BMI was >3rd and <85th percentile.

Statistical evaluation

A χ^2 test or Fisher's exact test (for small sample sizes) was used in the statistical analysis. To determine the strength of association and the dependence between variables, χ^2 statistics and odds ratios were calculated. Results were considered to be statistically significant at $P < 0{\cdot}05$.

Ethics

The study was approved by the institutional Bioethics Committee. It was carried out as part of the project 'Implementation of the system for prevention and early diagnosis of allergic disorders in Poland' (No. 6 P05 2005 C/06572) funded by the Minister for Health and the Minister for Science.

Results

The prevalence of obesity and overweight and of allergic diseases and sensitization in the study population is shown in Table 2.

Among adults (based on the questionnaire), a more frequent presence of symptomatic asthma was significantly associated with being overweight (OR = 1·34; $P < 0{\cdot}0001$) and obese (OR = 1·80; $P < 0{\cdot}0001$). In 13–14-year-olds symptomatic asthma was more frequent only in the obese (OR = 1·76; $P = 0{\cdot}017$). Being overweight was significantly associated with an increased prevalence of declared asthma in 6–7-year-olds (OR = 2·44; $P < 0{\cdot}0001$) and 13–14-year-olds (OR = 1·66; $P = 0{\cdot}016$). Obese patients had no increase of declared asthma. Data based on medical evaluation showed that being overweight (OR = 1·99; $P = 0{\cdot}032$) and obese (OR = 2·17; $P = 0{\cdot}031$) were associated with an increased occurrence of asthma just in 6–7-year-old children. An increased prevalence of sensitization was only found in obese children aged 6–7 years (OR = 1·84; $P = 0{\cdot}017$). Detailed data are shown in Table 3.

When we divided the patients into two groups: sensitized to seasonal (positive SPT just for seasonal aeroallergens) and perennial (positive SPT just for perennial aeroallergens) aeroallergens, we found no effect of being overweight and obese on the prevalence of sensitization. We also found no effect of being overweight and obesity on monovalent *v.* polyvalent atopy (data not presented).

In adults, there was a significantly higher prevalence of symptomatic asthma in overweight (OR = 1·53; $P < 0{\cdot}001$) and obese (OR = 2·01; $P < 0{\cdot}001$) females (Table 4(a)). Among 13–14-year-olds, the same significance and tendency were also seen only in obese girls (OR = 2·25; $P = 0{\cdot}026$). In adults, overweight (OR = 0·81; $P = 0{\cdot}015$) and obese (OR = 0·76; $P < 0{\cdot}05$) males had a significantly decreased prevalence of allergic rhinitis.

Among participants from urban areas, the prevalence of symptomatic asthma was significantly higher in overweight (OR = 1·36; $P < 0{\cdot}01$) and obese (OR = 1·88; $P < 0{\cdot}01$) adults and obese 13–14-year-olds (OR = 2·07; $P < 0{\cdot}01$). Similar correlations were not observed in inhabitants from rural areas. In rural adult inhabitants, being overweight was associated with a decreased prevalence of allergic rhinitis (OR = 0·59; $P = 0{\cdot}02$; Table 4(b)).

Discussion

To our knowledge, the present study is first and largest one in this part of Europe assessing the relationship between overweight and obesity and the prevalence of allergic diseases and sensitization among children and adults, using data from a large questionnaire-based survey. The data were collected from almost 20 000 participants and additionally from medical evaluation of more than

Table 2 Prevalence of obesity, overweight and allergic diseases and sensitization in the study population, part of the Epidemiology of Allergic Disorders in Poland study (ECAP)

	Total	6–7-year-olds	13–14-year-olds	20–44-year-olds	Female	Male	Urban region	Rural region
Overweight	16·13	9·11	4·90	25·61	11·78	21·85	16·27	17·73
Obesity	6·41	7·16	2·45	8·36	5·15	8·24	6·38	8·17
Declared asthma	4·62	4·41	6·22	4·02	3·98	5·37	4·84	2·87
Symptomatic asthma	15·71	19·23	15·91	13·80	12·71	14·36	14·01	9·15
Clinically diagnosed asthma	10·56	11·44	11·36	9·52	9·24	12·14	10·62	10·09
Allergic rhinitis	21·11	23·72	24·57	21·01	21·22	24·03	23·33	15·96
Clinically diagnosed allergic rhinitis	28·29	23·78	30·05	30·00	26·42	30·53	28·34	27·89
Atopic dermatitis	3·91	5·34	4·30	3·02	4·61	3·08	4·12	1·90
Clinically diagnosed atopic dermatitis	6·50	8·73	9·01	3·56	6·75	6·21	6·87	3·67
Sensitization	45·81	39·31	48·62	48·22	42·94	49·29	43·46	64·22
SPT ≥ 6 mm	22·02	13·22	25·54	25·41	17·91	26·99	23·88	7·71

SPT, skin prick test.
Data are presented as percentages.

Table 3 Relationship between overweight and obesity and the prevalence of allergic diseases and sensitization in the study population, part of the Epidemiology of Allergic Disorders in Poland study (ECAP)

	6–7-year-olds				13–14-year-olds				20–44-year-olds			
	Overweight		Obesity		Overweight		Obesity		Overweight		Obesity	
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Declared asthma	**2·44**	**1·52, 3·91**	1·29	0·62, 2·66	**1·66**	**1·09, 2·53**	1·21	0·59, 2·45	1·15	09·13, 1·47	1·22	0·85, 1·75
Symptomatic asthma	1·23	0·99, 1·73	1·21	0·85, 1·71	1·13	0·78, 1·62	**1·76**	**1·10, 2·82**	**1·34**	**1·17, 1·55**	**1·80**	**1·48, 2·21**
Clinically diagnosed asthma	**1·99**	**1·05, 3·76**	**2·17**	**1·05, 4·47**	1·43	0·79, 2·57	0·57	0·13, 2·44	1·02	0·731, 1·43	0·98	0·57, 1·68
Allergic rhinitis	1·26	0·98, 1·63	1·05	0·75, 1·47	1·24	0·96, 1·60	1·56	1·08, 2·26	0·88	0·78, 1·00	0·84	0·69, 1·02
Clinically diagnosed allergic rhinitis	1·77	1·10, 2·84	1·46	0·83, 2·59	1·45	0·96, 2·20	1·71	0·83, 3·52	0·91	0·73, 1·14	1·21	0·87, 1·68
Atopic dermatitis	1·71	0·47, 6·22	1·17	0·24, 5·71	0·49	0·20, 1·19	0·49	0·13, 1·84	1·08	0·67, 1·74	0·99	0·49, 1·97
Clinically diagnosed atopic dermatitis	1·45	0·73, 2·88	0·67	0·23, 1·93	0·74	0·36, 1·50	1·14	0·38, 3·36	0·93	0·53, 1·61	0·62	0·22, 1·76
Sensitization	1·31	0·85, 2·03	**1·84**	**1·11, 3·04**	1·31	0·89, 1·94	1·50	0·75, 3·02	1·20	0·98, 1·46	0·98	0·72, 1·35
SPT ≥ 6 mm	**2·00**	**1·12, 3·57**	1·30	0·61, 2·79	1·45	0·91, 2·30	1·44	0·48, 2·70	1·09	0·87, 1·37	1·21	0·86, 1·72

SPT, skin prick test.
Reference category is normal weight. Statistically significant values are shown in bold.

4500 out-patients. The study was conducted in accordance with the standards of ISAAC and ECRHS and due to the Polish specificity (rural residents constitute 39 % of the Polish population) included one rural area.

In the literature, there are conflicting reports about the influence of BMI on allergic status. At the present state of knowledge, it appears that no study has confirmed objective evidence for the association, and results might be due to increased reporting of symptoms in obese individuals or to diagnostic bias. Similar contradictory results were also found for BMI and atopy. Our study confirmed previous reports of cross-sectional epidemiological studies that being overweight and obese is associated with an increased risk of asthma in adults (especially symptomatic asthma). Additionally, the adverse effect increased with increasing BMI: being obese compared with being overweight substantially increased the risk of asthma. Several investigations have already shown that the relationship between obesity and asthma is more likely to be observed among females, which is consistent with our present finding. It has been speculated that female sex hormones may contribute to the increased risk of asthma in obesity, although the precise mechanisms remain to be elucidated[18]. Confirmation of the profound impact of environmental factors and lifestyle on the development of asthma was our finding of the relationship between being overweight and obese and the prevalence of asthma only in urban residents. There was no such trend in the rural population. This could be due to the representation of the rural inhabitants, who accounted for approximately 20 % of our study population; this is relatively low compared with the true percentage of the entire Polish population and the proportion of the urban population. The second reason for such a result could be the fact that in addition to a high BMI increasing the prevalence of asthma, other environmental factors could also play a role (e.g. air pollution, smoking and lifestyle). Further detailed study is required to analyse the impact of obesity and overweight in allergic diseases in rural populations.

In 6–7-year-old children, based on a questionnaire survey, we confirmed no correlation between obesity and asthma, but there was a statistically significant increased prevalence of clinically diagnosed asthma. In overweight children, there was an increased occurrence of clinically diagnosed asthma and declared asthma. This finding, as well as a trend towards atopy in this group, is also supported by the significant association with SPT ≥ 6 mm. It seems that this discrepancy may be due to underdiagnosis of asthma in the Polish population, which was recorded in ECAP and presented in previous reports[19].

Although the association between obesity and asthma has been gaining more attention, few studies have been conducted concerning the relationship between obesity and other allergic diseases. The results are ambiguous and often contradictory. Most of the published studies suggest that being overweight and obese has a positive association with atopic dermatitis in children and adults[6–8,10,20,21].

Table 4 Association of different BMI categories with the prevalence of allergic diseases and sensitization according to gender (a) and place of residence (b), study population part of the Epidemiology of Allergic Disorders in Poland study (ECAP)

	6–7-year-olds				13–14-year-olds				20–44-year-olds			
	Overweight		Obesity		Overweight		Obesity		Overweight		Obesity	
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
(a)												
Declared asthma												
Female	1·76	0·83, 3·73	1·39	0·57, 3·38	1·40	0·59, 3·29	1·25	0·38, 4·09	1·33	0·94, 1·90	1·31	0·77, 2·22
Male	1·45	0·83, 2·55	0·97	0·49, 1·93	1·12	0·59, 2·13	0·54	0·16, 1·74	0·94	0·67, 1·33	0·99	0·59, 1·63
Symptomatic asthma												
Female	1·30	0·88, 1·92	1·37	0·90, 2·08	0·73	0·31, 1·70	**2·25**	**1·07**, **4·72**	**1·53**	**1·24**, **1·89**	**2·01**	**1·51**, **2·68**
Male	1·67	0·81, 1·66	1·15	0·79, 1·67	1·36	0·82, 2·26	1·63	0·86, 3·07	1·20	0·97, 1·48	**1·51**	**1·14**, **2·01**
Clinically diagnosed asthma												
Female	1·33	0·44, 4·00	**2·70**	**1·19**, **6·13**	0·43	0·05, 3·27	0·60	0·07, 4·67	0·96	0·58, 1·61	1·50	0·76, 2·95
Male	0·68	0·28, 1·68	1·00	0·45, 2·24	1·37	0·61, 3·05	0·43	0·05, 3·34	1·05	0·64, 1·72	0·54	0·22, 1·31
Allergic rhinitis												
Female	0·80	0·53, 1·19	0·82	0·53, 1·26	1·07	0·64, 1·78	1·43	0·76, 2·69	0·96	0·80, 1·15	0·92	0·70, 1·22
Male	1·26	0·91, 1·74	1·22	0·87, 1·71	1·14	0·78, 1·66	1·07	0·64, 1·79	**0·81**	**0·68**, **0·96**	**0·76**	**0·59**, **0·99**
Clinically diagnosed allergic rhinitis												
Female	1·90	0·94, 3·86	1·59	0·81, 3·11	0·80	0·29, 2·21	1·64	0·58, 4·58	0·81	0·58, 1·14	1·12	0·68, 1·82
Male	1·30	0·69, 2·45	1·14	0·59, 2·20	1·07	0·57, 2·02	2·02	0·74, 5·46	0·95	0·68, 1·31	1·15	0·73, 1·82
Atopic dermatitis												
Female	1·60	0·33, 7·69		TSS	0·24	0·03, 1·52	0·73	0·06, 8·37	1·51	0·77, 2·69	1·00	0·38, 2·65
Male	5·10	0·6, 42·13	2·55	0·51, 12·54	0·73	0·20, 2·56	0·58	0·05, 6·77	0·84	0·38, 1·85	1·11	0·39, 3·16
Clinically diagnosed atopic dermatitis												
Female	1·23	0·41, 3·70	0·72	0·21, 2·48		TSS	1·20	0·26, 5·42	0·70	0·31, 1·58	1·10	0·38, 3·15
Male	1·90	0·83, 4·36	0·43	0·10, 1·87	0·80	0·24, 2·71	2·67	0·73, 9·74	2·56	0·88, 7·46		TSS
Sensitization												
Female	1·35	0·70, 2·61	**2·07**	**1·14**, **3·75**	1·12	0·47, 2·64	1·04	0·38, 2·85	1·28	0·95, 1·72	1·12	0·71, 1·77
Male	0·91	0·50, 1·65	1·15	0·63, 2·08	1·14	0·62, 2·08	1·46	0·52, 4·07	0·98	0·73, 1·33	0·84	0·54, 1·29
SPT > 6 mm												
Female	1·15	0·42, 3·11	1·13	0·45, 2·83	0·98	0·32, 2·69	1·02	0·28, 3·64	0·89	0·62, 1·29	1·24	0·73, 2·09
Male	0·97	0·43, 2·17	1·18	0·54, 2·55	0·63	0·31, 1·26	1·20	0·43, 3·35	0·93	0·67, 1·28	0·98	0·61, 1·56
(b)												
Declared asthma												
Urban region	1·80	1·13, 2·86	1·38	0·80, 2·38	1·31	0·78, 2·19	0·83	0·36, 1·92	1·24	0·97, 1·590	1·24	0·85, 1·80
Rural region	0·32	0·04, 2·56		TSS		TSS		TSS		TSS		TSS
Symptomatic asthma												
Urban region	1·28	0·97, 1·68	1·25	0·93, 1·68	1·11	0·71, 1·73	**2·07**	**1·27**, **3·37**	**1·36**	**1·17**, **1·58**	**1·88**	**1·53**, **2·32**
Rural region	0·91	0·33, 2·52	1·57	0·66, 3·75	1·52	0·33, 6·89		TSS	1·27	0·79, 2·03	0·87	0·40, 1·89
Clinically diagnosed asthma												
Urban region	1·00	0·48, 2·08	1·80	0·99, 3·26	0·95	0·42, 2·14	0·51	0·12, 2·19	1·07	0·75, 1·52	1·00	0·57, 1·73
Rural region		TSS		TSS		TSS		TSS		TSS		TSS
Allergic rhinitis												
Urban region	1·03	0·79, 1·35	1·14	0·86, 1·51	1·05	0·76, 1·45	1·16	0·76, 1·77	0·92	0·81, 1·04	0·87	0·71, 1·06
Rural region	1·16	0·54, 2·46	0·55	0·22, 1·38	2·53	1·00, 6·62	1·93	0·58, 6·41	**0·59**	**0·37**, **0·93**	0·73	0·38, 1·40
Clinically diagnosed allergic rhinitis												
Urban region	1·43	0·86, 2·38	1·45	0·89, 2·37	0·92	0·52, 1·62	1·62	0·78, 3·36	0·93	0·73, 1·17	1·18	0·84, 1·67
Rural region	2·58	0·71, 9·37		TSS		TSS		TSS	0·86	0·43, 1·72	1·05	0·39, 2·80
Atopic dermatitis												
Urban region	2·57	0·73, 9·03	2·25	0·49, 10·36	0·51	0·19, 1·39		TSS	0·99	0·60, 1·63	0·84	0·42, 1·77
Rural region		TSS		TSS		TSS		TSS		TSS		TSS
Clinically diagnosed atopic dermatitis												
Urban region	1·57	0·79, 3·13	0·61	0·23, 1·56	0·46	0·14, 1·50	1·75	0·65, 4·67	0·82	0·45, 1·50		TSS
Rural region		TSS		TSS		TSS		TSS		TSS		TSS
Sensitization												
Urban region	1·08	0·67, 1·75	1·51	0·96, 2·36	1·06	0·63, 1·78	1·21	0·59, 2·48	1·16	0·94, 1·44	1·08	0·77, 1·49
Rural region	1·03	0·25, 4·26		TSS		TSS		TSS	1·50	0·77, 2·91	0·67	0·27, 1·67
SPT ≥ 6 mm												
Urban region	1·13	0·60, 2·12	1·23	0·68, 2·23	0·80	0·44, 1·46	0·87	0·38, 1·98	1·12	0·88, 1·42	1·30	0·92, 1·86
Rural region		TSS		TSS		TSS		TSS	0·63	0·19, 2·03		TSS

SPT, skin prick test; TSS, too small sample.
Reference category is normal weight. Statistically significant values are shown in bold.

However, there are also reports of the non-existence of such a relationship[13,22], which is consistent with our results. We found no effect of higher BMI on the prevalence of atopic dermatitis in children and adults, as well as in men and women, and urban and rural inhabitants.

Another interesting and unexpected finding of our study was that being overweight and obese had a negative association with rhinitis prevalence in males 20–44 years of age. The odds ratio for occurrence of allergic rhinitis in overweight men was 0·81, but the risk was even lower in obese men

(OR = 0·76). Of note, similar results were obtained in the Japanese population in adults[9] and schoolchildren[10]. These results may support our findings of opposing effects of obesity on asthma and rhinitis. The explanation for this phenomenon may be found in the results of the study by Johnston *et al.*[23], who showed enhanced airway responsiveness with attenuation of airway inflammation in obese mice. These observations were confirmed by Yoo *et al.*[24], who indicated an increased bronchial hyperresponsiveness in obese patients. In addition, at the same time, obesity is associated with increased breathing effort, decreased physical activity and poorer skill performance, which could also cause the development and exacerbation of asthma.

The lack of an association between adiposity and atopic sensitization, which has also been observed in our and other studies[13,14,20], suggests that the underlying biological pathway of development of asthma may involve non-immunological mechanisms.

Also, some confirmation of this assumption is the study by Chen *et al.*[5]. Their results demonstrated that the association between increased BMI and asthma was stronger among non-allergic adults compared with allergic adults. If one assumes that those without a history of allergy are less likely to have allergic asthma, Chen's observations suggest that obesity has a stronger relationship with non-allergic than allergic asthma. On the other hand, we have the results of several research groups that indicate a significant association between obesity and atopic sensitization[1,13,24]. It seems that the mechanisms for atopic sensitization associated with obesity need to be explored, and further cross-sectional studies are required.

Conclusion

In conclusion, our cross-sectional study using the ISAAC and ECRHS standards showed that being overweight and obese is associated with an increased prevalence of symptomatic asthma in adults, especially in women. This correlation was only observed in obese 13–14-year-olds. Being overweight in the 6–7-year-old group was associated with an increased prevalence of clinically diagnosed asthma and declared asthma and a trend towards atopy. Higher BMI was negatively associated with the occurrence of allergic rhinitis in overweight and obese men. Being overweight and obese were not significant factors in increased prevalence of atopy for either males or females. Further study of the relationship between obesity and allergic diseases should shed light on the complex aetiologies of the diseases and lead to new management options for allergy.

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Appendix

Definition of allergic diseases

Allergic diseases are defined if answers to the questions are 'yes'.

Declared asthma (DA): 'Have you ever had asthma?'

Symptomatic asthma (AS): 'Have you had wheezing or whistling in your chest at any time in the last 12 months?'

Allergic rhinitis (AR): 'Do you have any nasal allergies, including hay fever?'

Atopic dermatitis (AD) is defined if the answers to questions 1 and 2 and 3 are 'yes':

1. 'Have you ever had an itchy rash that was coming and going for at least 6 months?'
2. 'Have you had this itchy rash in the last 12 months?'
3. 'Has this itchy rash at any time affected any of the following places: the folds of the elbows, behind the knees, in front of the ankles under the buttocks or around the neck, ears or eyes?'