Association between Obesity and Atopy in Adults

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Key Words

Allergy · Atopy · Obesity

Abstract

Background/Aim: Previous literature on the association between obesity and atopy has been inconsistent. The aim of the study was to determine the relationship between obesity and atopic sensitization in adults. **Methods:** The study included a total of 1,997 residents aged 18–79 years and was conducted in the town of Humboldt, Sask., Canada in 2003. Body mass index (BMI) and waist circumference (WC) were objectively measured. Allergy skin tests were conducted to determine atopic sensitization. **Results:** Overall, the prevalence of one or more positive skin tests for atopy was 33.3% among those with a BMI of at least 30.0, 28.2% among those with a BMI of 25.0–29.9 and 27.3% among those with a BMI of less than 25 ($p = 0.003$). The odds ratio for atopy among those with a BMI of at least 30.0 versus those with a BMI of less than 25.0 was 1.51 (95% confidence interval, CI: 1.17, 1.95) after adjustment for sex, age, and other covariates. Stratified by sex, the adjusted odds ratios for obesity versus normal weight were 1.27 (95% CI: 0.73, 1.93) for men and 1.63 (95% CI: 1.18, 2.26) for women. WC was also significantly associated with the prevalence of atopy in both sexes after controlling for covariates. **Conclusion:** The data demonstrated a significant association between obesity, defined either by BMI or by WC, and atopy.

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Introduction

Obesity is becoming a major threat to population health. There is a substantial increase in mortality among the obese [1–3]. Adiposity is an important determinant for a number of chronic diseases including certain types of cancer [4], cardiovascular disease [5], diabetes [6], chronic kidney disease [7] and respiratory disease [8]. Obesity may also be an important risk factor for allergic diseases [9]. Epidemiological studies have provided relatively consistent results for obesity associated with the prevalence and incidence of asthma [10]. However, the association tends to be stronger in nonallergic or nonatopic individuals than in allergic or atopic individuals [11, 12]. Studies of obesity and atopic sensitization have not been consistent. As a number of the studies have been conducted among children, some have demonstrated an increased risk of atopy among overweight or obese individuals [13–18], while others have found no association between adiposity and atopy [19, 20]. Similarly, associations between obesity and atopic sensitization among adults were observed in some studies [21–23], but not in another study [24]. There is also a possibility that the relationship between adiposity and atopy is modified by sex [16, 18, 25].

We hypothesized that obesity might increase the likelihood of a T helper 2 cell immune response. Adipokines and cytokines secreted by white adipose tissue might result in decreased immunological tolerance [9]. Therefore,

in this study, we examined the associations between body mass index (BMI), waist circumference (WC) and atopic sensitization in adults living in a rural community.

Methods

In a cross-sectional study conducted in the rural town of Humboldt, Sask., Canada and surrounding area in 2003, we selected all residents from 18–79 years of age as the target population. A total of 2,090 adult residents from 18–79 years of age participated in the study, and the study methods have been detailed in previous reports with a response rate of 70.1% [26, 27]. Canvassers contacted all households within the town and surrounding areas and asked all eligible adult subjects in each home to participate in the study and to complete a written consent of participation. A questionnaire, left by the canvassers for completion by subjects at home, requested information on sociodemographic factors, allergy, smoking, alcohol consumption, exercise and home environment.

Subsequently, an appointment was made for each adult participant to visit a clinic where lung function tests, skin prick test, blood pressure, height, weight and WC were obtained. Weight was measured to the nearest 0.1 kg using a calibrated hospital spring scale with subjects dressed in normal indoor clothing without shoes. Height and WC were measured in centimeters. Height was measured against a wall using a fixed tape measure with participants standing shoeless on a hard surface. WC was measured between the lowest rib and the iliac crest, horizontally through the narrowest part of the torso. BMI was calculated as weight (kg)/[height (m)]². Skin prick testing included 4 allergens: *Dermatophagoides pteronyssinus*, mixed grasses (Western Allergy, Vancouver, B.C., Canada), *Fel d*, *Alternaria tenius*, as well as positive (histamine) and negative (saline) controls (Omega Laboratories and Hollister-Stier, Mississauga, Ont., Canada). Adults were considered atopic if they had a raised wheal to an allergy that was 3 mm or greater compared to the saline control on skin prick testing [28].

Subjects were grouped into three categories based on BMI (<25.0, 25.0–29.9 and ≥ 30) and two categories based on WC (men: ≤ 102 and >102 cm; women: ≤ 88 and >88 cm) according to the NIH cutoff points [29]. Current smokers were participants who reported smoking every day or almost every day, and had smoked at least 20 packs during their lifetime. Ex-smokers were those who were regular smokers but had quit for at least 6 months, at the time of the survey. Participants in the low-education category did not proceed beyond secondary school; the high-education category included subjects admitted to college or university, as well as those with a postsecondary school certificate or diploma. Subjects were classified into low- (USD <50,000) and high-income (USD $\geq 50,000$) groups based on total household income. A positive history of respiratory allergy was defined by an affirmative response to the question: 'Have you ever had an allergic reaction to things that are inhaled (e.g., pollen, dust, animal fur or smoke)?' Other variables included in the analysis were age (years), household size (<3 or ≥ 3 people), number of bedrooms (<4 , ≥ 4), pets at home (yes, no), regular alcohol drinking (yes, no), regular coffee drinking (yes, no) and household dampness (yes, no).

This analysis was based on data from 1,997 participants who had valid data of skin prick testing and BMI. We calculated the prevalence of atopy according to various risk factors. Logistic regression models were used to evaluate associations between obesity variables and the prevalence of atopy, taking other important variables into consideration. Model parameters were estimated by the method of maximum likelihood and were tested for significance using the Wald statistic.

Results

Of the 1,997 participants, 29.7% had atopic sensitization, and 35.3% were obese (BMI ≥ 30). Table 1 shows that the crude prevalence of atopy was significantly increased with increasing BMI, but was not significantly associated with WC. The crude prevalence of atopy was significantly associated with age, smoking status and coffee drinking (table 1). Number of household people, pets at home and education level were also significantly associated with the prevalence of atopy, but the associations were not significant after adjustment for other covariates. Income level and alcohol drinking were not significantly related to atopic status.

Table 2 shows that the prevalence of atopy was increased with increasing BMI in women and the test for linear trend was significant ($\chi^2_{\text{trend}} = 5.39$, $p = 0.020$). The difference among the BMI groups was not significant in men ($\chi^2 = 3.59$, $p = 0.166$). The crude prevalence of atopy was not significantly associated with WC either in men or women.

A multiple logistic regression model was used to assess the association between BMI and atopy after taking other covariates into consideration. Compared to those with a BMI of less than 25, the odds ratio for both men and women with a BMI of at least 30.0 was 1.51 (95% confidence interval, CI: 1.17, 1.95) after adjustment for sex, age, coffee drinking, smoking status and being a farmer (table 3). The corresponding adjusted odds ratio was 1.63 (95% CI: 1.18, 2.26) for women and was not significantly different from 1 for men. The risk of atopy was significantly higher among those with a WC value greater than 102 cm for men and 88 cm for women compared with those with a lower WC value.

Discussion

Atopy is a major risk factor for asthma and other allergic diseases [30]. Our study demonstrated that the prevalence of atopic sensitization, as indicated by a positive skin test result to common aeroallergens, was sig-

nificantly associated with obesity (BMI ≥ 30). Abdominal obesity (WC >102 cm for men and >88 cm for women) was also associated with an increased risk of topic sensitization. Our data support the hypothesis that adiposity is associated with a T helper 2 immune response.

The association between obesity and atopic sensitization has been examined in a number of previous studies of adults and children, but study results have not been consistent. In adults, an analysis of cross-sectional data from Caucasian Australians demonstrated that severe obesity (BMI >35) was associated with a higher prevalence of wheeze, diagnosed asthma and medication use, but not with atopy, airway hyperresponsiveness and airway obstruction [22]. Another analysis of cross-sectional data from young adults who participated in the European Community Respiratory Health Survey, BMI was not associated with 'hay fever or nasal allergies', specific immunoglobulin E (IgE) to house dust mite, grass or cat or with total IgE in men or women [24]. However, in a Finnish birth cohort study, sensitization was found to be more common among adults, and atopy was not only associated with current BMI in adults but also with ponderal index at birth and mother's BMI [23]. Another study that was specific to women suggests a direct relationship between obesity and a T helper 2 cell immune response [21]. High BMI was associated with the risks of asthma and atopy in women but not in men in a birth cohort [25]. Birth weight may also be an independent risk factor for asthma and atopy in adulthood [31].

In children, the US National Health and Nutrition Examination Survey showed that obesity was associated with total IgE level, atopy and food sensitization [13]. BMI was significantly related to asthma but not to atopy after adjustment for confounders [15, 32]. Reported atopy was significantly higher in overweight or obese children compared to normal weight children in a study of children in Greece [14]. In a study of Chinese schoolchildren, atopy and presence of allergen-specific IgE did not differ between overweight or obese children and those with a normal BMI [19]. In Belgian schoolchildren, an increased prevalence of atopic sensitization was only found in underweight girls [20]. A Finnish longitudinal cohort of children demonstrated that high birth weight was associated with an increased risk of atopy [33]. In a cross-sectional study of grade 8 students in Taiwan, BMI was a significant predictor for atopy, allergic symptoms and bronchial hyperresponsiveness in girls but not in boys [16]. Similarly, a study of Australian children aged 7–12 years showed that a high BMI was a risk factor for atopy, wheeze and cough in girls but not in boys [18].

Table 1. Prevalence of atopy according to potential risk factors, the Humboldt Study, 2003

	Subjects, n	Subjects with atopy, n ¹	Subjects with atopy, %	p value
Sex				
Male	864	271	31.7	0.167
Female	1,133	323	28.5	
Age				
18–39 years	532	188	35.3	<0.001
40–59 years	778	240	30.8	
≥ 60 years	166	242	29.7	
People in household				
<3	1,180	319	27.0	<0.001
3+	800	274	34.3	
Unknown	17	1		
Bedrooms				
<3	1,146	330	28.8	0.097
3+	824	260	31.6	
Unknown	27	4		
Pets at home				
No	1,403	394	28.1	0.013
Yes	594	200	33.7	
Secondary school completed				
No	892	293	32.8	0.023
Yes	1,069	292	27.3	
Unknown	36	9		
Coffee drinker				
No	1,074	359	33.4	<0.001
Yes	878	226	25.7	
Unknown	45	9		
Regular alcohol drinker				
No	793	231	29.1	0.356
Yes	1,181	359	30.1	
Unknown	23	4		
Smoking status				
Nonsmoker	1,069	332	31.1	0.037
Ex-smoker	678	178	26.3	
Current smoker	250	84	33.6	
Being a farmer				
No	1,441	442	30.7	0.144
Yes	556	152	27.3	
Respiratory allergy				
No	1,377	340	24.7	<0.001
Yes	620	254	41.0	
BMI				
<25	539	147	27.3	0.033
25–29.9	753	212	28.2	
≥ 30	705	235	33.3	
WC ²				
Low	1,015	284	28.0	0.214
High	778	245	31.5	
Unknown	204	65	31.9	

¹ Participants were considered atopic if they had a raised wheal to an allergy (*D. pteronyssinus*, mixed grasses or Fel d, *Alternaria tenuis*) that was 3 mm or greater compared to the saline control on skin prick testing; ² Men: ≤ 102 cm (low) and >102 cm (high); women: ≤ 88 cm (low) and >88 cm (high).

Table 2. Prevalence of atopy associated with BMI and WC in men and women, the Humboldt Study, 2003

	Men				Women			
	Subjects, n	Subjects with atopy, n	Subjects with atopy, %	χ^2	Subjects, n	Subjects with atopy, n	Subjects with atopy, %	χ^2
BMI								
<25	153	51	33.3		386	96	24.9	
25–29.9	385	108	28.1	0.47 ^a	368	104	28.3	5.39 ^a
≥30	326	112	34.4	0.491 ^b	379	123	32.5	0.020 ^b
WC ^c								
Low	466	143	30.7		549	141	25.7	
High	319	104	32.6	0.01	459	141	30.7	2.00
Unknown	79	24	30.4	0.929 ^b	125	41	32.8	0.157 ^b

^a Trend; ^b p value; ^c Men: ≤102 cm (low) and >102 cm (high); women: ≤88 cm (low) and >88 cm (high).

Table 3. Unadjusted and adjusted odds ratios and 95% CIs for atopy in relation to BMI and WC, the Humboldt Study, 2003

	Men		Women		Total	
	OR	95% CI	OR	95% CI	OR	95% CI
<i>Unadjusted estimates</i>						
BMI						
<25.0	1.00		1.00		1.00	
25.0–29.9	0.78	0.52, 1.17	1.19	0.86, 1.65	1.05	0.82, 1.34
≥30.0	1.05	0.70, 1.57	1.45	1.06, 1.99	1.33	1.04, 1.71
WC ¹						
Low	1.00		1.00		1.00	
High	1.09	0.81, 1.48	1.28	0.97, 1.69	1.18	0.97, 1.45
Unknown	0.99	0.59, 1.66	1.41	0.93, 2.15	1.20	0.87, 1.67
<i>Adjusted estimates</i>						
BMI						
<25.0	1.00		1.00		1.00	
25.0–29.9	0.87	0.58, 1.32	1.30	0.98, 1.82	1.12	0.87, 1.45
≥30.0	1.27	0.73, 1.93	1.63	1.18, 2.26	1.51	1.17, 1.95
WC ¹						
Low	1.00		1.00		1.00	
High	1.38	1.00, 1.92	1.42	1.07, 1.88	1.39	1.13, 1.72
Unknown	1.13	0.66, 1.93	1.55	1.01, 1.37	1.36	0.97, 1.89

Adjusted odds ratios (OR) were adjusted for sex, age, coffee drinking, smoking status and being a farmer.

¹ Men: ≤102 cm (low) and >102 cm (high); women: ≤88 cm (low) and >88 cm (high).

These results suggest a possible sex difference in the association between obesity and atopic sensitization. Plasma concentrations of 17 β -estradiol, the ratio of 17 β -estradiol to sex hormone-binding globulin, the fasting insulin resistance index, and C-peptide and leptin concentrations are higher in obese than in nonobese women

[21]. As a major female sex hormone, 17 β -estradiol up-regulates the expression and secretion of interleukin 4 (IL-4) from CD4⁺ helper cells [34] and IL-4 signaling in response to atopy [35]. In our study, BMI was significantly associated with atopy in women, but the association did not reach statistical significance in men. However, in our

study there was a lack of statistical evidence for the heterogeneity in the association between the two sexes.

It is unclear how obesity, atopy and asthma might be interrelated. In a national study of Canadian adults, a stronger association between obesity and asthma was observed in nonallergic rather than in allergic persons [11]. Central obesity was found significantly associated with an increased risk of nonatopic asthma but not of atopic asthma [12]. In the North West Adelaide Health Study of adults, an increased risk of asthma was associated with levels of WC, waist-hip ratio and BMI in women but not in men [12]. If stratified by atopic status, the relationship held only for the nonatopic men and women [12]. In a community study conducted in southern Sweden, the risk of developing asthma was associated with increased body weight and abdominal circumference, and the increase in asthma morbidity in overweight subjects was found almost exclusively in nonatopic asthma patients [36]. The European Community Respiratory Health Survey showed that BMI was not associated with atopic conditions and IgE levels [24]. These studies indicate that obesity may be associated primarily with nonatopic asthma and not with atopic asthma. Thus, the obesity-asthma relationship and sex-related differences may not be explained by an increased risk of atopy in the obese. Reasons for inconsistent results from studies of obesity and atopic sensitization are still not clear. The relationships of both BMI and WC to percentage fat vary by sex, age and

race-ethnicity group [37]. The selection of WC cutoff for the analysis is somewhat arbitrary. Different cutoffs may be used for different subgroups according to sex, age and race/ethnicity and recommendations vary. BMI has been most frequently used as an exposure measure, which is not always an ideal indicator of adiposity especially for children and young adults. Outcome measures also vary from one study to another. The European Community Respiratory Health Survey of young adults used specific IgE and total IgE as indicators of atopy [24]. In our study, we used skin prick testing and selected four common allergens for the testing. In addition, studies may not include all important variables. For example, most studies did not examine the impact of birth weight and mother's BMI on the association between obesity and atopy, which has been found to play an important moderating role [23]. Our study indicated a significant association between obesity and atopic sensitization. The mechanisms for atopic sensitization associated with obesity need to be explored.

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