

Relationship between obesity and sex, and prevalence of asthma-like disease and current wheeze in Han children in Nanjing, China

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Abstract

Objective: To investigate the relationships between body mass index (BMI) and sex, and asthma-like disease and current wheeze in Han children in Nanjing, China.

Methods: Han children aged 3–14 years were recruited. Height and weight were measured; individuals were classified into obesity, thinness and normal-weight groups on the basis of the calculated BMI. Questionnaires were used to measure prevalence of asthma-like disease and current wheeze. Results were evaluated using the χ^2 -test, odds ratios with 95% confidence intervals and multivariate logistic regression analyses.

Results: In total 12 092 children (6331 boys and 5761 girls) were included. Rates of normal weight, obesity and thinness were 8915/12 092 (73.73%), 1479/12 092 (12.23%) and 1698/12 092 (14.04%), respectively. Asthma-like disease and current wheeze were reported in 2051/12 092 (16.96%) and 400/12 092 (3.31%), respectively. An increased BMI was associated with a greater risk of asthma-like disease; this relationship was strongest in girls. Current wheeze was associated positively with obesity and negatively with thinness, but only among boys. Boys had a greater risk of asthma-like disease and current wheeze than girls.

Conclusions: BMI and sex were associated independently with the prevalence of asthma-like disease and current wheeze in Han Chinese children.

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Introduction

Asthma is a major cause of chronic morbidity and mortality throughout the world and its prevalence has increased considerably over the past 20 years, especially in children.¹ In recent decades there has also been a substantial increase in the prevalence of obesity among children.² A number of studies have shown that obesity is an important risk factor for asthma and wheeze. A study carried out in the USA found that the risk of obese children having asthma was two times higher than for children with normal body weight.³ An Asian study by the Prediction of Allergies in Taiwanese Children (PATCH) group, involving 5476 children showed that an elevated body mass index (BMI), was associated with a greater prevalence of wheezing and eczema.⁴ In many studies, especially those based in the USA, the term 'overweight/obese' has usually been defined as the 95th centile of the US Center for Disease Control reference curves for BMI, with children at or above the 85th (but below the 95th) centile classified as being at risk.⁵ The prevalence of asthma in the USA has been reported to be higher than in many other countries.⁶ Furthermore, in a US study in children from racial minority subgroups with different genetic backgrounds, obesity prevalence ranged from 4.4% in Asian Indian children up to 13.0% in American Indian/Alaska Native children.⁷ Therefore, it is important for such surveys to take ethnicity into account. A number of studies investigating the relationship between the incidence of asthma or asthma-like symptoms and increasing BMI have included information on individuals' sex.^{3,4,6-8} Nevertheless, there

is still a need for further studies that include these key factors and involve large numbers of individuals.

The present large population study aimed to investigate whether BMI and sex are associated with the prevalence of asthma-like disease and current wheeze, in children from the Han ethnic group in Nanjing, China.

Subjects and methods

Every child belonging to the Han ethnic group from 16 kindergartens and 12 elementary schools, covering the age range 3–14 years old, in the northern part of Nanjing City, China, was selected to participate in the study. Data collection took place between August 2010 and January 2011. Children with major systemic diseases or syndromes were excluded.

The children's parents completed a set of questions derived from the International Study of Asthma and Allergies in Childhood (ISAAC) core questionnaire.⁹ The ISAAC is a well-validated standard tool for epidemiological investigation of the prevalence and severity of atopic disorders, such as wheezing and rhinitis, for use in children living in different countries.^{10,11} In the present study, the presence of asthma-like disease was based on a positive response to the question, 'Has your child ever been diagnosed with asthma, asthmatic bronchitis, chronic bronchitis or asthmatic pneumonia?'. The presence of current wheeze was based on a positive response to the question on asthma-like disease, plus a positive response to the question, 'In the last 12 months, has your child had wheezing in the chest?'. The questionnaire also gathered

information on birth date, sex, height, weight, home address, and a history of asthma or other allergic disorders in the parents and grandparents. The date on which the questionnaire was completed was recorded for each individual.

All the parents provided verbal informed consent and anonymity was preserved in the data analysis. The study was approved by the Committee on Human Experimentation, Nanjing Children's Hospital, Nanjing Medical University, Nanjing, China, and was conducted in accordance with the Helsinki Declaration of 1964, as revised in 2013.¹²

The weight and height of each participant were measured according to a standard protocol. All children were weighed while wearing light clothes and without shoes. Measurements were conducted using a calibrated weighing scale and stadiometer. Weight (in kg) was measured to the nearest 1 kg and height (in cm) was measured to the nearest 1 cm. The BMI for each study participant (defined as weight in kg divided by height in m²), was calculated from these measurements.

The study population was divided according to age (<7 years versus ≥7 years) and sex. Participants were also divided into three groups according to BMI, based on age- and sex-specific criteria for normal weight, obesity¹³ and thinness,¹⁴ using well-validated standards developed on the basis of worldwide surveys.^{15,16}

Statistical analyses

The prevalence of asthma-like disease and current wheeze in the different BMI and sex groups were compared using the χ^2 -test. Odds ratio (OR) and 95% confidence intervals (CI) were derived in the different BMI, sex and age groups. Multivariate logistic regression analysis was performed to estimate the effects of BMI, sex and age independently; the confounding factor of BMI was treated as ranked data, whereas sex and age were treated as dichotomous data. A *P*-value <0.05 was considered to be statistically significant. All statistical analyses were performed using SPSS® software, version 13.0 (SPSS Inc., Chicago, IL, USA).

Results

A total of 12 110 children were recruited to the study. Eighteen questionnaires were incomplete; therefore data from 12 092 participants were available for statistical analysis. Of these, 6 331 participants were male and 5 761 were female, with a mean ± SD age of 8.24 ± 2.99 years and 8.21 ± 3.01 years, respectively; this difference was not statistically significant. Prevalence rates of obesity, thinness, asthma-like disease and current wheeze are shown in Table 1.

BMI

Of the 2 051 children with asthma-like disease, 292 (14%) were in the obesity group.

Table 1. Prevalence of obesity, thinness, asthma-like disease and current wheeze in Han Chinese children.

Parameter	Male <i>n</i> = 6 331	Female <i>n</i> = 5 761	Total <i>n</i> = 12 092
Obesity group	652 (10.30)	827 (14.36)	1479 (12.23)
Thinness group	1244 (19.65)	454 (7.88)	1698 (14.04)
Normal-weight group	4435 (70.05)	4480 (77.76)	8915 (73.73)
Asthma-like disease	1178 (18.61)	873 (15.15)	2051 (16.96)
Current wheeze	281 (4.44)	119 (2.07)	400 (3.31)

Data presented as *n* (%) of children.

Table 2. Odds ratio analysis of the prevalence of asthma-like disease and current wheeze in the obesity and thinness groups compared with the normal-weight group in Han Chinese children.

Parameter	Obesity group		Thinness group	
	OR	95% CI	OR	95% CI
<i>Total, n = 12 092</i>				
Asthma-like disease	1.223 ^a	1.064, 1.406	0.923	0.801, 1.065
Current wheeze	1.323	1.002, 1.748	0.847	0.619, 1.157
<i>Male participants, n = 6 331</i>				
Asthma-like disease	1.190	0.973, 1.455	0.825	0.689, 0.977
Current wheeze	1.517 ^a	1.083, 2.124	0.607 ^a	0.421, 0.873
<i>Female participants, n = 5 761</i>				
Asthma-like disease	1.289 ^a	1.061, 1.567	0.990	0.753, 1.302
Current wheeze	1.174	0.711, 1.938	1.355	0.735, 2.496

OR, odds ratio.

CI, confidence intervals.

^a $P < 0.05$.

In contrast, of the 10 041 children who did not have asthma-like disease, only 1 187 (12%) were obese. This difference was statistically significant ($P = 0.002$). A similar difference was observed when comparing obesity rates in those with and without current wheeze. Of the 400 children with current wheeze, 63 (16%) were in the obesity group, whereas only 1 416 (12%) of the 11 692 children who did not have current wheeze were obese ($P = 0.029$).

The prevalences of asthma-like disease and current wheeze in the obesity and thinness groups were compared with that in the normal-weight group using OR (Table 2). The overall risk of asthma-like disease in obese children was significantly higher than that in normal-weight children ($P < 0.05$). There was no statistically significant difference in the overall risk of current wheeze between the different BMI groups. However, when considered according to sex, the increased risk of asthma-like disease in obese children was only statistically significant in female subjects ($P < 0.05$). In addition, the risk of current wheeze was significantly higher in the obesity group

and significantly lower in the thinness group compared with the normal-weight group in male subjects only ($P < 0.05$ for both) (Table 2). On interaction analysis, the effect of BMI on the prevalence of current wheeze was different between sexes (OR 0.624, 95% CI 0.404, 0.964, $P = 0.034$).

Sex

The overall prevalence of asthma-like disease and current wheeze were compared between the sexes, using OR. The risk of asthma-like disease was significantly higher in male subjects than in female subjects (OR 1.284, 95% CI 1.167, 1.414, $P < 0.001$). Likewise, a significantly higher risk of current wheeze was observed in male, compared with female, subjects (OR 2.202, 95% CI 1.772, 2.737, $P < 0.001$).

Multivariate logistic regression analysis

Multivariate logistic regression analysis was conducted to assess the effects of BMI, sex and age on asthma-like disease and current wheeze, independently (Table 3). After

Table 3. Multivariate logistic regression analyses of risk factors for asthma-like disease and current wheeze in Han Chinese children.

Parameter	Adjusted OR	95% CI	Statistical significance
<i>Asthma-like disease</i>			
Obesity versus normal weight	1.242	1.080, 1.429	$P = 0.001$
Thinness versus normal weight	0.868	0.752, 1.003	NS
Male versus female participants	1.313	1.191, 1.447	$P < 0.001$
<i>Current wheeze</i>			
Obesity versus normal weight	2.320	1.298, 4.148	$P = 0.005$
Thinness versus normal weight	0.431	0.241, 0.770	$P = 0.005$
Male versus female participants	1.381	0.833, 2.294	$P = 0.01$
Age ≥ 7 years versus age < 7 years	0.633	0.516, 0.776	$P < 0.001$

OR, odds ratio.

CI, confidence intervals.

NS, not statistically significant ($P \geq 0.05$).

controlling for age and sex, the risk of asthma-like disease among obese individuals was 0.242 higher than in those of normal weight ($P = 0.001$). After adjusting for BMI and age, male subjects had a significantly higher risk for asthma-like disease than female subjects ($P < 0.001$). For current wheeze, an increase in BMI was associated with an increase in risk ($P = 0.005$ for both obesity and thinness compared with normal weight). In addition, the risk of current wheeze in children ≥ 7 years was lower than that in younger children ($P < 0.05$) and was lower in female, than in male, subjects ($P < 0.05$).

Discussion

The present study revealed a significant relationship between asthma-like disease and obesity among children from the Han ethnic group in Nanjing, China.

Both χ^2 -test and multivariate logistic regression analyses showed that an increasing BMI was significantly and independently associated with a higher prevalence of asthma-like disease in children. While a number of studies have shown that asthma or asthma-like symptoms were significantly

more frequent among obese children,^{4,17–19} the associated OR have varied. Interaction analysis of BMI and sex suggested that the effect of BMI on asthma-like disease does not differ between the sexes. This is in line with some reports,²⁰ but some studies have revealed a stronger association between BMI and asthma-like disease in boys than in girls^{3,8} or conversely a stronger association in girls than in boys.^{18,21,22} Reported differences between the sexes in the effect of body size on asthma suggest it is important to specify the age at which an effect is observed, as some associations may only be seen during certain periods of development.²³ The present study also demonstrated a significant association between BMI and current wheeze, but only in boys.

While the epidemiological evidence linking asthma or asthma-like symptoms and obesity is impressive, the mechanism of the link between these diseases is far from clear. Since variations in this association are seen in results from different areas and ethnic groups,^{3,4,10,21} it has been proposed that asthma and obesity may be linked via specific regions of the human genome, such as chromosomes 5q and 6p21.²⁴ It is thought

that interactions between genetic and environmental factors may be important.²⁴ In addition, it has been suggested that mechanical factors such as the functional residual capacity of the lung (which is lower in obese subjects), breathing patterns (obese subjects have a higher breathing rate and a lower tidal volume) and alterations in smooth-muscle structure and function may also play a role.¹⁸

Adipose tissue is not a passive energy storage depot;²⁵ it has been shown that obesity affects the immune system and promotes inflammation, which could potentially promote the development of a variety of chronic conditions and diseases.²⁶ Furthermore, it has been reported that the cellular and signalling networks linked to the immune system undergo changes in lean individuals, and activated macrophages and eosinophils have been found in adipose tissues.²⁷ Changes in macrophage function have been reported in organs other than adipose tissue, which could contribute to the development of steatohepatitis.²⁷ In addition, studies have suggested that alveolar macrophage function may be altered in obesity.²⁵

The results of the present study indicated that boys were more likely than girls to suffer from current wheeze, which is consistent with the results of previous studies.⁸ This may be due to a higher degree of physical activity among boys, leading to a greater likelihood of discovering their symptoms.²⁸ The hormone oestrogen may also play a role in the sex difference.²⁴

In conclusion, the present study, which had a high participation rate and used the well-validated ISAAC criteria, showed that an increase in BMI was associated with an increased risk of asthma-like disease in Han children from Nanjing, China. In addition, sex may also play a role in the presence of current wheeze. Knowledge of this association may help inform public health decisions concerning asthma diagnosis,

management and prevention. However, because of the cross-sectional design of the study, and since only sex and age were used as confounding factors, a causal association cannot be assumed on the basis of the present study. Additional investigations are needed to gain further insight into the underlying mechanisms.

Declaration of conflicting interest

The authors declare that there are no conflicts of interest.

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