Severe Airway Hyperresponsiveness in School-aged Boys with a High Body Mass Index

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INTRODUCTION

The prevalence rates of asthma and obesity continue to rise. A number of environmental factors, including air pollution, cigarette smoking, allergen exposure, and diet have been proposed as explanations for the increases in the prevalence of asthma. The prevalence of asthma in Korea increased from 5.7% in 1980 to 10.1% in 1990. Asthma and allergy in developing countries may be associated with the adoption of an urbanized “western” lifestyle. The total intake of calories is increasing with the industrialization of Korea. Recent studies have found an association between body mass index (BMI) and asthma in young adults. A study of diet and asthma from Norway observed a positive relationship between BMI and asthma symptoms. In a nationally representative British birth cohort, BMI was positively associated with the prevalence of asthma and wheezing in individuals studied at 26 years of age. General obesity and central obesity are potential risk factors of asthma in relatively non-obese Korean adults. BMI is associated with wheezing in older adults living in rural areas in Korea. In the large Nurses’ Health Study II in the USA, a strong positive association between BMI and the risk of

Background: An association between obesity and asthma has been reported. The prevalence of airway hyperresponsiveness (AH), results of skin prick tests, body mass index (BMI), and asthma symptoms were examined in schoolchildren.

Methods: The results of BMI (kg/m²) determination, skin prick testing, spirometry, asthma questionnaires, and methacholine challenge tests were obtained in a cross-sectional survey of 667 schoolchildren. The methacholine concentration causing a 20% fall in FEV₁ (PC₂₀) was used as the threshold of AHR. If the PC₂₀ was less than 16 mg/mL, the subject was considered to have methacholine mediated AHR.

Results: The mean BMI was 17.1±0.09 kg/m². The prevalence of AHR was 42.7%. The sensitization rate to common inhalant allergens was 30.3%. PC₂₀ in children with BMIs >17.1 kg/m² was significantly lower than that in children with BMIs 17.1 kg/m². The mean BMIs of boys and girls were not significantly different. The levels of PC₂₀ by sex were not different. The children were grouped by sex into percentile of BMI. PC₂₀ in boys was lower in the obese group than in the non-weight and overweight groups (p<0.05). PC₂₀ in boys and girls with atopy was significantly lower than in those without atopy. In a multiple logistic regression model that included all of the children and adjusted for confounding variables, independent associations with AHR were seen with BMI, asthma symptoms, and atopy. .

Conclusions: BMI had an association with AHR in school-age boys.

Key Words: Body mass index, Bronchial hyperreactivity, Boys
incidence of asthma was observed in women aged 27-44 years who were followed over four years\(^9\). The effects of diet may be mediated through an increase in the synthesis of prostaglandin E\(_2\), which in turn can promote the formation of immunoglobulin E\(^1\).

Recent cross-sectional studies have suggested that there is an association between being overweight or obese and experiencing asthma symptoms. This association seems to be much stronger in females than in males, suggesting the possibility that female hormones may be directly involved in the putative causal pathway that relates obesity to asthma\(^4, 8-11\).

Therefore, we have examined the relationship between BMI and AHR, atopy, and asthma symptoms in schoolchildren.

**MATERIALS AND METHODS**

**Study population and questionnaire**

All children were 10 to 12 years of age living in both polluted and non-polluted areas. A questionnaire on respiratory and allergic disorders was administered that included questions developed for the International Study of Asthma and Allergies in Childhood (ISAAC). The focus of this survey was on responses to the ISAAC questions on “wheezing in the last 12 months”, “number of wheezing attacks in the last 12 months”, and on “sleep-disturbing” and “speech limiting” wheezing in the last 12 months. Symptoms of allergic rhinoconjunctivitis (sneezing or runny nose, or blocked nose without a cold and itchy-watery eyes) were assessed\(^12\). In addition, a question on morning coughing as a symptom of nonspecific airway irritation was asked (“Did you frequently cough in the morning right after waking up in the last 12 months?”). A total of 667 schoolchildren were enrolled in this study (Table 1). None of the subjects took any drugs such as anti-histamines, cromolyn, theophylline, or sympathomimetics that could interfere with the performance of skin tests or methacholine challenge test within 72 hours of the tests. This study was approved by the Research Committee of the Soonchunhyang University, and all guardians signed informed consent forms before the study.

**Pulmonary function studies**

Spirometry was performed with a SensorMedics 2200 spirometer (Cardiopulmonary Care Company\(^7\), Yorba Linda, California). Baseline measurements of VC and FEV\(_1\) were selected according to American Thoracic Society criteria\(^11\), and reference values were taken from Choi et al\(^14\).

**Allergy skin testing**

Allergy skin prick tests were performed with eleven common allergen extracts (Dermatophagoides farinae, Dermatophagoides pteronyssinus, Aspergillus spp, alder, birch, hazel, rye, timothy, mugwort, ragweed, Blatella germanica, histamine (1 mg/mL), and saline; Allergopharma, Germany). The reactions were read 15 minutes later. A wheal and erythema size equal to or greater than that of histamine (positive control) was read as 3+. Reactors were defined as exhibiting atopy when they showed a response >3+ to one or more allergens in the skin prick tests\(^15\).

**Body mass index**

The BMI for an individual was defined as weight (kg) divided by the square of height (m). The children were grouped into percentile of BMI. Children <85\(^\text{th}\) percentile were “non-weighted”, 85\(^\text{th}\) to 95\(^\text{th}\) percentile were “overweighted”, and >95\(^\text{th}\) percentile were “obese”.

**Airway hyperresponsiveness**

Methacholine challenge tests were carried out by a modified method as described by Chai et al\(^16\). Concentrations of 0.075, 1.25, 2.5, 5, 10, and 25 mg/mL methacholine were prepared by dilution in buffered saline. A Micro-dosimeter (S&M Instrument Co., Doylestown, PA) was used to deliver the aerosol generated by a DeVilbiss 646 nebulizer. Subjects inhaled 5 breaths of increasing concentrations of methacholine until FEV\(_1\) fell by more than 20% of its baselinel value, or until the highest concentration was reached. The largest value of triplicate FEV\(_1\) measurements at 30, 90, or 180 seconds after each inhalation was used in the analysis. If the PC\(_{20}\) was less than 16 mg/mL, a subject was considered to have AHR to methacholine.

**Statistical analyses**

All data were analyzed using SPSS version 7.5 for Windows. Each biochemical assay was repeated at least twice. Data are