High Body Mass Index is Associated with Wheezing Among Older Adults Living in High-Altitude Area in Korea

Although the association between obesity and asthma has been well documented, the nature of this association has yet to be clarified. The aim of this study was to examine the association of body mass index (BMI), lipid profiles, and atopy, wheezing, and lung function in older adults living in a rural area in Korea. BMI (kg/m²), lipid profiles, skin prick test, spirometry, and questionnaire including airway symptoms were obtained in a cross-sectional survey in 707 (259 males and 448 females) older adults (aged 50 to 93; mean, 65.7 yr) living in a high-altitude rural area in Korea. The prevalence of self-reported wheezing was 17.1% (121/707). The prevalence of atopy was 13.8%. The mean of BMI was 23.3 ± 0.13 (14.6-32.8). The BMI was higher in females than in males (23.8 ± 0.16 vs 22.4 ± 0.17; p<0.01). The prevalence of wheezing was higher in group with BMI ≥ 25 than in group with BMI <25 [57/201 (28.3%) vs 64/505 (12.6%), p<0.01]. The BMI was higher in group with wheezing than in group without wheezing (24.3 ± 0.34 vs 23.1 ± 0.13, p<0.01). No association between BMI and atopy was found. These findings suggest that BMI associated with wheezing in older adults.

Key Words: Body Mass Index; Respiratory Sounds; Atopy

INTRODUCTION

The prevalence of asthma continues to rise. A number of environmental factors, including air pollution, cigarette smoking, allergen exposure, and diet have been proposed to explain the changes in the prevalence of asthma. Changes in the diet may explain the increase in the prevalence of asthma, eczema, and allergic rhinitis (1).

The prevalence of asthma (2) has increased in Korea (5.7% in 1980 and 10.1% in 1990). Asthma and allergy in developing countries may be associated with adoption of an urbanized "western" lifestyle. The intake of total calories is increasing with the industrialization in 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 relation between BMI and asthma symptoms (3). In a representative national British birth cohort, BMI was positively associated with the prevalence of asthma and wheeze in individuals studied at 26 yr of age (4).

In the large Nurses’ Health Study II in the U.S.A., a strong positive association between BMI and risk of incident asthma was observed in women aged 27-44 yr who were followed over four years (5). Young et al. (6) also reported that the increasing BMI is a key factor predicting the prevalence of asthma. Recently the effect of altitude on the prevalence, morbidity, and treatment of bronchial asthma was reported (7, 8).

There is little information about relation between BMI and atopy, wheezing in elderly adults. We have therefore investigated the association of BMI, lipid profiles and atopy, wheezing, and lung function among older adults living in a rural area in Korea.

MATERIALS AND METHODS

Study population and questionnaire

Seven-hundred and seven (259 males and 448 females) older adults (age, 50 to 93 yr; mean, 65.7 yr) living in a high-altitude (700 m above sea level or higher) rural area in Korea were randomly recruited into the study (Table 1). Each subject was interviewed by trained field investigators using a structured questionnaire. All subjects filled in a questionnaire, which was modified from the Expert panel report 2 (9). The focus of this survey was on responses to Expert panel report questions on "wheezing in the last 12 months", "number of wheezing attacks in the last 12 months", and on "sleeping-disturbing" and "exercise-limiting" wheezing in the last 4 weeks. Respiratory symptoms including wheezing and rhinitis were based on self-reports.

Exclusion criteria were the existence of any acute or inflammatory disease, anti-allergic therapy at study entry, presence
of respiratory infection for 4 weeks prior to the study. The ethics committee of the authors’ hospital approved the study protocol and written informed consents were obtained by subjects before the study.

Pulmonary function test

Spirometry was performed with SensorMedics 2200 spirometer (Cardiopulmonary care company Mallinckrodt, Yorba Linda, CA U.S.A.). Baseline measurements of VC and FEV1 were selected according to American Thoracic Society criteria (10) and reference values were taken from the report by Choi et al. (11).

Allergy skin test

Allergy skin prick tests were performed with 11 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 min after application. When the wheal size was equal or greater than that of histamine, the reaction was read as positive. Atopy was defined as a reaction that was higher in group with BMI ≥ 25 than in group without BMI ≥ 25 [25/201 (28.3%) vs 64/505 (12.6%), p<0.01]. The BMI was higher in group with wheezing than in group without wheezing (24.3 ± 0.34 vs 23.1 ± 0.13, p<0.01). The prevalence of wheezing was higher in group with BMI ≥ 25 than in group with BMI <25 [57/201 (28.3%) vs 64/505 (12.6%), p<0.01]. The BMI was higher in group with wheezing than in group without wheezing (24.3 ± 0.34 vs 23.1 ± 0.13, p<0.01, Table 2). Atopy prevalences were higher in males than in females [104/258 (40.3%) vs 107/448 (23.8%), p<0.01]. No association

### RESULTS

The prevalence of self-reported wheezing was 17.1% (121/707, Table 1). The sensitization rate (skin prick test A/H ≥ 1) to common inhalant allergens were: Dermatophagoides farinae 8.1%, Dermatophagoides pteronyssinus 4.1%, alder 1.01%, birch 0.38%, hazel 0.5%, rye 0.63%, timothy 0.88%, mugwort 1.01%, ragweed 0.63%, Aspergillus spp. 0.25%, and cockroach 2.4%. The prevalence of atopy was totally 13.8%. BMI was 23.3 ± 0.15 (14.6-32.8). The subjects were grouped into BMI. The subjects <25 were "non-weighted", ≥ 25 to 29.9 were "overweighted", and ≥ 30 were "obese" (492/191/24). The BMI was higher in females than in males (23.8 ± 0.16 vs 22.4 ± 0.17; p<0.01). The prevalence of wheezing was higher in group with BMI ≥ 25 than in group with BMI <25 [57/201 (28.3%) vs 64/505 (12.6%), p<0.01]. The BMI was higher in group with wheezing than in group without wheezing (24.3 ± 0.34 vs 23.1 ± 0.13, p<0.01, Table 2). Atopy prevalences were higher in males than in females [104/258 (40.3%) vs 107/448 (23.8%), p<0.01]. No association

### Table 1. Characteristics of subjects

| Subjects (n)       | 707               |
|-------------------|-------------------|
| Sex (M/F)         | 259/448           |
| Age (yr)          | 65.7 (50-93)      |
| Smoking status (Current/Ex/never) | 147/42/488 |
| Wheezing (yes/no) | 121/586           |
| Atopic/nonatopic  | 211/496           |
| FEV1 (% pred)     | 77.6% (68.3-105.4) |
| FVC (% pred)      | 78.7% (65.1-101.2) |
| FEV1/FVC*         | 85 (0.61-0.98)    |

 Statistical analyses

All data were analyzed using the SPSS version 7.5 for Windows. Each biochemical assays were repeated at least twice. Data were expressed as mean ± standard error of the mean (SEM). Statistical analysis was performed by Student’s t-test, Mann-Whitney U test, and Chi-square test, as appropriate. Pearson’s correlations and Spearman’s correlations were also used. In multivariate analysis, logistic regression was performed with a stepwise selection method with p<0.05 for entry into the model. Atopy and wheezing were treated as binary outcome variables in the logistic regression analysis. A p-value of <0.05 was considered significant.

### Table 2. Body mass index, atopy, pulmonary function test, smoking status, and lipid profiles according to wheezing

| Wheezing (-)          | 23.1±0.13 | 24.3±0.34* |
|-----------------------|-----------|------------|
| Prevalence of atopy   | 178/586   | 33/121     |
| FEV1 (% pred)*        | 85.3% (74.2-105.4) | 76.8% (63.2-96.7) |
| FVC (% pred)*         | 87.6% (67.3-101.2) | 75.3% (59.5-98.3) |
| FEV1/FVC*             | 87.1% (65-96) | 84.2% (61-98) |
| Smoking status (current/ex/never) | 126/29386 | 21/13/102 |
| Total cholesterol (mmol/L) | 187.8±2.8 | 186.6±3.4 |
| Triglyceride (mmol/L)  | 129.6±7.5 | 139.5±4.4 |
| HDL-cholesterol (mmol/L) | 50.8±0.56 | 52.0±0.02 |
| LDL-cholesterol (mmol/L) | 107.1±2.8 | 106.6±2.8 |

*p<0.01 versus did not developing wheezing. * range in parenthesis; % pred, group mean value of individual percentage predicted lung function parameter; FEV1, forced expiratory volume in one second; FVC, forced vital capacity; M, male; F, female; HDL-cholesterol, high-density lipoprotein cholesterol; LDL-cholesterol, low-density lipoprotein cholesterol.
between BMI and atopy was found. The levels of total cholesterol and LDL-cholesterol were higher in females than in males (192.6 ± 3.6 vs 174.5 ± 2.1, p < 0.01 and 113.9 ± 3.5 vs 95.8 ± 2.0, p < 0.01, respectively; Table 3). In a multiple logistic regression model, wheezing demonstrated an independent association with BMI (OR = 1.1; 95% CI = 1.03-1.18, p = 0.0038), when adjusted for age, smoking status, FEV1, sex, atopy, and lipid profiles.

Table 3. Body mass index and lipid profiles according to sex

|                      | Male       | Female    |
|----------------------|------------|-----------|
| Body mass index (kg/m²) | 22.4 ± 0.17 | 23.8 ± 0.16* |
| Total cholesterol (mmol/L) | 174.5 ± 2.1 | 192.6 ± 3.6* |
| Triglyceride (mmol/L)    | 136.2 ± 7.3 | 138.9 ± 4.4 |
| HDL-cholesterol (mmol/L) | 51.4 ± 0.87 | 50.9 ± 0.59 |
| LDL-cholesterol (mmol/L) | 95.8 ± 2.0  | 113.9 ± 3.5* |

*p < 0.01 versus male. HDL-cholesterol: high-density lipoprotein cholesterol; LDL-cholesterol: low-density lipoprotein cholesterol.

DISCUSSION

This epidemiological study showed that the prevalence of atopy in elderly adults living in a rural area in Korea was 13.8% and the house dust mite was the most prevalent allergen. BMI was associated with wheezing.

Asthma in the elderly is not a rare disease and may be associated with severe symptoms and chronic airway obstruction. If severe, it rarely goes into complete remission and tends to remain a severe, disabling disorder (13). In this study, the prevalence of self-reported wheezing was 17.3%, demonstrating a high incidence of airway obstruction in the elderly.

The usefulness of BMI as an indicator of adiposity in children and adolescents has been demonstrated (14, 15). The prevalence of atopy and rhinitis symptoms in girls (16) was higher in those with the highest BMI quintile. The BMI-rhinitis association was dependent on the BMI-atopy relation. On the other hand, wheezing and bronchial hyperresponsiveness (BHR) were significantly less common in girls with the lowest BMI quintile, which was true after adjusting for atopy and other potential risk factors for BHR. No association between BMI and atopy, BHR, or allergic symptoms was observed in boys. We have found that the self-reported wheezing was associated with BMI. This result is consistent with findings of previous epidemiological study in teenage girls (16). In recent studies (5, 16-18) in young children population, many investigators has suggested the possibility that female hormones may directly or indirectly be involved in the putative causal pathway that relates obesity to asthma. Further study is needed to clarify a mechanism for the finding of increased prevalence of wheezing in high BMI population in older adults. In this study, we used a multiple logistic regression model including smoking status, because it is not easy to separate asthma from chronic obstructive pulmonary disease in this study.

Asthma induces a decrease in energy intake that does not result in a decreased body weight, suggesting that there is a reduction in energy expenditure in asthma, perhaps due to a disease-induced limitation of physical activity (19).

A number of studies over the last few decades have reported a higher prevalence of asthma in higher socioeconomic groups (20, 21). The Nottingham group (22) has demonstrated that there is a greater degree of allergic sensitization in those with higher socioeconomic status. Skin sensitivity to five common aeroallergens was higher in social class I (33%) than in social class V (28%). In Zutphen in the Netherlands (23), 793 middle-aged males were followed during the period from 1960 to 1985. The intake of linoleic acid was positively associated with the risk of developing chronic nonspecific lung disease, but 74% of the study population was smokers, hence it is likely that they had chronic obstructive pulmonary disease rather than asthma. In the present study, we have not found the differences of the prevalence of wheezing according to lipid profiles. More research is needed to clarify the inter-relations between BMI, atopy, lipid profiles, and asthma.

Wheezing and asthma are especially rare in rural subsistence areas, and atopy may be associated with a reduced prevalence of these symptoms in this environment. In urban Jinma, self-reported asthma seemed to emerge as a clinical problem about 10 yr before the beginning of our study, which also suggests an effect of new environmental exposures. The factor or factors leading to the increase in the prevalence of asthma and allergy have not been identified, although exposures related to general changes in the domestic environment are likely to be involved (24). Environmental factors play an important role for the development of allergic manifestations in allergic conditions in genetically predisposed subjects. In this study, we observed 13.8% of prevalence of atopy in older subjects living in a high-altitude area with low aeroallergen exposure. Further epidemiological studies are needed to evaluate the role of atopy and altitude in asthma development in older subjects.

In conclusion, this study suggests that BMI is associated with wheezing in older adults.

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