J Korean Med Sci 2002; 17: 479-82
ISSN 1011-8934

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/m^2), 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*

An-Soo Jang, Myung-Ho Son*, Inseon-S Choi†, Young-Il Koh†

Department of Internal Medicine, Cheju National University College of Medicine, Cheju; Department of Preventive Medicine*, Seonam University Hospital, Gwangju; Department of Internal Medicine†, Chonnam National University Hospital, Gwangju, Korea

Received : 16 November 2001
Accepted : 8 April 2002

Address for correspondence
An Soo Jang, M.D.
Division of Allergy and Pulmonology, Department of Internal Medicine, Cheju National University College of Medicine, 154 Samdo-2-dong, Jeju 690-716, Korea
Tel : +82.64-757-8276, Fax : +82.64-750-1234
E-mail : jas877@cheju.ac.kr

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" life style. 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™, Yorba Linda, CA U.S.A.). Baseline measurements of VC and FEV_1 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 germinica,* 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 (positive control) and erythema size was equal and greater than that of histamine, the reaction was read as positive. Atopy was defined as a reactor who showed A/H ratio≥1 response to one or more allergens on skin prick tests (12).

Body mass index

The BMI for an individual was defined as weight (in kg) divided by the square of height (m^2).

Lipid profiles

Serum was taken, and stored in Eppendorf tubes at -70°C for later assay. Fatty acids extracted from serum were measured by Express 550 plus (Bayer, German) using enzymatic kits (Abbott, U.S.A.).

Table 1. Characteristics of subjects

	Total group
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 (n)	211/496
FEV_1 (% pred)*	77.6% (68.3-105.4)
FVC (% pred)*	78.7% (65.1-101.2)
FEV_1/FVC*	85 (0.61-0.98)

*, range in parenthesis; % pred, group mean value of individual percentage predicted lung function para-meter; FEV_1, forced expiratory volume in one second; FVC, forced vital capacity; M, male; F, female.

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.

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 cockcroach 2.4%. The prevalence of atopy was totally 13.8%. BMI was 23.3±0.13 (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 2. Body mass index, atopy, pulmonary function test, smoking status, and lipid profiles according to wheezing

	Wheezing (-)	Wheezing (+)
Body mass index (kg/m^2)	23.1±0.13	24.3±0.34*
Prevalence of atopy	178/586	33/121
FEV_1 (% 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)
FEV_1/FVC*	87.1% (65-96)	84.2% (61-98)
Smoking status (Current/Ex/Never)	126/29/386	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-chol (mmol/L)	50.8±0.56	52.0±0.02
LDL-chol (mmol/L)	107.1±2.8	108.6±2.8

*$p<0.01$ versus did not developing wheezing. *, range in parenthesis; % pred, group mean value of individual percentage predicted lung function parameter; FEV_1, forced expiratory volume in one second; FVC, forced vital capacity; M, male; F, female. HDL-chol, high-density lipoprotein cholesterol; LDL-chol, low-density lipoprotein cholesterol.

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

	Male	Female
Body mass index (kg/m^2)	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-chol (mmol/L)	51.4±0.87	50.9±0.59
LDL-chol (mmol/L)	95.8±2.0	113.9±3.5*

*p<0.01 versus male. HDL-chol: high-density lipoprotein cholesterol; LDL-chol: 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, FEV_1, sex, atopy, and lipid profiles.

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 potential 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 Jimma, 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.

ACKNOWLDGEMENT

The authors thank Mrs. Eun Mee Park for psychological support and Ms. Yun Kyung Kim for survey assistance.

REFERENCES

1. Black PN, Sharpe S. *Dietary fat and asthma: is there connection? Eur Respir J 1997; 10: 6-12.*
2. Shin TS, Lee KJ, Yun HS. *Prevalence of allergic disease in school children in Korea. Korean J Allergy 1990; 10: 201-12.*

3. Fluge Ø, Omenaas E, Eide GE, Gulsvik A. *Fish consumption and respiratory symptoms among young adults in a Norwegian community. Eur Respir J 1998; 12: 336-40.*
4. Shaheen SO, Sterne JAC, Montgomery SM, Azima H. *Birth weight, body mass index in young adults. Thorax 1999; 54: 396-402.*
5. Camargo CA Jr, Weiss ST, Zhang S, Willett WC, Speizer FE. *Prospective study of body mass index and risk of adult-onset asthma in women. Arch Intern Med 1999; 159: 2582-8.*
6. Young SY, Gunzenhauser JD, Malone KE, McTiernan A. *Body mass index and asthma in the military population of the northwestern United States. Arch Intern Med 2001; 161: 1605-11.*
7. Grootendorst DC, Dahlen SE, Van Den Bos JW, Duiverman EJ, Veselic-Charvat M, Vrijlandt EJ, O'Sullivan S, Kumlin M, Sterk PJ, Roldaan AC. *Benefits of high altitude allergen avoidance in atopic adolescents with moderate to severe asthma, over and above treatment with high dose inhaled steroids. Clin Exp Allergy 2001; 31: 400-8.*
8. Gourgoulianis KI, Brelas N, Hatziparasides G, Papayianni M, Molyvdas PA. *The influence of altitude in bronchial asthma. Arch Med Res 2001; 32: 429-31.*
9. Expert Panel Report 2, National Asthma Education and Prevention Program. *Guidelines for the diagnosis and management of asthma. National Heart, Lung, and Blood Institute. NIH Publication No. 1997; 97-4051A: 1-34.*
10. American Thoracic Society. *Lung function testing: selection of reference values and interpretative strategies. Am Rev Respir Dis 1991; 144: 1202-18.*
11. Choi IS, Greville HW, Park KO. *Addition of peak expiratory flow rate to the selection criteria of the representative spirometric result. Chonnam J Med Sci 1990; 3: 23-8.*
12. Crockcroft DW, Murdock KY, Berscheid BA. *Relationship between atopy and bronchial responsiveness to histamine in a random population. Ann Allergy 1984; 53: 26-9.*
13. Burrows B, Barbee RA, Cline MG, Knudson RJ, Lebowitz MD. *Characteristics of asthma among elderly adults in a sample of the general population. Chest 1991; 100: 935-42.*
14. White EM, Wilson AC, Greene SA, McCowan C, Thomas GE, Cairns AY, Ricketts IW. *Body mass index centile charts to assess fatness of British children. Arch Dis Child 1995; 72: 38-41.*
15. Daniels SR, Khoury PR, Morrison JA. *The utility of body mass index as a measure of body fatness in children and adolescents: differences by race and gender. Pediatrics 1997; 99: 804-7.*
16. Huang SL, Shiao GM, Chou P. *Association between body mass index and allergy in teenage girls in Taiwan. Clin Exp Allergy 1999; 29: 323-9.*
17. Chen Y, Dales R, Krewski D, Breithaupt K. *Increased effects of smoking and obesity on asthma among female Canadians: the National Population Health Survey, 1994-1995. Am J Epidemiol 1999; 150: 255-62.*
18. Castro-Rodriguez JA, Holberg CJ, Morgan WJ, Wright AL, Martinez FD. *Increased incidence of asthmalike symptoms in girls who become overweight or obese during the school years. Am J Respir Crit Care Med 2001; 163: 1344-9.*
19. Picado C, Deulofeu R, Lleonart R, Agusti M, Casals E, Quinto L, Mullol J. *Lipid and protein metabolism in asthma. Effects of diet and corticosteroid therapy. Allergy 1999; 54: 569-75.*
20. Peckham C, Butler N. *A national study of asthma in childhood. J Epidemiol Commun Health 1978; 32: 79-85.*
21. Hamman RF, Halil T, Holland WW. *Asthma in school children: demographic associations and peak expiratory flow rates compared with children with bronchitis. Br J Prev Soc Med 1975; 29: 228-38.*
22. Britton J, Pavord I, Richards KA, Knox AJ, Wisniewski AF, Lewis SA, Tattersfield AZ, Weiss ST. *Socioeconomic status and allergen sensitivity in a random adult population sample. Am J Respir Crit Care Med 1995; 151: A31.*
23. Miedema I, Feskens EJ, Heederik D, Kromhout D. *Dietary determinants of long-term incidence of chronic nonspecific lung disease: the Zutphen study. Am J Epidemiol 1993; 138: 37-45.*
24. Yemaneberhan H, Bekele Z, Venn A, Lewis S, Parry E, Britton J. *Prevalence of wheeze and asthma and relation to atopy in urban and rural Ethiopia. Lancet 1997; 350: 85-90.*