Korean Youth with Comorbid Allergic Disease and Obesity Show Heightened Psychological Distress

Soo Yeon Kim, MD[1], Sun Ha Choi, MD[1], Jong Deok Kim, MD[1,2], In Suk Sol, MD[1], Min Jung Kim, MD, PhD[1], Yoon Hee Kim, MD[1], Young-Chul Jung, MD, PhD[3], Myung Hyun Sohn, MD, PhD[1], and Kyung Won Kim, MD, PhD[1]

Objective To explore psychological distress in Korean adolescents having allergic disease comorbid with obesity.

Study design A total of 703 869 adolescents who completed the Korean Youth Risk Behavior Web-based Survey between 2007 and 2016 were analyzed. Participants were divided into 4 groups—healthy control, allergic disease only, obesity only, and comorbidity of allergic disease and obesity—and compared them to determine whether they showed differences in mental health.

Results Adolescents with both atopic dermatitis and obesity had significantly greater odds of experiencing unhappiness (OR, 1.17), stress (OR, 1.32), and suicidal ideation (OR, 1.25) than those without both conditions. The same was true of adolescents with obesity and allergic rhinitis (OR, 1.21, 1.37, and 1.27, respectively) or bronchial asthma (OR, 1.37, 1.39, and 1.37). The comorbidity groups also showed significantly greater odds of stress and suicidal ideation than the allergic disease-only (atopic dermatitis with obesity, 1.21 and 1.15, respectively; allergic rhinitis with obesity, 1.11 and 1.09; bronchial asthma with obesity, 1.17 and 1.14) and obesity-only groups (atopic dermatitis with obesity, 1.13 and 1.09; allergic rhinitis with obesity, 1.18 and 1.10; bronchial asthma with obesity, 1.18 and 1.21).

Conclusions Allergic disease and obesity negatively and additively influence mental health in adolescents. *(J Pediatr 2019;206:99-104).*

Allergic diseases and obesity are complex and multifactorial chronic health conditions possessing psychosomatic components.[1] There is a growing body of research on how allergic diseases such as atopic dermatitis, allergic rhinitis, and bronchial asthma (BA) are associated with psychological problems in children[2-5] and adults.[6-9] Patients with atopic dermatitis show significantly increased risk of depression, anxiety, and suicidal behaviors,[4,6,10] and patients with allergic rhinitis exhibit a higher prevalence of stress, depressive mood, psychological consultations, and impaired health-related quality of life.[7,11] There is also consistent evidence that anxiety/depression is associated with the onset of BA, as well as the severity of its symptomatology and poorer control status.[12,13] The mechanisms underlying the linkage of psychological problems and allergic diseases are not well-understood, but several studies have suggested dysregulation in the neurobiological components of the stress response system, as well as alterations in the hypothalamic-pituitary-adrenal axis, as possibilities.[14,15]

Obesity is also known to have bidirectional associations with poor mental health and negative health-related behaviors.[16-19] Obesity can have effects on mental health as a result of poor self-image and physical illnesses.[16,17] Psychiatric illness can in turn lead to further weight gain owing to hormone imbalances, behavioral issues, and medication effects.[18]

Allergic disease and obesity are both linked with psychological impairment, and these 2 conditions can co-occur; however, few studies have confirmed how comorbidity of these conditions influences mental health.

In this study, we aimed to explore the mental health problems and describe the sociodemographic features of adolescents with comorbidity of allergic disease and obesity from a nationally representative sample from Korea. In addition, the associations between obesity and each allergic disease, and the secular trends in the prevalence of adolescents with allergic disease, obesity, and both allergic disease and obesity over a 10-year period, were investigated.

Methods

This cross-sectional descriptive study used public datasets from the Korean Youth Risk Behavior Web-based Survey (KYRBWS), which is a nationwide, school-based survey annually conducted by the Korea Centers for Disease Control and

BA	Bronchial asthma
KYRBWS	Korean Youth Risk Behavior Web-based Survey

From the [1]Department of Pediatrics, Severance Hospital, Institute of Allergy, Brain Korea 21 PLUS Project for Medical Science, Yonsei University College of Medicine; [2]Department of Pediatrics, Hanyang University College of Medicine; and [3]Department of Psychiatry, Yonsei University College of Medicine, Seoul, Republic of Korea

M.H.S. and K.W.K. were supported by a Korea Research Foundation Grant funded by the Korean Government (NRF-2015R1D1A1A01061217), Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT & Future Planning (NRF-2017R1A2B2004043), and an Institute for Information & communications Technology Promotion (IITP) grant, also funded by the Korea government (MSIT, No. 2017-0-00599, Development of Big Data Analytics Platform for Military Health Information). The authors declare no conflicts of interest.

https://doi.org10.1016/j.jpeds.2018.10.037

Prevention. The KYRBWS uses a stratified, multistage probability design to obtain a nationally representative sample of middle and high school students; annually, around 70 000 participants aged 12-18 years anonymously complete the self-administered questionnaire assessing health risk behavior. The Korea Centers for Disease Control and Prevention's institutional review board approved the protocol, and all participants signed a consent form before participating in each survey. The details of the survey procedure have been described previously,[20] and the validity and reliability of the KYRBWS have been documented.[21] We used the KYRBWS data collected from 2007 to 2016. Of the total of 726 135 participants, 22 266 participants who did not record their height or weight were excluded; the remaining 703 869 participants (363 180 boys and 340 689 girls) were analyzed (**Figure 1**; available at www.jpeds.com). Because the KYRBWS data are secondary and do not contain any private information, this study did not require ethical approval.

A diagnosis of allergic disease was evaluated by an affirmative response to the following questions: "Have you ever been diagnosed with atopic dermatitis/allergic rhinitis/bronchial asthma by a doctor?" Weight categories were defined according to age- and sex-specific body mass index (calculated as the self-reported weight in kilograms divided by the square of the self-reported height in meters) percentiles according to the growth charts developed in 2007 for Korean children and adolescents, as follows: obese ≥95th percentile; overweight ≥85th to <95th percentile; healthy weight ≥5th to <85th percentile; and underweight <5th percentile.

Sociodemographic variables included age, sex, residential area, socioeconomic status, participants' academic performance, and parental education level. Residential area was grouped according to the participant's specific administrative district as a large city, medium- or small-sized city, and rural area. Economic level and academic performance were both classified into 5 groups (low, middle low, middle, middle high, and high), which were then recategorized as low (low and middle low), middle, or high (middle high and high). Father's and mother's education were analyzed separately, and classified as middle school or less, high school, and college or more. Participants who did not know their parents' education levels or who did not have a parent were still included in the analysis as unknown.

Physical activity was divided into frequency of participation in vigorous exercise and muscle-strengthening exercise; participants answered by citing the number of days that they performed each exercise in the most recent 7 days. Vigorous exercise was defined as exercising for >20 minutes that leads to rapid breathing and a substantial increase in heart rate. Exercises aimed at increasing muscle strength such as push-ups, sit-ups, and lifting weights or dumbbells were defined as muscle-strengthening exercises. Because the mean duration of physical activity was 3 days for each exercise for the total sample, we classified participants into high and low physical activity groups (≥3 and <3 days of exercise per week, respectively). Sleep duration was calculated using bedtime and wake-up time, which was recorded by the hour in 10-minute increments, during the most recent 7 days. For sleep satisfaction, there were 5 possible responses (well enough, enough, so-so, not enough, and never enough), which were recategorized into enough, so-so, and not enough. For drinking and smoking, participants who had experienced it either more than once in their lifetime were termed the experienced group; all others were considered nondrinkers or nonsmokers.

The main independent variables for mental health were subjective happiness, stress, depression, and suicidal ideation. Self-reported happiness and stress were evaluated via a 5-point Likert scale (none, a little, so-so, some degree, and very much). For the ease of comparison and interpretation, the first 2 answers on this scale were grouped into a single category (a little), as were the last two (much). Depression and suicidal ideation were assessed using 2 questions: "During the past 12 months, did you ever feel so sad or hopeless almost every day for 2 weeks or more in a row that you stopped doing some usual activities?" and "During the past 12 months, have you ever seriously thought of committing suicide?" Answers to these questions were coded dichotomously (yes/no).

The statistical analysis was performed via SPSS Statistics for Windows 23.0 (IBM Corp, Armonk, New York) using procedures that accommodate the weighted sampling design of the KYRBWS. The total sample was divided into 4 groups: healthy controls, allergic disease (atopic dermatitis/allergic rhinitis/BA) only, obesity only, and comorbidity of allergic disease and obesity (atopic dermatitis + obesity, allergic rhinitis + obesity, or BA + obesity). Descriptive statistics were presented as prevalence (% ± standard error) or mean ± standard error, and compared between the groups using χ^2 tests with Rao-Scott corrections. The age-adjusted prevalence of each allergic disease and weight status was calculated using Korean youth in 2010 as the reference population. The subsequent absolute and relative changes in the prevalence of each allergic disease, weight status, and comorbidity of allergic disease and obesity were assessed by arbitrarily dividing the decade into 3 periods: 2007-2009, 2010-2012, and 2013-2016. The strength of the associations between the variables were calculated as ORs and their 95% CIs, first using simple logistic regression analysis with complex sampling, followed by multiple logistic regression analysis (also with complex sampling) while controlling for potential confounders, including age, sex, residential area, socioeconomic status, academic performance, parental education level, and drinking and smoking experience. To exclude the potential confounding effects of other allergic diseases, only subjects with one of the allergic diseases were included in the respective comparison analysis. The statistical significance was defined as $P < .05$.

Results

Figure 2 shows the trends in the age-adjusted prevalence of each allergic disease, weight status, and comorbidity of allergic disease and obesity over the 10-year study period. The prevalence of obesity and overweight significantly increased between 2007 and 2009 (8.1% ± 0.1% and 3.7% ± 0.1%, respectively) and 2013-2016 (10.7 ± 0.1% and 4.5 ± 0.1%, respectively;

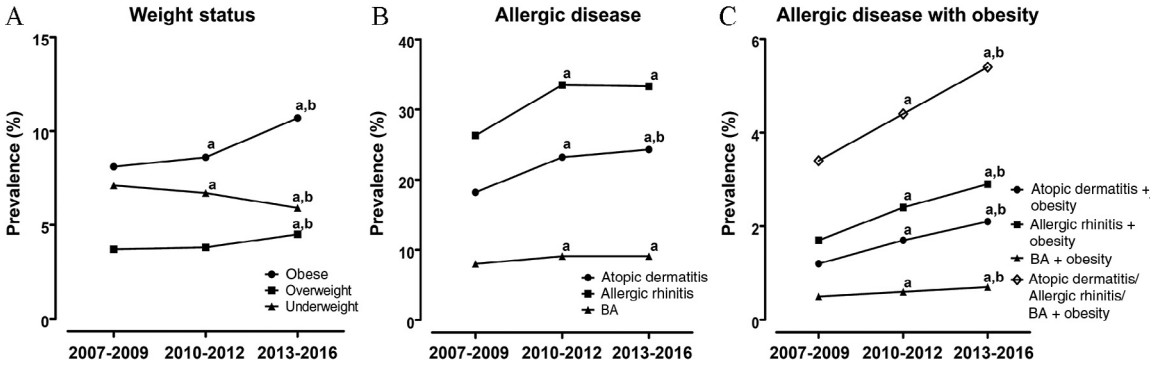

Figure 2. Secular trends in the age-adjusted prevalence (% ± SE) of youth with each allergic disease, weight status, and comorbid allergic disease and obesity among the KYRBWS cohorts. **A,** The age-adjusted prevalence of youth with atopic dermatitis, allergic rhinitis, and BA. **B,** The age-adjusted prevalence of youth with obesity, overweight, and underweight. **C,** The age-adjusted prevalence of youth with comorbidity of allergic disease and obesity. The estimated prevalence rate was adjusted by the age of the standard population based on the 2010 Census data of the Korea National Statistical Office. [a]Significant difference compared with 2007-2009 ($P < .001$). [b]Significant difference compared with 2010-2012 ($P < .001$).

$P < .001$). Conversely, the prevalence of underweight decreased from 7.1% ± 0.1% in 2007-2009 to 5.9% ± 0.1% in 2013-2016 ($P < .001$; **Table I** [available at www.jpeds.com]). Among the allergic diseases, the prevalence of atopic dermatitis showed a consistent annual increase of 0.7% on average, whereas the prevalence of allergic rhinitis and BA both recently plateaued. The estimated prevalence of comorbidity of obesity and any allergic disease significantly increased over the 10-year period from 3.4% ± 0.1% in 2007-2009 to 5.4% ± 0.1% in 2013-2016 ($P < .001$). These increasing trends were significant for atopic dermatitis + obesity, allergic rhinitis + obesity, and BA + obesity (all $P < .001$; **Table I**).

Table II shows the associations between allergic disease and weight status. The obesity and overweight groups had significantly greater odds of having any allergic disease (OR, 1.18 [95% CI, 1.15-1.20] and OR, 1.11 [95% CI, 1.07-1.14] for atopic dermatitis; OR, 1.05 [95% CI, 1.03-1.07] and OR, 1.08 [95% CI, 1.05-1.11] for allergic rhinitis; OR, 1.23 [95% CI, 1.19-1.27] and OR, 1.19 [95% CI, 1.14-1.24] for BA), and the underweight group had a significantly lower odds of any allergic disease (OR, 0.88 [95% CI, 0.85-0.90] for atopic dermatitis; OR, 0.97 [95% CI, 0.94-0.99] for allergic rhinitis; OR, 0.89 [95% CI, 0.86-0.93] for BA).

Table II. ORs with 95% CIs for allergic diseases in relation to body weight status

Multiple logistic regression*

	Atopic dermatitis		Allergic rhinitis		BA	
	OR	95% CI	OR	95% CI	OR	95% CI
Obesity	1.18	1.15-1.20	1.05	1.03-1.07	1.23	1.19-1.27
Overweight	1.11	1.07-1.14	1.08	1.05-1.11	1.19	1.14-1.24
Healthy	1	(reference)	1	(reference)	1	(reference)
Underweight	0.88	0.85-0.90	0.97	0.94-0.99	0.89	0.86-0.93

*ORs were adjusted for age, sex, residential area, socioeconomic status, academic performance, father's education level, mother's education level, and drinking and smoking experience.

Tables III-V (available at www.jpeds.com) show the sociodemographic and mental health characteristics of youth with comorbid allergic disease and obesity. Youth in the atopic dermatitis + obesity group reported a significantly higher prevalence of low economic level, short sleep duration, being unhappy, and stress than youth in the atopic dermatitis-only (all $P < .05$), obesity-only (all $P < .05$), and healthy control (all $P < .05$) groups. Similarly, the allergic rhinitis + obesity group showed a significantly higher prevalence of drinking experience, short sleep duration, and stress than the other groups (all $P < .05$). Finally, the BA + obesity group had a significantly higher prevalence of low economic level and paternal education level than did the other groups (all $P < .05$).

The strength of the associations between the mental health variables and comorbidity of allergic disease and obesity are shown in **Table VI**. Participants with comorbidity of allergic disease and obesity showed a significantly higher odds of being unhappy (OR, 1.17 [95% CI, 1.08-1.26] for atopic dermatitis + obesity; OR, 1.21 [95% CI, 1.13-1.29] for allergic rhinitis + obesity; and OR, 1.37 [95% CI, 1.18-1.58] for BA + obesity) than healthy controls. In addition, the allergic rhinitis + obesity (OR, 1.11 [95% CI, 1.03-1.20]) and BA + obesity (OR, 1.25 [95% CI, 1.08-1.45]) groups showed significantly greater odds of being unhappy than those in the obesity-only group. Youth with comorbidity of allergic disease and obesity also showed greater odds of reporting stress than healthy controls (OR, 1.32 [95% CI, 1.25-1.39] for atopic dermatitis + obesity; OR, 1.37 [95% CI, 1.31-1.43] for allergic rhinitis + obesity; OR, 1.39 [95% CI, 1.26-1.53] for BA + obesity). Similar associations were found when comparing the comorbidity groups to the obesity-only (OR, 1.13 [95% CI, 1.07-1.20] for atopic dermatitis + obesity; OR, 1.18 [95% CI, 1.13-1.24] for allergic rhinitis + obesity; OR, 1.18 [95% CI, 1.07-1.31] for BA + obesity), and

Table VI. ORs with 95% CIs for the main outcomes in youth with comorbid allergic disease and obesity compared to those with only allergic disease, only obesity, and healthy controls

	Atopic dermatitis + obesity vs atopic dermatitis		Atopic dermatitis + obesity vs obesity		Atopic dermatitis + obesity vs HC	
	OR	95% CI	OR	95% CI	OR	95% CI
Atopic dermatitis						
Unhappiness	1.07	0.98-1.16	1.07	0.98-1.17	1.17	1.08-1.26
Stress	1.21	1.15-1.28	1.13	1.07-1.20	1.32	1.25-1.39
Depression	1.03	0.97-1.09	1.12	1.06-1.20	1.09	1.03-1.16
Suicidal ideation	1.15	1.07-1.23	1.09	1.02-1.18	1.25	1.17-1.34
	Allergic rhinitis + obesity vs allergic rhinitis		Allergic rhinitis + obesity vs obesity		Allergic rhinitis + obesity vs HC	
	OR	95% CI	OR	95% CI	OR	95% CI
Allergic rhinitis						
Unhappiness	1.05	0.98-1.12	1.11	1.03-1.20	1.21	1.13-1.29
Stress	1.11	1.07-1.16	1.18	1.13-1.24	1.37	1.31-1.43
Depression	0.93	0.89-0.98	1.10	1.04-1.16	1.07	1.02-1.12
Suicidal ideation	1.09	1.03-1.16	1.10	1.03-1.17	1.27	1.20-1.34
	BA + obesity vs BA		BA + obesity vs obesity		BA + obesity vs HC	
	OR	95% CI	OR	95% CI	OR	95% CI
BA						
Unhappiness	1.15	0.98-1.34	1.25	1.08-1.45	1.37	1.18-1.58
Stress	1.17	1.05-1.30	1.18	1.07-1.31	1.39	1.26-1.53
Depression	0.89	0.79-0.99	1.12	1.01-1.24	1.09	0.98-1.21
Suicidal ideation	1.14	0.99-1.30	1.21	1.06-1.37	1.37	1.21-1.55

HC, healthy control.
ORs were adjusted for age, sex, residential area, socioeconomic status, academic performance, father's education level, mother's education level, and drinking and smoking experience.

allergic-disease-only (OR, 1.21 [95% CI, 1.15-1.28] for atopic dermatitis + obesity; OR, 1.11 [95% CI, 1.07-1.16] for allergic rhinitis + obesity; OR, 1.17 [95% CI, 1.05-1.30] for BA + obesity) groups. The atopic dermatitis + obesity and allergic rhinitis + obesity had increased odds of depression compared with the healthy control (OR, 1.09 [95% CI, 1.03-1.16] and OR, 1.07 [95% CI, 1.02-1.12], respectively) and obesity-only (OR, 1.12 [95% CI, 1.06-1.20] and OR, 1.10 [95% CI, 1.04-1.16]) groups. However, the atopic dermatitis + obesity group did not experience significantly different odds of depression compared with the atopic dermatitis-only group. Furthermore, the allergic rhinitis + obesity and BA + obesity groups reported lower odds of depression than the allergic rhinitis-only and BA-only groups (OR, 0.93 [95% CI, 0.89-0.98] and OR, 0.89 [95% CI, 0.79-0.99], respectively). Regarding suicidal ideation, participants with comorbid allergic disease and obesity had significantly greater ORs than those in the obesity-only (OR, 1.09 [95% CI, 1.02-1.18] for atopic dermatitis + obesity; OR, 1.10 [95% CI, 1.03-1.17] for allergic rhinitis + obesity; and OR, 1.21 [95% CI, 1.06-1.37] for BA + obesity), allergic disease-only (OR, 1.15 [95% CI, 1.07-1.23] for atopic dermatitis + obesity; OR, 1.09 [95% CI, 1.03-1.16] for allergic rhinitis + obesity; OR, 1.14 [95% CI, 0.99-1.30] for BA + obesity], and healthy controls (OR, 1.25 [95% CI, 1.17-1.34] for atopic dermatitis + obesity; 1.27 [95% CI, 1.20-1.34] for allergic rhinitis + obesity; and OR, 1.37 [95% CI, 1.21-1.55] for BA + obesity) groups.

Discussion

Consistent with the results of earlier studies,[22-26] there was a strong association between each allergic disease and the presence of obesity, which supports the possible linkage between obesity and atopy.[15,27-29] The overall mean prevalence of atopic dermatitis, allergic rhinitis, and BA were similar to those reported by previous studies,[30] and the trends in each allergic disease and weight status were in accordance with earlier reports.[30-32] Notably, the prevalence of obesity has recently increased rapidly, probably reflecting the more westernized diet and lifestyle changes in Korea. This increasing trend in allergic diseases, obesity, and allergic disease comorbid with obesity were consistently found across sexes and school types.

Not only is mental illness common in adolescence, it is also debilitating and hinders social, emotional, and academic development.[33] It is also well-documented that adolescents with chronic health conditions such as allergic diseases and obesity are more likely to suffer from psychological problems.[5,10,17,34,35] Given the rapidly increasing prevalence of obesity among adolescents worldwide,[31,32] and the high comorbidity between allergic diseases and obesity,[22,23] expanding our understanding of the mental health characteristics of those with both conditions is necessary. Although this area of research remains rather small, there are several previous studies exploring quality of life and mental health among obese children with asthma with which we can compare our results. Fedele et al compared health-related quality of life between children with asthma and obesity and those with only obesity, and found no meaningful differences.[36] They included 248 children, aged 7-12 years, residing in a rural county in the US and compared the quality of life scores using well-established scales. In addition, Acosta-Perez et al conducted a large-scale study with Puerto Rican children, who have distinctively high prevalence of asthma and obesity.[37] Using the Spanish version of the instrument for the assessment of psychiatric disorders using the *Diagnostic and Statistical Manual of Mental Disorders, 4th edition*, they found that, although both asthma and obesity were associated with a greater risk of depressive or anxiety disorders, having both

conditions did not lead to a further increase in risk over and above either condition on its own. The discrepancy of these results with our study results could be explained by not only the methodology, but also different population and cultural settings.

We used unhappiness, stress, depression, and suicidal ideation as indicators of psychological distress, and found that youth with both allergic disease and obesity had a 1.07-1.39 times greater odds of having psychological distress than those without both conditions (ie, healthy controls). In particular, all comorbidity groups had significantly greater odds of stress perception and suicidal ideation. For example, obese youth with atopic dermatitis showed a significantly (1.32- and 1.25-fold) greater odds of experiencing stress and suicidal ideation, respectively, than healthy controls. They even showed greater odds (1.09-1.21) of these conditions than those with only atopic dermatitis or obesity. Similar trends were observed for the youth with comorbidity of obesity and allergic rhinitis or BA, which led us to conclude that the effect of allergic disease and obesity were negative and additive for stress and suicidal ideation. Interestingly, we observed no significant differences in odds of unhappiness or depression when compared with those with only allergic disease. In fact, the odds of depression were rather low in obese youth with allergic rhinitis or BA. These findings suggest that allergic diseases, especially allergic rhinitis and BA, have a stronger effect on unhappiness and depression than does obesity, thus indicating the need for future epidemiologic and neurobiological investigations.

Our findings extend previous findings by using a large sample of adolescents from a representative, nationwide, observational, cross-sectional study, and including a comprehensive range of covariates. Nevertheless, the study has several limitations that should be considered when interpreting the results. The cross-sectional nature of the data does not allow for the determination of causal relationships. Additionally, the results are based on a self-administered survey that has a certain degree of subjectivity. Notably, the findings of our study might not be directly applicable to other populations owing to sociocultural differences. Therefore, caution is necessary for extrapolating our results to other ethnic groups. Despite these limitations, our study is noteworthy because it examined the mental health and sociodemographic characteristics of obese adolescents with allergic disease in Korea and identified the combined impacts of obesity and allergic diseases.

Adolescents with comorbid allergic disease and obesity have greater odds of experiencing psychological distress. Both allergic disease and obesity seem to negatively and additively influence the mental health of youth. Physicians who provide care for youth with allergic disease should be aware of the additional effect of weight status on mental health, and pay attention to their mental health needs. Future prospective research on youth with allergic disease is required to advance the identification and intervention for weight control and psychological support. ■

Submitted for publication Jun 11, 2018; last revision received Oct 20, 2018; accepted Oct 23, 2018

Reprint requests: Kyung Won Kim, MD, Department of Pediatrics, Institute of Allergy, Severance Children's Hospital, Yonsei University College of Medicine, 50-1, Yonsei-ro, Seodaemun-gu, Seoul 03722, Republic of Korea. E-mail: kwkim@yuhs.ac

References

1. Perrin JM, Gnanasekaran S, Delahaye J. Psychological aspects of chronic health conditions. Pediatr Rev 2012;33:99-109.
2. Chang HY, Seo JH, Kim HY, Kwon JW, Kim BJ, Kim HB, et al. Allergic diseases in preschoolers are associated with psychological and behavioural problems. Allergy Asthma Immunol Res 2013;5:315-21.
3. Hammer-Helmich L, Linneberg A, Obel C, Thomsen SF, Tang Mollehave L, Glumer C. Mental health associations with eczema, asthma and hay fever in children: a cross-sectional survey. BMJ Open 2016;6:e012637.
4. Yaghmaie P, Koudelka CW, Simpson EL. Mental health comorbidity in patients with atopic dermatitis. J Allergy Clin Immunol 2013;131:428-33.
5. Goodwin RD, Bandiera FC, Steinberg D, Ortega AN, Feldman JM. Asthma and mental health among youth: etiology, current knowledge and future directions. Expert Rev Respir Med 2012;6:397-406.
6. Thyssen JP, Hamann CR, Linneberg A, Dantoft TM, Skov L, Gislason GH, et al. Atopic dermatitis is associated with anxiety, depression, and suicidal ideation, but not with psychiatric hospitalization or suicide. Allergy 2018;73:214-20.
7. Kim DH, Han K, Kim SW. Relationship between allergic rhinitis and mental health in the general Korean adult population. Allergy Asthma Immunol Res 2016;8:49-54.
8. Scott KM, Von Korff M, Ormel J, Zhang MY, Bruffaerts R, Alonso J, et al. Mental disorders among adults with asthma: results from the World Mental Health Survey. Gen Hosp Psychiatry 2007;29:123-33.
9. Chun TH, Weitzen SH, Fritz GK. The asthma/mental health nexus in a population-based sample of the United States. Chest 2008;134:1176-82.
10. Lee S, Shin A. Association of atopic dermatitis with depressive symptoms and suicidal behaviors among adolescents in Korea: the 2013 Korean Youth Risk Behavior Survey. BMC Psychiatry 2017;17:3.
11. Meltzer EO. Quality of life in adults and children with allergic rhinitis. J Allergy Clin Immunol 2001;108:S45-53.
12. Eisner MD, Katz PP, Lactao G, Iribarren C. Impact of depressive symptoms on adult asthma outcomes. Ann Allergy Asthma Immunol 2005;94:566-74.
13. Lavoie KL, Bacon SL, Barone S, Cartier A, Ditto B, Labrecque M. What is worse for asthma control and quality of life: depressive disorders, anxiety disorders, or both? Chest 2006;130:1039-47.
14. Wright RJ, Rodriguez M, Cohen S. Review of psychosocial stress and asthma: an integrated biopsychosocial approach. Thorax 1998;53:1066-74.
15. Wright RJ, Cohen RT, Cohen S. The impact of stress on the development and expression of atopy. Curr Opin Allergy Clin Immunol 2005;5:23-9.
16. Simon GE, Von Korff M, Saunders K, Miglioretti DL, Crane PK, van Belle G, et al. Association between obesity and psychiatric disorders in the US adult population. Arch Gen Psychiatry 2006;63:824-30.
17. Rankin J, Matthews L, Cobley S, Han A, Sanders R, Wiltshire HD, et al. Psychological consequences of childhood obesity: psychiatric comorbidity and prevention. Adolesc Health Med Ther 2016;7:125-46.
18. Rofey DL, Kolko RP, Iosif AM, Silk JS, Bost JE, Feng W, et al. A longitudinal study of childhood depression and anxiety in relation to weight gain. Child Psychiatry Hum Dev 2009;40:517-26.
19. Muhlig Y, Antel J, Focker M, Hebebrand J. Are bidirectional associations of obesity and depression already apparent in childhood and adolescence as based on high-quality studies? A systematic review. Obes Rev 2016;17:235-49.
20. Kim Y, Choi S, Chun C, Park S, Khang YH, Oh K. Data resource profile: the Korea Youth Risk Behavior Web-based Survey (KYRBS). Int J Epidemiol 2016;45:1076-e.
21. Bae J, Joung H, Kim JY, Kwon KN, Kim Y, Park SW. Validity of self-reported height, weight, and body mass index of the Korea Youth Risk

Behavior Web-based Survey questionnaire. J Prev Med Public Health 2010;43:396-402.
22. Kusunoki T, Morimoto T, Nishikomori R, Heike T, Ito M, Hosoi S, et al. Obesity and the prevalence of allergic diseases in schoolchildren. Pediatr Allergy Immunol 2008;19:527-34.
23. Weinmayr G, Forastiere F, Buchele G, Jaensch A, Strachan DP, Nagel G. Overweight/obesity and respiratory and allergic disease in children: International Study of Asthma and Allergies in Childhood (ISAAC) Phase Two. PLoS ONE 2014;9:e113996.
24. Silverberg JI, Kleiman E, Lev-Tov H, Silverberg NB, Durkin HG, Joks R, et al. Association between obesity and atopic dermatitis in childhood: a case-control study. J Allergy Clin Immunol 2011;127:1180.e1-6.e1.
25. Egan KB, Ettinger AS, Bracken MB. Childhood body mass index and subsequent physician-diagnosed asthma: a systematic review and meta-analysis of prospective cohort studies. BMC Pediatr 2013;13:121.
26. Chen Z, Salam MT, Alderete TL, Habre R, Bastain TM, Berhane K, et al. Effects of childhood asthma on the development of obesity among school-aged children. Am J Respir Crit Care Med 2017;195:1181-8.
27. Chrousos GP. Stress, chronic inflammation, and emotional and physical well-being: concurrent effects and chronic sequelae. J Allergy Clin Immunol 2000;106:S275-91.
28. Hersoug LG, Linneberg A. The link between the epidemics of obesity and allergic diseases: does obesity induce decreased immune tolerance? Allergy 2007;62:1205-13.
29. Liezmann C, Klapp B, Peters EM. Stress, atopy and allergy: a re-evaluation from a psychoneuroimmunologic perspective. Dermatoendocrinol 2011;3:37-40.
30. Kang SY, Song WJ, Cho SH, Chang YS. Time trends of the prevalence of allergic diseases in Korea: a systematic literature review. Asia Pac Allergy 2018;8:e8.
31. Ogden CL, Carroll MD, Lawman HG, Fryar CD, Kruszon-Moran D, Kit BK, et al. Trends in obesity prevalence among children and adolescents in the United States, 1988-1994 through 2013-2014. JAMA 2016;315:2292-9.
32. Ezzati M, Bentham J, Di Cesare M, Bilano V, Bixby H, Zhou B. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. Lancet 2017;390:2627-42.
33. Keyes CL. Mental health in adolescence: is America's youth flourishing? Am J Orthopsychiatry 2006;76:395-402.
34. Dudeney J, Sharpe L, Jaffe A, Jones EB, Hunt C. Anxiety in youth with asthma: a meta-analysis. Pediatr Pulmonol 2017;52:1121-9.
35. Slattery MJ, Essex MJ, Paletz EM, Vanness ER, Infante M, Rogers GM, et al. Depression, anxiety, and dermatologic quality of life in adolescents with atopic dermatitis. J Allergy Clin Immunol 2011;128:668-71.
36. Fedele DA, Janicke DM, Lim CS, Abu-Hasan M. An examination of comorbid asthma and obesity: assessing differences in physical activity, sleep duration, health-related quality of life and parental distress. J Asthma 2014;51:275-81.
37. Acosta-Perez E, Canino G, Ramirez R, Prelip M, Martin M, Ortega AN. Do Puerto Rican youth with asthma and obesity have higher odds for mental health disorders? Psychosomatics 2012;53:162-71.

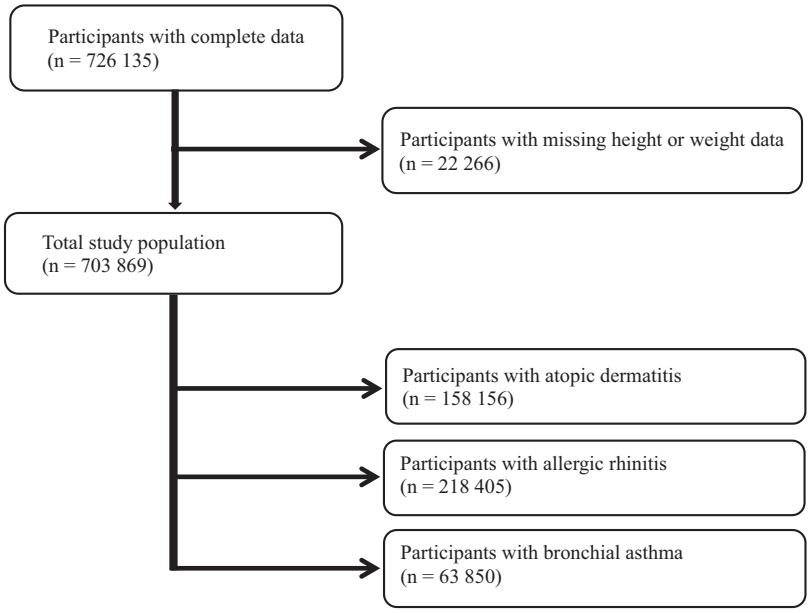

Figure 1. Flow chart of the study population.

Table I. Age adjusted prevalence (% ± SE) of youth with each allergic disease, weight status, and comorbid allergic disease and obesity in 2007-2009, 2010-2012, and 2013-2016

	2007-2009	2010-2012	2013-2016	2007-2016
Atopic dermatitis	18.2 ± 0.1	23.2 ± 0.1*	24.3 ± 0.1*,†	22.0 ± 0.1
Allergic rhinitis	26.3 ± 0.1	33.5 ± 0.1*	33.3 ± 0.1*	31.1 ± 0.1
BA	8.0 ± 0.1	9.1 ± 0.1*	9.1 ± 0.1*	8.7 ± 0.1
Underweight	7.1 ± 0.1	6.7 ± 0.1*	5.9 ± 0.1*,†	6.5 ± 0.1
Overweight	3.7 ± 0.1	3.8 ± 0.1	4.5 ± 0.1*,†	4.0 ± 0.1
Obesity	8.1 ± 0.1	8.6 ± 0.1*	10.7 ± 0.1*,†	9.3 ± 0.1
Atopic dermatitis + obesity	1.2 ± 0.0	1.7 ± 0.0*	2.1 ± 0.0*,†	1.7 ± 0.0
Allergic rhinitis + obesity	1.7 ± 0.0	2.4 ± 0.0*	2.9 ± 0.0*,†	2.3 ± 0.0
BA + obesity	0.5 ± 0.0	0.6 ± 0.0*	0.7 ± 0.0*,†	0.6 ± 0.0
Atopic dermatitis/allergic rhinitis/BA + obesity	3.4 ± 0.1	4.4 ± 0.1*	5.4 ± 0.1*,†	4.5 ± 0.0

The estimated prevalence was adjusted according to the age of the standard population based on the 2010 Census data from the Korea National Statistical Office.
*Significant difference compared to year 2007-2009, $P < .001$.
†Significant difference compared to year 2010-2012, $P < .001$.

Table III. Sociodemographic and mental health characteristics of youth with comorbid atopic dermatitis and obesity compared to the atopic-dermatitis-only, obesity-only, and healthy control groups

	Atopic dermatitis + obesity	Atopic dermatitis	Obesity	HC	
	n (%)	n (%)	n (%)	n (%)	*P* value
Sex					
Male	4782 (64.1)	26 691 (42.3)	24 563 (72.7)	160 509 (53.3)	<.001
Female	2891 (35.9)	37 876 (57.7)	9989 (27.3)	146 115 (46.7)	
Age (y)	15.3 ± 0.0	14.9 ± 0.0	15.4 ± 0.0	15.0 ± 0.0	<.001
Region of residence					
Large cities	3501 (45.9)	30 498 (46.9)	15 838 (46.9)	142 743 (46.7)	<.001
Medium or small-sized cities	3284 (47.0)	26 889 (47.0)	14 221 (45.6)	124 697 (46.5)	
Rural area	888 (7.1)	7180 (6.1)	4493 (7.4)	39 184 (6.8)	
Economic level					
Low	2009 (26.5)	13 849 (21.0)	8772 (24.9)	66 276 (21.0)	<.001
Middle	3532 (45.3)	31 893 (49.0)	15 789 (45.3)	149 506 (48.5)	
High	2132 (28.2)	18 825 (30.0)	9991 (29.8)	90 842 (30.5)	
Father's education level					
Middle school or less	376 (4.7)	2709 (3.8)	2243 (6.1)	16 469 (4.8)	<.001
High school	2910 (39.3)	22 277 (34.7)	12 694 (38.0)	107 006 (35.6)	
College or more	2954 (42.3)	28 397 (48.2)	12 242 (39.8)	120 676 (44.0)	
Unknown	1074 (13.7)	8530 (13.3)	5530 (16.0)	47 613 (15.5)	
Mother's education level					
Middle school or less	358 (4.6)	2770 (4.0)	2180 (6.1)	15 928 (4.8)	<.001
High school	3632 (48.9)	28 769 (45.8)	15 439 (46.8)	133 819 (45.6)	
College or more	2360 (33.2)	22 356 (37.4)	9579 (30.9)	93 846 (33.9)	
Unknown	1033 (13.3)	8385 (12.8)	5629 (16.1)	48 301 (15.7)	
Academic performance					
Low	3272 (42.7)	22 890 (35.6)	15 208 (44.1)	115 653 (37.7)	<.001
Middle	1997 (28.7)	17 996 (27.8)	9258 (26.7)	86 211 (28.1)	
High	2404 (30.6)	23 681 (36.6)	10 086 (29.2)	104 760 (34.2)	
Vigorous exercise					
≥3 days/week	2843 (37.0)	21 112 (32.3)	12 979 (37.4)	106 421 (34.6)	<.001
Muscle strengthening exercise					
≥3 days/week	1426 (18.8)	12 369 (19.2)	7051 (20.7)	67 210 (22.0)	<.001
Sleep duration (hr)	6.2 ± 0.0	6.3 ± 0.0	6.3 ± 0.0	6.4 ± 0.0	<.001
Sleep satisfaction					
Not enough	3100 (40.1)	26 794 (41.6)	12 292 (35.7)	116 258 (38.2)	<.001
So-so	2429 (32.4)	21 072 (32.7)	11 907 (34.5)	103 647 (33.8)	
Enough	2144 (27.5)	16 701 (25.7)	10 353 (29.8)	86 719 (28.0)	
Drinking experience					
Yes	4004 (52.4)	31 569 (48.9)	17 874 (52.3)	151 260 (49.5)	<.001
Smoking experience					
Yes	1914 (25.1)	14 186 (22.0)	9173 (26.5)	74 378 (24.2)	<.001
Happiness scale					
Little	978 (12.8)	7635 (11.7)	3986 (11.8)	33 390 (10.9)	<.001
So-so	2359 (31.0)	19 891 (30.9)	10 453 (30.0)	94 583 (30.8)	
Much	4336 (56.2)	37 041 (57.4)	20 113 (58.2)	178 651 (58.3)	
Stress scale					
Little	1219 (15.9)	10 326 (15.9)	6335 (18.1)	57 245 (18.6)	<.001
So-so	3015 (39.3)	27 159 (42.3)	14 260 (41.6)	131 227 (43.0)	
Much	3439 (44.7)	27 082 (41.8)	13 957 (40.3)	118 152 (38.4)	
Depression					
Yes	2498 (32.6)	21 503 (33.3)	9957 (29.1)	94 796 (31.0)	<.001
Suicidal ideation					
Yes	1408 (18.1)	11 471 (17.8)	5442 (16.0)	48 229 (15.8)	<.001

HC, healthy control.

Table IV. Sociodemographic and mental health characteristics of youth with comorbid allergic rhinitis and obesity compared to the allergic-rhinitis-only, obesity-only, and healthy control groups

	Allergic rhinitis + obesity	Allergic rhinitis	Obesity	HC	
	n (%)	n (%)	n (%)	n (%)	*P* value
Sex					
Male	8424 (73.1)	53 527 (53.3)	24 563 (72.7)	160 509 (53.3)	<.001
Female	3382 (26.9)	48 586 (46.7)	9989 (27.3)	146 115 (46.7)	
Age (y)	15.6 ± 0.0	15.2 ± 0.0	15.4 ± 0.0	15.0 ± 0.0	<.001
Region of residence					
Large cities	5602 (46.9)	49 488 (47.1)	15 838 (46.9)	142 743 (46.7)	<.001
Medium or small-sized cities	5110 (47.8)	43 665 (48.1)	14 221 (45.6)	124 697 (46.5)	
Rural area	1094 (5.3)	8960 (4.7)	4493 (7.4)	39 184 (6.8)	
Economic level					
Low	2730 (23.1)	19 558 (18.7)	8772 (24.9)	66 276 (21.0)	<.001
Middle	5222 (43.9)	48 141 (47.0)	15 789 (45.3)	149 506 (48.5)	
High	3854 (33.0)	34 414 (34.3)	9991 (29.8)	90 842 (30.5)	
Father's education level					
Middle school or less	554 (4.6)	3990 (3.6)	2243 (6.1)	16 469 (4.8)	<.001
High school	4083 (35.2)	33 023 (32.4)	12 694 (38.0)	107 006 (35.6)	
College or more	5338 (49.3)	50 626 (53.6)	12 242 (39.8)	120 676 (44.0)	
Unknown	1308 (10.9)	10 701 (10.3)	5530 (16.0)	47 613 (15.5)	
Mother's education level					
Middle school or less	586 (4.9)	4127 (3.7)	2180 (6.1)	15 928 (4.8)	<.001
High school	5310 (45.5)	44 440 (44.2)	15 439 (46.8)	133 819 (45.6)	
College or more	4210 (38.6)	39 763 (41.6)	9579 (30.9)	93 846 (33.9)	
Unknown	1336 (11.0)	10 845 (10.4)	5629 (16.1)	48 301 (15.7)	
Academic performance					
Low	4360 (37.2)	31 879 (31.2)	15 208 (44.1)	115 653 (37.7)	<.001
Middle	3170 (27.0)	28 000 (27.6)	9258 (26.7)	86 211 (28.1)	
High	4276 (35.8)	42 234 (41.2)	10 086 (29.2)	104 760 (34.2)	
Vigorous exercise					
≥3 days/week	4340 (36.6)	35 439 (34.5)	12 979 (37.4)	106 421 (34.6)	<.001
Muscle strengthening exercise					
≥3 days/week	2347 (19.9)	21 930 (21.6)	7051 (20.7)	67 210 (22.0)	<.001
Sleep duration (hr)	6.1 ± 0.0	6.2 ± 0.0	6.3 ± 0.0	6.4 ± 0.0	<.001
Sleep satisfaction					
Not enough	4768 (40.0)	42 987 (42.2)	12 292 (35.7)	116 258 (38.2)	<.001
So-so	3806 (32.4)	33 270 (32.6)	11 907 (34.5)	103 647 (33.8)	
Enough	3232 (27.5)	25 856 (25.2)	10 353 (29.8)	86 719 (28.0)	
Drinking experience					
Yes	6312 (54.1)	51 048 (49.9)	17 874 (52.3)	151 260 (49.5)	<.001
Smoking experience					
Yes	2958 (25.1)	23 104 (22.5)	9173 (26.5)	74 378 (24.2)	<.001
Happiness scale					
Unhappy	1485 (12.6)	12 005 (11.7)	3986 (11.8)	33 390 (10.9)	<.001
So-so	3601 (30.3)	30 520 (30.0)	10 453 (30.0)	94 583 (30.8)	
Happy	6720 (57.1)	59 588 (58.3)	20 113 (58.2)	178 651 (58.3)	
Stress scale					
Little	1835 (15.4)	16 050 (15.6)	6335 (18.1)	57 245 (18.6)	<.001
So-so	4746 (40.8)	42 515 (41.8)	14 260 (41.6)	131 227 (43.0)	
Much	5225 (43.9)	43 548 (42.6)	13 957 (40.3)	118 152 (38.4)	
Depression					
Yes	3735 (31.2)	34 187 (33.6)	9957 (29.1)	94 796 (31.0)	<.001
Suicidal ideation					
Yes	2062 (17.5)	17 549 (17.3)	5442 (16.0)	48 229 (15.8)	<.001

Table V. Sociodemographic and mental health characteristics of youth with comorbid BA and obesity compared to the bronchial-asthma-only, obesity-only, and healthy control groups

	BA + obesity	BA	Obesity	HC	
	n (%)	n (%)	n (%)	n (%)	*P* value
Sex					
Male	1839 (79.6)	9945 (64.5)	24 563 (72.7)	160 509 (53.3)	<.001
Female	518 (20.4)	6445 (38.5)	9989 (27.3)	146 115 (46.7)	
Age (y)	15.2 ± 0.0	14.8 ± 0.0	15.4 ± 0.0	15.0 ± 0.0	<.001
Region of residence					
Large cities	1041 (45.5)	7652 (47.2)	15 838 (46.9)	142 743 (46.7)	<.001
Medium or small-sized cities	1004 (47.3)	6777 (46.5)	14 221 (45.6)	124 697 (46.5)	
Rural area	312 (7.2)	1961 (6.3)	4493 (7.4)	39 184 (6.8)	
Economic level					
Low	617 (25.8)	3716 (21.9)	8772 (24.9)	66 276 (21.0)	<.001
Middle	983 (40.9)	7593 (45.8)	15 789 (45.3)	149 506 (48.5)	
High	757 (33.3)	5081 (32.3)	9991 (29.8)	90 842 (30.5)	
Father's education level					
Middle school or less	170 (7.6)	846 (4.9)	2243 (6.1)	16 469 (4.8)	<.001
High school	839 (36.4)	5397 (33.5)	12 694 (38.0)	107 006 (35.6)	
College or more	843 (40.6)	6787 (46.9)	12 242 (39.8)	120 676 (44.0)	
Unknown	376 (15.4)	2431 (14.7)	5530 (16.0)	47 613 (15.5)	
Mother's education level					
Middle school or less	160 (6.5)	826 (4.9)	2180 (6.1)	15 928 (4.8)	<.001
High school	1039 (46.1)	6727 (42.6)	15 439 (46.8)	133 819 (45.6)	
College or more	672 (32.0)	5398 (37.2)	9579 (30.9)	93 846 (33.9)	
Unknown	374 (15.4)	2527 (15.3)	5629 (16.1)	48 301 (15.7)	
Academic performance					
Low	986 (42.4)	6274 (37.9)	15 208 (44.1)	115 653 (37.7)	<.001
Middle	646 (27.7)	4427 (27.4)	9258 (26.7)	86 211 (28.1)	
High	725 (29.9)	5689 (35.0)	10 086 (29.2)	104 760 (34.2)	
Vigorous exercise					
≥3 days/week	937 (39.2)	6363 (38.9)	12 979 (37.4)	106 421 (34.6)	<.001
Muscle strengthening exercise					
≥3 days/week	529 (22.4)	4019 (25.2)	7051 (20.7)	67 210 (22.0)	<.001
Sleep duration (h)	6.5 ± 0.0	6.5 ± 0.0	6.3 ± 0.0	6.4 ± 0.0	<.001
Sleep satisfaction					
Not enough	876 (36.9)	6306 (38.6)	12 292 (35.7)	116 258 (38.2)	<.001
So-so	783 (33.8)	5508 (33.8)	11 907 (34.5)	10 3647 (33.8)	
Enough	698 (29.4)	4576 (27.6)	10 353 (29.8)	86 719 (28.0)	
Drinking experience					
Yes	1195 (50.6)	8380 (51.0)	17 874 (52.3)	15 1260 (49.5)	<.001
Smoking experience					
Yes	643 (27.3)	4470 (27.0)	9173 (26.5)	74 378 (24.2)	<.001
Happiness scale					
Unhappy	297 (13.3)	2126 (12.9)	3986 (11.8)	33 390 (10.9)	<.001
So-so	691 (28.5)	5066 (30.8)	10 453 (30.0)	94 583 (30.8)	
Happy	1369 (58.2)	9198 (56.3)	20 113 (58.2)	178 651 (58.3)	
Stress scale					
Little	421 (17.2)	2770 (16.6)	6335 (18.1)	57 245 (18.6)	<.001
So-so	932 (39.8)	6822 (41.9)	14 260 (41.6)	131 227 (43.0)	
Much	1004 (43.0)	6798 (41.5)	13 957 (40.3)	118 152 (38.4)	
Depression					
Yes	719 (30.6)	5765 (35.2)	9957 (29.1)	94 796 (31.0)	<.001
Suicidal ideation					
Yes	420 (18.3)	3112 (18.6)	5442 (16.0)	48 229 (15.8)	<.001