

The Relationship between Pollen Count Levels and Prevalence of Japanese Cedar Pollinosis in Northeast Japan

Kohei Honda¹, Hidekazu Saito¹, Naoko Fukui¹, Eiko Ito¹ and Kazuo Ishikawa¹

ABSTRACT

Background: The prevalence of Japanese cedar (JC) pollinosis in Japanese children is increasing. However, few studies have reported the relationship between pollen count levels and the prevalence of pollinosis. To evaluate the relationship between JC pollen count levels and the prevalence of pollinosis in children, we investigated the sensitization and development of symptoms for JC pollen in two areas of Akita in northeast Japan with contrasting levels of exposure to JC pollen.

Methods: The study population consisted of 339 elementary school students (10-11 years of age) from the coastal and mountainous areas of Akita in 2005-2006. A questionnaire about symptoms of allergic rhinitis was filled out by the students' parents. A blood sample was taken to determine specific IgE antibodies against five common aeroallergens.

Results: The mean pollen count in the mountainous areas was two times higher than that in the coastal areas in 1996-2006. The prevalence rates of nasal allergy symptoms and sensitization for mites were almost the same in both areas. On the other hand, the rates of nasal allergy symptoms and sensitization for JC pollen were significantly higher in the mountainous areas than in the coastal areas. The rate of the development of symptoms among children sensitized for JC pollen was almost the same in both areas.

Conclusions: These results suggest that pollen count levels may correlate with the rate of sensitization for JC pollinosis, but may not affect the rate of onset among sensitized children in northeast Japan.

KEY WORDS

allergen-specific IgE, allergic rhinitis, Japanese cedar pollen, Japanese cedar pollinosis

INTRODUCTION

Recently, the prevalence of atopic disorders has increased around the world and the prevalence of allergic rhinoconjunctivitis showed a 30-fold variation in 56 countries, while the prevalence of asthma symptoms varied 20-fold in the International Study of Asthma and Allergies in Childhood (ISAAC).¹ Japanese cedar (JC) pollinosis, caused by the pollen of the JC tree (*Cryptomeria japonica*), is one of the most common allergic respiratory disease in Japan.² The prevalence of JC pollinosis has increased 2.6 times between 1980 and 2000 and currently the disease has

been reported to occur at a prevalence of >16% of the Japanese population.^{3,4} Factors associated with air pollution, experience of farming, and western lifestyle, such as western diet and insulated housing conditions, have been proposed as risk factors of increasing prevalence of atopic disorders.⁵⁻⁸ In the study based on ISAAC, exposure to allergenic pollen did not appear to increase the risk of acquiring symptoms of rhinoconjunctivitis, but may actually give some protection.⁹ On the other hand, a study in southeastern France showed high exposure to pollen as a risk factor for developing hay fever, but consistency among studies is lacking.¹⁰ To evaluate the relation-

¹Department of Otorhinolaryngology-Head and Neck Surgery, Akita University Graduate School of Medicine, Akita, Japan.
Conflict of interest: No potential conflict of interest was disclosed.
Correspondence: Kohei Honda, Department of Otorhinolaryngology-Head and Neck Surgery, Akita University Graduate School

of Medicine, Akita 010-8543, Japan.

Email: kohei@med.akita-u.ac.jp

Received 5 December 2012. Accepted for publication 9 April 2013.

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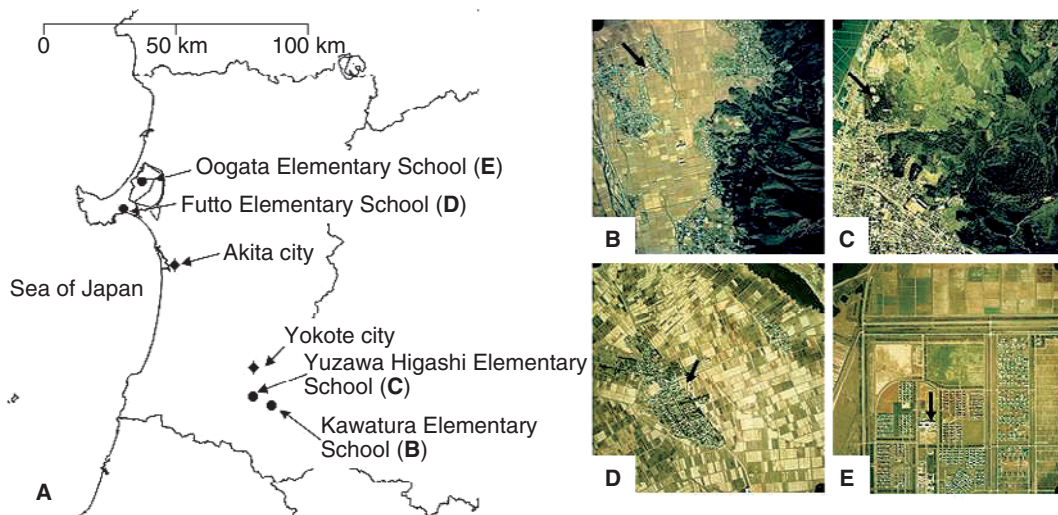


Fig. 1 A. Yuzawa Higashi Elementary School and Kawamura Elementary School are located in the mountainous area. Oogata Elementary School and Futto Elementary School are located in the coastal area. Japanese cedar pollen was counted at Yokote city and Akita city. B-E. Aerial photographs (1/8000) of the four elementary schools in this study. Arrows indicate Kawamura Elementary School (B) and Yuzawa Higashi Elementary School (C) in Yuzawa city in the mountainous area. These schools are located in the region enclosed by the Japanese cedar woods. Arrows indicate Futto Elementary School (D) in Oga city and Oogata Elementary School (E) in Oogata village in the coastal area. These schools are located in a region with rice fields in Akita prefecture. These pictures were obtained from the National Land Information, Ministry of Land, Infrastructure, Transport, and Tourism, Japan.

ship between pollen count levels and the prevalence of pollinosis in children, we investigated the sensitization and development of symptoms for JC pollen in two areas with contrasting pollen count levels.

METHODS

STUDY POPULATION

In June 2005 and 2006, the study was performed in the coastal and mountainous areas in Akita prefecture, which consists of 25 municipalities and 1.08 million people. It is located in northeast Japan and it faces the Sea of Japan. The mountainous area is located in the southeast about 100 Km from the coastal area. In June 2005 and 2006, we undertook a cross-sectional survey with 339 children in four schools. Two elementary schools, enrolling 183 children (82 males and 101 females: Yuzawa Higashi Elementary School and Kawamura Elementary School in Yuzawa city) in the mountainous area, are located in a region enclosed by Japanese cedar woods. The other two elementary schools, enrolling 156 children (79 males and 77 females: Oogata Elementary School in Oogata village and Futto Elementary School in Oga city) in the coastal area, are located in a region with rice fields in Akita prefecture (Fig. 1). All students attending classes of the fifth and sixth graders (age 10-11 years) were studied in the four schools.

The study protocol was approved by the Ethics Committee of Akita University Faculty of Medicine

and written informed consent was obtained from each subject and his or her parents prior to participation in the study.

MEASUREMENT OF JAPANESE CEDAR POLLEN COUNTS

Japanese cedar pollen was counted by Durham pollen collectors at Yokote Public Health Center in Yokote city (mountainous area) and Akita Prefectural Institute of Public Health in Akita city (coastal area) from 1996-2006 in February to May. Each slide glass, which was covered with paraffin jelly, was replaced every 24 h and the pollen count per cm² was measured under a microscope.

QUESTIONNAIRE

Identical self-administered questionnaires were distributed to the parents of the children in these two areas. The questionnaire included questions concerning typical symptoms of allergic rhinitis and other allergic disorders.

1. Has your child ever had sneezing or a runny or blocked nose, in the absence of a common cold? (a) no, (b) persistently yes, (c) seasonally yes: spring summer autumn winter (check the season).
2. Has your child ever had itchy eyes with or without nasal symptoms? (a) no, (b) persistently yes, (c) seasonally yes: which month?
3. Has your child ever had a wheeze?

4. Has your child had a wheeze in the past 12 months?
5. Has your child ever had atopic eczema?
6. Had your child had atopic eczema in the past 12 months?
7. Is your child currently taking any medications for allergic disease? (asthma, allergic rhinitis, atopic eczema)

The response rate to the questionnaire was 92.1% in the mountainous area and 97.5% in the coastal area.

MEASUREMENT OF SPECIFIC IgE

A blood sample was taken to determine specific IgE antibodies against five measured antigens (house dust, mites, JC pollen, orchard grass, wormwood) using an Immuno-CAP system (Phadia, Uppsala, Sweden) in June. Atopic sensitization was defined to be positive if specific IgE antibodies were present (CAP-RAST score ≥ 2). The specific IgE level was classified using the following scores: 6, ≥ 100 UA/ml; 5, 50.0-99.9 UA/ml; 4, 17.5-49.9 UA/ml; 3, 3.50-17.4 UA/ml; 2, 0.70-3.49 UA/ml; 1, 0.35-0.69 UA/ml; 0, ≤ 0.34 UA/ml. A CAP-RAST score of 2-6 was regarded as positive, a score of 1 as borderline, and a score of 0 as negative. The sensitization rates were calculated based on the number of subjects with a score of 2-6. The participation rate for the measurement of serum specific IgE was 90.6% in the mountainous area and 97.5% in the coastal area.

DIAGNOSIS OF ALLERGIC RHINITIS

Allergic rhinitis was defined as the presence of typical nasal symptoms and a serum CAP-RAST score for allergens of ≥ 2 . Seasonal allergic rhinitis induced by pollen was defined as the presence of nasal and eye symptoms in pollen season (JC, March to May; orchard grass, June to August; wormwood, September to October) and a serum CAP-RAST score for pollen of ≥ 2 .

STATISTICAL ANALYSIS

Chi-squared tests were used to compare the prevalence of allergic disorders, sensitization for allergens, and nasal allergic symptoms between the coastal area and the mountainous area. We also calculated prevalence odds ratios with a 95% confidence interval (CI). A multivariate logistic regression analysis was used to assess the independent effects of several determinants of sensitization for JC and development of nasal allergic symptoms. A p value < 0.05 was considered statistically significant.

RESULTS

MEASUREMENT OF JAPANESE CEDAR POLLEN COUNTS

The mean JC pollen counts/cm² in the mountainous area in 1996-2006 were about two times higher than those in the coastal area (coastal area, 1167 counts/

Table 1 Measurement of JC pollen counts in 1996-2006

Year	JC pollen counts (/cm ²)	
	Coastal area	Mountainous area
1996	20	80
1997	420	1280
1998	590	1090
1999	440	330
2000	3910	4850
2001	500	1200
2002	200	1560
2003	1190	4140
2004	530	1870
2005	2580	5730
2006	2460	4780
Mean	1167	2446

cm² vs. mountainous area, 2446 counts/cm²) (Table 1).

PREVALENCE OF ALLERGIC DISORDERS

The prevalence (%) of JC pollinosis in the mountainous area as assessed by the questionnaire and antigen-specific IgE assessment was significantly higher than that in the coastal area (coastal area, 5.8% vs. mountainous area, 13.7%; odds ratio, 2.58; $P = 0.016$). On the other hand, there was no difference in the prevalence of allergic rhinitis (coastal area, 42.9% vs. mountainous area, 48.1%), asthma (coastal area, 10.3% vs. mountainous area, 11.5%) and eczema (coastal area, 13.5% vs. mountainous area, 8.7%) between the mountainous and coastal areas (Table 2). There was no difference in the prevalence of mite allergic rhinitis (coastal area, 26.3% vs. mountainous area, 25.1%) between the mountainous and coastal areas. The prevalence rate of orchard grass pollinosis in the mountainous area was significantly lower than that in the coastal area (coastal area, 10.3% vs. mountainous area, 2.7%; odds ratio, 0.25; $P = 0.008$).

PREVALENCE OF SENSITIZATION FOR SPECIFIC ALLERGENS

The prevalence of atopic sensitization for JC pollen, as assessed by antigen-specific IgE, was significantly higher in the mountainous area than that in the coastal area (coastal area, 20.5% vs. mountainous area, 41.5%; odds ratio, 2.8; $P < 0.0001$). On the other hand, there was no difference in the prevalence of atopic sensitization for mites (coastal area, 48.1% vs. mountainous area, 50.8%) and wormwood (coastal area, 7.1% vs. mountainous area, 6.0%) between the mountainous area and the coastal area. The prevalence of atopic sensitization for orchard grass in the coastal area was significantly higher than that in the mountainous area (coastal area, 26.9% vs. mountainous area, 12.6%; odds ratio, 0.4; $P < 0.001$) (Table 3).

Table 2 The prevalence rate of allergic disease

Symptoms	Prevalence in % (number of children)		Odds ratio (95% CI)	P
	Coastal area (n = 156)	Mountainous area (n = 183)		
Allergic rhinitis	42.9 (67)	48.1 (88)	1.2 (0.8-1.9)	0.4
JC pollinosis	5.8 (9)	13.7 (25)*	2.6 (1.2-5.7)	0.02
Asthma	10.3 (16)	11.5 (21)	1.1 (0.6-2.3)	0.8
Eczema	13.5 (21)	8.7 (16)	0.6 (0.3-1.2)	0.2

* $p < 0.05$; compared to the coastal area group.

Table 3 The positive rate of antigen-specific IgE

Antigen	Positive rate % (number of children)		Odds ratio (95% CI)	P
	Coastal area (n = 156)	Mountainous area (n = 183)		
Mite	48.1 (75)	50.8 (93)	1.1 (0.7-1.7)	0.7
Japanese cedar	20.5 (32)	41.5 (76)*	2.8 (1.7-4.5)	<0.0001
Grass	26.9 (42)	12.6 (23)**	0.4 (0.2-0.7)	<0.005
Wormwood	7.1 (11)	6.0 (11)	0.8 (0.3-2.0)	0.8

* $p < 0.0001$; ** $p < 0.001$; compared to the coastal area group.

Table 4 Rate of development of nasal allergic symptoms among sensitized children

Antigen	% (number of positive symptoms/number of sensitized children)		Odds ratio (95% CI)	P
	Coastal area	Mountainous area		
Mite	54.7 (41/75)	49.5 (46/93)	0.8 (0.4-1.5)	0.7
Japanese cedar	28.1 (9/32)	32.9 (25/76)	1.3 (0.5-3.1)	0.8
Grass	38.1 (16/42)	21.7 (5/23)	0.5 (0.1-1.5)	0.3
Wormwood	9.1 (1/11)	0 (0/11)	0 (1-1)	1

PREVALENCE OF NASAL ALLERGIC SYMPTOMS AMONG SENSITIZED CHILDREN

There was no difference in the rate of development of nasal allergic symptoms among sensitized children for mites (coastal area, 54.7% vs. mountainous area, 49.5%), JC (coastal area, 28.1% vs. mountainous area, 32.9%), orchard grass (coastal area, 38.1% vs. mountainous area, 21.7%), and wormwood (coastal area, 9.1% vs. mountainous area, 0%) allergens between the mountainous and coastal areas (Table 4).

MULTIVARIATE ANALYSIS WITH SENSITIZATION FOR JAPANESE CEDAR AND DEVELOPMENT OF NASAL ALLERGIC SYMPTOMS AMONG SENSITIZED CHILDREN

The relation of both sensitization for JC and development of nasal allergic symptoms among sensitized children to sex, sensitization for mite, asthma, eczema and study area was assessed in a multivariate logistic regression analysis (Table 5). The sensitization for mite, asthma and mountainous area were significant risk factors for sensitization for JC (sensitization for mite; odds ratio, 5.2; $P < 0.0001$, asthma; odds ratio, 2.2; $P < 0.05$, mountainous area; odds ratio, 2.8; $P < 0.0001$). On the other hand, there was no significant risk factor for development of nasal allergic

symptoms among sensitized children for JC.

DISCUSSION

Recently, the prevalence of allergic rhinitis and other atopic disorders has increased in many countries.^{1,9} The prevalence of JC pollinosis has especially increased in Japan.^{3,4,11,12} However, few studies have reported the relationship between pollen count levels and the prevalence of pollinosis. In this study, we assessed the relationship between pollen count levels and the prevalence of pollinosis in two areas, coastal and mountainous areas, with contrasting levels of exposure to JC pollen (coastal area, 1167 counts/cm² vs. mountainous area, 2446 counts/cm²). There was no difference in the prevalence of atopic sensitization as assessed by antigen-specific IgE for mites between the mountainous area and the coastal area. On the other hand, the prevalence of atopic sensitization for JC pollen in the mountainous area was significantly higher than that in the coastal area. However, there was no difference in the rate of development of nasal allergic symptoms among sensitized children for JC pollen between the mountainous and coastal areas. These results indicated that the level of antigen exposure may affect the sensitization for antigens but may not affect the development of nasal symptoms in JC

Table 5 Results of the multivariate logistic regression analysis with sensitization for JC and development of nasal allergic symptoms among sensitized children

	Sensitization for JC		Development to JC pollinosis	
	Odds ratio (95% CI)	P	Odds ratio (95% CI)	P
Male	1.2 (0.7-1.9)	0.5	0.9 (0.4-2.1)	0.9
Sensitization for mite	5.2 (3.1-8.7)	<0.0001	2.0 (0.7-6.1)	0.3
Asthma	2.2 (1.2-4.0)	<0.05	1.6 (0.6-4.2)	0.4
Eczema	1.2 (0.7-2.1)	0.6	2.2 (0.8-5.8)	0.2
Mountainous area	2.8 (1.7-4.5)	<0.0001	1.3 (0.5-3.1)	0.8

pollinosis. Interestingly, a cross-sectional survey in Yamanashi and Chiba prefectures with heavy JC pollen count levels in middle Japan (southern Yamanashi, 7000/cm²; Chiba, 4000/cm²; northern Yamanashi, 2000/cm²) reported that the positive rate for JC pollen in elementary school students was about 60% in all these areas.¹² These results indicated that the excessive JC pollen count level may not be correlated with the rate of sensitization for JC pollen in Japanese students if the JC pollen count level is higher than a certain level. A high rate of allergic sensitization can be induced by a relatively small amount of JC pollen.

The risk factors for sensitization to an antigen and allergic rhinitis have been reported and within the risk factors reported, environmental factors are very important.^{5-8,13-15} Several surveys in children and adults have shown significantly lower prevalence rates of asthma and allergic diseases in Eastern Europe than in Western countries.^{1,7} The prevalence rates of hay fever and atopic sensitization increased significantly between 1991-92 and 1995-96 in Leipzig, East Germany, where tremendous changes towards western lifestyle have occurred since Germany's unification. However, there was no significant change in the prevalence rates of asthma, asthma-related symptoms, or bronchial hyper-responsiveness. Regarding this discrepancy, researchers speculate that factors operating very early in life are important for the acquisition of childhood asthma, whereas the development of atopic sensitization and hay fever is affected by environmental factors occurring beyond infancy in addition to early-life factors.⁷ The farming environment has been reported to reduce the risk of allergic diseases such as asthma, rhinoconjunctivitis, and atopic eczema among both children and adults.^{14,15} Increasing physical activity in childhood also has been reported to prevent hay fever.¹⁶

In this study, we did not obtain the information on environment factors on each subject but the difference in environmental factors between the coastal and mountainous areas was quite small because the distance between the two areas is only 100 Km and the weather, atmosphere, and dietary habits of the residents are quite similar. The result of almost the

same prevalence rate of mite sensitization between the two areas in this study supports similar environmental factors between the two areas.

It is concluded that pollen count levels may correlate with the rate of sensitization for JC pollinosis, but may not affect the rate of onset among sensitized children in northeast Japan.

ACKNOWLEDGEMENTS

This study was supported by grants-in-aid from the Ministry of Health, Labour, and Welfare in Japan and supervised by Prof. Yoshitaka Okamoto (Chiba University, Chiba, Japan). We wish to express our thanks to him. The authors are indebted to all parents, children, and teachers who participated in the surveys.

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