CEO Clinical and Experimental Otorhinolaryngology Vol. 10, No. 2: 164-167, June 2017
https://doi.org/10.21053/ceo.2016.01116
pISSN 1976-8710 eISSN 2005-0720

Original Article

Low Concentration PM_{10} Had No Effect on Nasal Symptoms and Flow in Allergic Rhinitis Patients

Young Hyo Kim[1,*] · Kwang Pil Ko[2,*] · Il Gyu Kang[3] · Joo Hyun Jung[3] · Dae Kyu Oh[2] · Tae Young Jang[1] · Seon Tae Kim[3]

[1]Department of Otorhinolaryngology-Head and Neck Surgery, Inha University School of Medicine, Incheon;
[2]Department of Preventive Medicine, Gachon University College of Medicine, Incheon;
[3]Department of Otorhinolaryngology-Head and Neck Surgery, Gachon University Gil Medical Center, Gachon University College of Medicine, Incheon, Korea

Objectives. Since Korea is geographically close to China (the origin site for Asian sand dust [ASD]) the health influence of ASD event will be still greater in Korea. We aimed to evaluate the effect of PM_{10} (particulate matter with aerodynamic diameter <10 μm, below 150 μg/m^3) on the clinical course of allergic rhinitis (AR).

Methods. We enrolled 47 healthy volunteers (group A) and 108 AR patients sensitized to house dust mites (group B). For 120 consecutive days (from February 1st to May 30th, 2012), all subjects reported their daily nasal symptoms and performed 2 peak flowmeter readings to measure peak nasal inspiratory flow (PNIF). We evaluated the correlation between the daily concentration of PM_{10}, symptoms, and PNIF of patients. We also investigated changes in symptoms and PNIF 2 days before and after 'dusty' days (daily concentration of PM_{10} >100 μg/m^3)

Results. There was no significant difference between group A and B in nasal symptoms and PNIF during the 120-day period. Changes in nasal symptoms and PNIF were not statistically significant before or after a PM_{10} concentration rise above 100 μg/m^3.

Conclusion. Low concentration PM_{10} does not have significant effect on nasal symptoms and PNIF in AR patients.

Keywords. *Allergic Rhinitis; Particulate Matter; Mites*

INTRODUCTION

Asian sand dust (ASD) is originated from China, Mongolia, and Kazakhstan area and moves eastward to affect eastern China, Japan, and Korea. Occasionally, ASD can exert its influence on the United States across the Pacific Ocean [1,2]. ASD events are closely correlated with an increase in outpatient visits, admissions and mortality due to the aggravation of respiratory diseases [3-6].

Some researchers studied the correlation between PM_{10} (particulate matter with aerodynamic diameter <10 μm) exposure and airway diseases. Adamkiewicz et al. [7] suggested that there was a significantly increased risk for pulmonary obstruction after exposure to high concentrations of PM_{10}. Clifford et al. [8] also suggested that geogenic exposure to PM_{10} could increase pulmonary inflammation and impair pulmonary function, and eventually exacerbate responses to respiratory virus infections.

There are still few studies regarding the effect of ASD on the clinical course of allergic disorders. Chang et al. [9] tried to analyze the correlation between the ASD storm and increases in clinic visit due to allergic rhinitis (AR), but found no significant correlation. Several researchers in Japan have tried to evaluate the correlation between ASD event and Japanese cedar pollinosis [10,11].

Since Korea is geographically so close to China, the origin area, we hypothesized that the influence of ASD events would be more significant in Korea than in any other nation. Because

• Received August 5, 2016
Revised September 24, 2016
Accepted October 10, 2016

• Corresponding author: **Seon Tae Kim**
Department of Otolaryngology, Gachon University Gil Medical Center, Gachon University College of Medicine, 21 Namdong-daero 774beon-gil, Namdong-gu, Incheon 21565, Korea
Tel: +82-32-460-3764, Fax: +82-32-467-9044
E-mail: kst2383@gilhospital.com

*The first two authors contributed equally to this study.

indoor allergens such as house dust mites are the most prevalent causative allergens in Korea, the characteristics of Korean patients are likely to differ significantly from those of Japanese ones. However, there are no studies that evaluated the effect of ASD on the clinical course of AR in Korea, to the best of our knowledge.

PM_{10} (particulate matter with less than a 10 μm aerodynamic diameter) comprises as much as 70% of ASD [12,13]. As PM_{10} is so tiny, it could directly infiltrate the upper and lower airway.

Therefore, we aimed to evaluate the effect of PM_{10} on the clinical course of AR by assessing: (1) the degree and change of nasal symptoms and (2) peak nasal inspiratory flow (PNIF) measured by peak flowmetry and their variability during 120-day period in patients with AR.

MATERIALS AND METHODS

Subjects

We planned to enroll 150 healthy volunteers and another 150 patients with allergic rhinitis before the beginning of ASD season (from October 1, 2011 through January 31, 2012). We enrolled 47 healthy volunteers with no nasal symptoms and negative results on the skin prick test (SPT) (group A, 19 males and 28 females, mean 25.4 years old). We enrolled another 108 patients who had suffered allergic rhinitis for more than 1 year (group B, 58 males and 50 females, mean 20 years old) between October 2011 and January 2012. All healthy volunteers and patients were living in Incheon city. Demographic variables such as gender and age were not significantly different between groups. In group B, the proportion of patients with mild, persistent disease according to the Allergic Rhinitis Impact on Asthma (ARIA) classification was 69.5%. We diagnosed allergic rhinitis if a patient had typical symptoms of allergic rhinitis and his SPT results were strongly positive to house dust mite (*Dermatophagoides pteronyssinus* and/or *Dermatophagoides farinae*, size of wheal larger than that of histamine). We performed the SPT using more than 40 antigens, including house dust mite, fungi, pet animals like cats and dogs, tree or weed pollens, and cockroaches (Lofarma, Milan, Italy). We excluded subjects who had used any anti-allergic drugs within 1 month, those with positive results to any allergens other than house dust mites, patients with unstable systemic disease, pregnant or lactating women, those who had nasal surgery within the past 3 months, and those with exposure to chemical irritants or smoking. We also excluded those with chronic rhinosinusitis and/or nasal polyposis upon nasal endoscopic examination.

Before enrollment, we obtained written informed consent from all patients after a full explanation about the aim of this study, and the study was approved by the Gachon University Gil Medical Center and Inha University Institutional Review Board Committee on Studies Involving Human Beings (IUH-IRB 11-2456).

Symptoms and PNIF

All patients and healthy volunteers completed a daily symptom diary for consecutive 120 days (from February 1st to May 30th, 2012). They recorded their daily symptom score for nasal obstruction according to a modified 6-point Likert scale (from 0 [absolutely no discomfort] to 5 [the most troublesome]) [14]. Patients who needed anti-allergic medication used it and reported this using a diary (0, no medication; 1, oral anti-histamines; 2, intra-nasal steroids; and 3, oral corticosteroids). There was no loss of follow-up during the study period.

All subjects also measured PNIF daily using portable nasal inspiratory flow meter (Clement Clarke International Ltd., Harlow, UK). They were asked to breathe in with their maximal effort with masks firmly attached to their face. Subjects recorded their PNIF (L/min) twice a day, at the same time of the day.

Measurement of PM_{10}

We measured PM_{10} concentrations for 120 consecutive days (from February 1st to May 30th, 2012) in 15 areas in Incheon, Korea with help from Environmental Health Center for Allergic Rhinitis, Inha University Hospital. The mean value of 15 PM_{10} concentrations was defined as PM_{10} concentration of that day.

Statistical analyses

We used SAS ver. 9.3 (SAS Institute, Cary, NC, USA) for all statistical analyses. We used a mixed regression model in evaluate the association between daily allergic symptoms and the PM_{10} concentration for each day, correcting within-subject covariance using a 1st-order autoregressive covariance structure. We also used linear correlation analysis. All data was expressed as mean±standard deviation and the P-value<0.05 was considered as statistically significant.

HIGHLIGHTS

- Low concentration PM_{10} (particulate matter with aerodynamic diameter<10 μm; below 150 μg/m^3) has no significant effect on nasal symptoms in allergic patients.
- Low concentration PM_{10} induces no significant change of peak nasal inspiratory flow.

RESULTS

Correlation between the PM_{10} concentration and nasal symptoms

The concentration of PM_{10} throughout the study period was significantly below 200 μg/m^3 (cf. the criteria for yellow-dust warning: which is above 400 μg/m^3). There was no definite correla-

Table 1. Correlation between nasal obstruction symptom and PM_{10} concentration

Effect	Estimate	Standard error	*P*-value
Nasal obstruction			
Group A	–0.00023	0.00034	0.495
Group B	0.00008	0.00032	0.795
Rhinorrhea			
Group A	–0.00002	0.00025	0.943
Group B	–0.00041	0.00031	0.179
Sneezing			
Group A	–0.00005	0.00027	0.862
Group B	–0.00033	0.00031	0.224
Itching			
Group A	0.00010	0.00016	0.521
Group B	–0.00037	0.00029	0.120

PM_{10}, particulate matter with aerodynamic diameter <10 μm.

tion between PM_{10} concentration and each nasal symptoms during the study period ($P>0.05$) (Table 1).

Throughout the 120-day period, we found 3 'dusty' days when PM_{10} concentration was above 100 μg/m^3 (February 24th, 105.53 μg/m^3; March 29th, 139.8 μg/m^3; May 5th, 116.13 μg/m^3). We compared each nasal symptoms 2 days before and 3 days after these 'dusty' days, and group A (healthy volunteers) and group B (allergic group) had no significant aggravation of nasal symptoms ($P>0.05$).

Correlation between the PM_{10} concentration and PNIF

There was no definite correlation between PM_{10} concentration and daily PNIF (measured in the afternoon) during the study period ($P>0.05$) (Table 2). We compared PNIF values 2 days before and after 'dusty' days (February 24th, March 29th, and May 5th), group A (healthy volunteers) and group B (allergic group) had no significant aggravation of nasal symptoms ($P>0.05$).

When we defined PNIF variability as: (the difference between morning PNIF and afternoon PNIF)/(mean PNIF)×100%, PNIF variability significantly decreased as the PM_{10} concentration was increased ($P=0.041$) (Table 3).

DISCUSSION

We did not identify a significant correlation between the PM_{10} concentration and nasal symptoms of AR patients in this study. In fact, Chang et al. [9] tried to evaluate the association between ASD storm events and increases in daily clinic visits in Taiwan. However, they also failed to find any significant correlation [9]. The most important reason for our negative finding is the relatively low PM_{10} concentration (below 150 μg/m^3) throughout the 120-day period. This lower PM_{10} concentration may be insufficient to provoke any symptoms. Although we set 3 'dusty' days, 2 of them were below the criteria for 'particulate matter warning' (criteria for warning is daily concentration above 120 μg/m^3 or above 200 μg/m^3 for 2 consecutive hours in Korea).

Table 2. Correlation between PM_{10} concentration and daily peak nasal inspiratory flow (measured in the afternoon) during the study period

Effect	Estimate	Standard error	*P*-value
Intercept	74.873	11.508	<0.001
Group	–3.972	6.153	0.520
PM_{10}	–0.003	0.012	0.818
Age	0.372	0.178	0.038
Sex	–5.054	5.765	0.382

PM_{10}, particulate matter with aerodynamic diameter <10 μm.

Table 3. Linear correlation analysis between PM_{10} concentration and PNIF variability

Effect	Estimate	Standard error	*P*-value
Intercept	47.244	16.672	0.005
Group	–33.453	8.927	<0.001
PM_{10}	–0.024	0.012	0.041
Age	–0.249	0.258	0.337
Sex	6.022	8.364	0.473

PNIF variability=(maximum PNIF–minimum PNIF)/½ (maximum PNIF+minimum PNIF).
PM_{10}, particulate matter with aerodynamic diameter<10 μm; PNIF, peak nasal inspiratory flow.

Furthermore, as we enrolled patients when they visited the clinic while suffering from symptoms of AR, their symptoms were already moderate to severe. Therefore, aggravation of symptoms by PM_{10} could be masked by the more powerful influence of causative allergens (house dust mites, in our study). Ogi et al. [10] suggested that in patients with Japanese cedar pollinosis, patients suffered from aggravated symptoms before the pollen season. However, during the pollen season, they reported no difference in their symptom in spite of ASD event. Therefore, further studies should be designed to enroll symptom-free patients with formerly diagnosed AR.

PNIF has many advantages in that it is non-invasive, inexpensive, and easy to perform. Furthermore, its results are quite well correlated with those of rhinomanometry, and with subjective feeling of patients about their nasal patency [15-19]. Cho et al. [20] suggested that as PNIF had good reproducibility, it could be used in various epidemiologic studies that evaluate the effect of air pollutants on the upper and lower airway. To the best of our knowledge, this is the first study which evaluated the effect of PM_{10} on the clinical course of AR using objective parameters such as PNIF. However, PNIF showed no significant differences according to the concentration of PM_{10}. Considering that PNIF is well-correlated with patients' subject feeling of nasal obstruction [16], it is natural that PNIF was not decreased in patients whose feeling of nasal obstruction was not aggravated. Further studies with higher PM_{10} concentration and symptom-free AR patients could yield more meaningful results.

In spite of these all negative findings, we found that as the

PM_{10} increased, the variability of PNIF was significantly decreased. This may be due to persistent turbinate hypertrophy as PM_{10} increases. As the inferior turbinate gets congested consistently, there is little change in the patent nasal airway and less variation of PNIF as a result. Procedures to measure the actual change of dimension and volume of the nasal cavity, such as acoustic rhinometry, could confirm this hypothesis.

The clinical course of AR is also affected by various pollens. In order to minimize the confounding effect of pollens, we selected patients whose skin prick test result was only positive to house dust mites. We excluded any patients who showed a positive result for pollens. Furthermore, we gained information about the concentration of 12 pollens in Incheon, with the help of Incheon City Health Environmental Research Center. When performing statistical analysis, we excluded the effect of pollen concentration as a confounding variable.

One of the limitations in our study is that we did not include other clinical data such as endoscopic findings in the nasal cavity, any accompanying allergic/sinonasal disorders, and/or clinical laboratory findings. And, during the enrollment period, young volunteers and patients had actively participated in this study. Therefore, the mean age of both groups is relatively young. In further study, we hope we will be able to evaluate the effect of PM_{10} in many different age groups.

In conclusion, low concentration PM_{10} did not have significant effect on symptoms and PNIF of AR patients.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

ACKNOWLEDGMENTS

This research was supported by a fund (2011E3302600) by Research of Korea Centers for Disease Control and Prevention, Cheongju, Korea.

REFERENCES

1. Duce RA, Unni CK, Ray BJ, Prospero JM, Merrill JT. Long-range atmospheric transport of soil dust from Asia to the tropical north pacific: temporal variability. Science. 1980 Sep;209(4464):1522-4.
2. Taylor DA. Dust in the wind. Environ Health Perspect. 2002 Feb; 110(2):A80-7.
3. Chen YS, Sheen PC, Chen ER, Liu YK, Wu TN, Yang CY. Effects of Asian dust storm events on daily mortality in Taipei, Taiwan. Environ Res. 2004 Jun;95(2):151-5.
4. Chiu HF, Tiao MM, Ho SC, Kuo HW, Wu TN, Yang CY. Effects of Asian dust storm events on hospital admissions for chronic obstructive pulmonary disease in Taipei, Taiwan. Inhal Toxicol. 2008 Jul; 20(9):777-81.
5. Lai LW, Cheng WL. The impact of air quality on respiratory admissions during Asian dust storm periods. Int J Environ Health Res. 2008 Dec;18(6):429-50.
6. Yang CY, Tsai SS, Chang CC, Ho SC. Effects of Asian dust storm events on daily admissions for asthma in Taipei, Taiwan. Inhal Toxicol. 2005 Dec;17(14):817-21.
7. Adamkiewicz L, Gayer A, Mucha D, Badyda AJ, Dabrowiecki P, Grabski P. Relative risk of lung obstruction in relation to PM10 concentration as assessed by pulmonary function tests. Adv Exp Med Biol. 2015;849:83-91.
8. Clifford HD, Perks KL, Zosky GR. Geogenic PM10 exposure exacerbates responses to influenza infection. Sci Total Environ. 2015 Nov;533:275-82.
9. Chang CC, Lee IM, Tsai SS, Yang CY. Correlation of Asian dust storm events with daily clinic visits for allergic rhinitis in Taipei, Taiwan. J Toxicol Environ Health A. 2006 Feb;69(3-4):229-35.
10. Ogi K, Takabayashi T, Sakashita M, Susuki D, Yamada T, Manabe Y, et al. Effect of Asian sand dust on Japanese cedar pollinosis. Auris Nasus Larynx. 2014 Dec;41(6):518-22.
11. Mimura T, Yamagami S, Fujishima H, Noma H, Kamei Y, Goto M, et al. Sensitization to Asian dust and allergic rhinoconjunctivitis. Environ Res. 2014 Jul;132:220-5.
12. Lei YC, Chan CC, Wang PY, Lee CT, Cheng TJ. Effects of Asian dust event particles on inflammation markers in peripheral blood and bronchoalveolar lavage in pulmonary hypertensive rats. Environ Res. 2004 May;95(1):71-6.
13. Takizawa H. Impact of air pollution on allergic diseases. Korean J Intern Med. 2011 Sep;26(3):262-73.
14. Anderson HR, Ruggles R, Pandey KD, Kapetanakis V, Brunekreef B, Lai CK, et al. Ambient particulate pollution and the world-wide prevalence of asthma, rhinoconjunctivitis and eczema in children: Phase One of the International Study of Asthma and Allergies in Childhood (ISAAC). Occup Environ Med. 2010 May;67(5):293-300.
15. Jones AS, Lancer JM. Rhinomanometry. Clin Otolaryngol Allied Sci. 1987 Jun;12(3):233-6.
16. Fairley JW, Durham LH, Ell SR. Correlation of subjective sensation of nasal patency with nasal inspiratory peak flow rate. Clin Otolaryngol Allied Sci. 1993 Feb;18(1):19-22.
17. Jones AS, Viani L, Phillips D, Charters P. The objective assessment of nasal patency. Clin Otolaryngol Allied Sci. 1991 Apr;16(2):206-11.
18. Gleeson MJ, Youlten LJ, Shelton DM, Siodlak MZ, Eiser NM, Wengraf CL. Assessment of nasal airway patency: a comparison of four methods. Clin Otolaryngol Allied Sci. 1986 Apr;11(2):99-107.
19. Holmstrom M, Scadding GK, Lund VJ, Darby YC. Assessment of nasal obstruction: a comparison between rhinomanometry and nasal inspiratory peak flow. Rhinology. 1990 Sep;28(3):191-6.
20. Cho SI, Hauser R, Christiani DC. Reproducibility of nasal peak inspiratory flow among healthy adults: assessment of epidemiologic utility. Chest. 1997 Dec;112(6):1547-53.