A Study on Acute Effects of Fine Particles on Pulmonary Function of Schoolchildren in Beijing, China

Dae-Seon Kim*, Seung Do Yu, Jung Hoon Cha, Seung Chul Ahn

National Institute of Environmental Research, Incheon, 404-170 Korea

Abstract

To evaluate the acute effects of fine particles on pulmonary function, a longitudinal study was conducted. This study was carried out for the schoolchildren (3rd and 6th grades) living in Beijing, China. Children were asked to record their daily levels of peak expiratory flow rate using portable peak flow meter (mini-Wright) for 40 days. The relationship between daily PEFR and fine particle levels was analyzed using a mixed linear regression models including gender, height, the presence of respiratory symptoms, and daily average temperature and relative humidity as extraneous variables. The total number of students participating in this longitudinal study was 87. Daily measured PEFR was in the range of 253~501L/min. On the daily basis, a PEFR measured in the morning was shown to be lower than that measured in the evening (or afternoon). The daily mean concentrations of PM_{10} and $PM_{2.5}$ over the study period were 180.2 $\mu g/m^3$ and 103.2 $\mu g/m^3$, respectively. The IQR (inter-quartile range) of PM_{10} and $PM_{2.5}$ were 91.8 $\mu g/m^3$ and 58.0 $\mu g/m^3$. Daily mean PEFR was regressed with the 24-hour average PM_{10} (or $PM_{2.5}$) levels, weather information such as air temperature and relative humidity, and individual characteristics including gender, height, and respiratory symptoms. The analysis showed that the increase of fine particle concentrations was negatively associated with the variability in PEFR. The IQR increments of PM_{10} or $PM_{2.5}$ (at 1-day time lag) were also shown to be related with 1.54L/min (95% Confidence intervals -2.14, -0.94) and 1.56L/min (95% CI -2.16, -0.95) decline in PEFR.

Introduction

As information about the health risks associated with air pollution has become available, attention has focused increasingly on smaller air particles such as particulate matter with an aerodynamic diameter to or less than a 10 or 2.5 μm (PM_{10} or $PM_{2.5}$, respectively). A number of recent studies conducted in Asia, Europe and the United States have shown that acute exposure to current levels of air particles is associated with adverse health status, including mortality, hospital admissions due to asthma, severity of preexisting chronic illness, low birth weight and pulmonary functions.

Our objective was to evaluate the relationship between ambient air particles and lung function measured by peak expiratory flow rate (PEFR) among Chinese school children.

This is a community-based diary study and used a classic design for the respiratory effects of ambient air particles and used longitudinal information for 40 days of follow-up starting from March 25, 2003 to May 3, 2003.

Materials and Method

Questionnaire :

This study was directed at the school children (3rd and 6th grades) living in a Beijing, China. The participants were informed that they were part of an environmental study. Using the self-administered questionnaire written by a parent of each participating child, we obtained information on sociodemographic factors, preexisting respiratory illness and symptoms, and indoor air pollution sources.

PEFR(Peak Expiratory Flow Rate) :

Each child was provided with a mini-Wright peak flow meter and a preformatted health symptom diary for 40 days, and was trained on their proper use. Participants were instructed to perform the peak flow test three times in the standing position, three times daily (9 am, 12 pm, and 8 pm), and to record all the readings along with the symptoms (cold, cough, and asthmatic symptoms) experienced that day.

PM_{10} and $PM_{2.5}$:

Daily measurement of ambient air particles (PM_{10} and $PM_{2.5}$) were obtained in the corner of the playground of the participating elementary school for the same period of this longitudinal study.

Statistical Analysis :

Because repeated observations are made on the same participant, the continuous response variable of lung function (PEFR) reported on successive days for 40 days is usually auto-correlated. The relationship between daily PEFR and ambient air particle levels was analyzed using a mixed linear regression models including gender, height, the presence of respiratory symptoms, and daily average temperature and relative humidity as an extraneous variable. The mixed model is a generalization of the standard linear model as follows [1]:

$y = \chi\beta + Zu + \varepsilon$

Where, u : unknown random-effects parameters,

β : fixed-effects parameters

[gender (male=1, female=0), height, respiratory symptom, temperature, relative humidity, PM_{10} or $PM_{2.5}$], u is an unknown vector of random effects with a design matrix Z.

y : daily average PEFR.

All statistical analyses were performed using the MIXED procedure in Windows/SAS Software version 6.12.

Results and Discussion

Characteristics of participants:

The total number of subjects participating in this longitudinal study was 87. About 55% of subjects were female students. There was no significant difference in age, and weight in male and female participants. But height of female students was higher than that of male students($p<0.05$).

Daily PEFR :

The range of daily measured PEFR in this study was 253~501L/min. Male students (in 3rd grade) showed higher PEFR on average than female students did, but opposite situation was appeared in 6th grade students. In general, a PEFR measured in the morning was lower than a PEFR measured in the evening (or afternoon) on the same day.

Daily Concentrations of Ambient Air Particles (PM_{10} and $PM_{2.5}$) :

The daily mean concentrations of PM_{10} and $PM_{2.5}$ over the study period were 180.2 $\mu g/m^3$ and 103.2 $\mu g/m^3$, respectively. The IQR (inter-quartile range) of PM_{10} and $PM_{2.5}$ were 91.8 $\mu g/m^3$ and 58.0 $\mu g/m^3$. During the study period, the national ambient air quality standard of 150 $\mu g/m^3$ was exceeded in 23 days (57.5%), which shows that the pollutant status of PM_{10} is very serious in the study area. The analysis showed that an increase of 1 $\mu g/m^3$ of PM_{10} corresponded to 0.59 $\mu g/m^3$ increment of $PM_{2.5}$.

Association between Daily PEFR and Ambient Air Particles :

The relationship between PEFR and individual characteristics including gender, age, height, weight, experience of respiratory allergic symptoms has been studied. Gender, height, and experience of respiratory allergic symptoms were significantly represented the variation of PEFR.

Daily mean PEFR was regressed with the 24-hour average PM_{10} (or $PM_{2.5}$) levels, weather information such as air temperature and relative humidity, and individual characteristics including gender, height, and respiratory symptoms. The analysis showed that the increase of fine particle concentrations was negatively associated

with the variability in PEFR. The IQR increment of PM_{10} or $PM_{2.5}$ (at 1-day time lag) were also shown to be related with 1.54L/min (95% Confidence intervals -2.14, -0.94) and 1.56L/min (95% CI -2.16, -0.95) decline in PEFR.

In the Six Cities study, which had the least statistical power, the association was very weak and statistically insignificant. The results suggest that a 10 $\mu g/m^3$ increase in PM_{10} was associated with only small declines in lung function (typically about 1~3%). However, lung function measures have been shown to be important measures of health with remarkable predictive capacity for survival [2]. Furthermore, as reported in the 24-Cities study, the risk of relatively large defects in lung function (less than 85% predicted) was much higher in the more polluted cities, suggesting detrimental effects of respirable particulates or particulate acidity on normal lung growth and development [3].

Conclusion

Our objective was to evaluate the relationship between ambient air particles and lung function measured by peak expiratory flow rate (PEFR) among school children. We conducted a community-based diary study and used a classic design for the respiratory effects of ambient air particles and used longitudinal information for 40 days of follow-up starting from March 25, 2003 to May 3, 2003. The relationship between daily PEFR and ambient air particle levels was analyzed using a mixed linear regression models including gender, height, the presence of respiratory symptoms, and daily average air temperature and relative humidity as an extraneous variable. In conclusion, we found a significant association between outdoor levels of particulate matter and PEFR, and estimated that the IQR increment of PM_{10} or $PM_{2.5}$ (91.8 $\mu g/m^3$, 58.0 $\mu g/m^3$, respectively) at 1-day time lag were significantly associated with 1.54L/min (95% Confidence intervals -2.14, -0.94) and 1.56L/min (95% CI -2.16, -0.95) decline in PEFR.

References

1. Litteil, R.C., Milliken, G.A., Strope, W.W. and Wolfinger, R.D. : SAS System for Mixed Models: SAS Institute Inc, 1996.
2. Bates, D.V. : Altered Physiologic States and Associated Syndromes, *In* Respiratory Function in Disease. Philadelphia, Pennsylvania: W. B. Saunders Company, 1989.
3. Pope, C.A.III. and Dockery, D.W. : Epidemiology of Particle Effects, *In* Air Pollution and Health, London: Academic Press, 1999.