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Effects of winter air pollution on pulmonary function of school children in Shenyang, China

Junya Kasamatsu[a], Masayuki Shima[b,*], Shin Yamazaki[c], Kenji Tamura[c], Guifan Sun[d]

[a]*Department of Public Health, Graduate School of Medicine, Chiba University, Chiba, Japan*
[b]*Department of Public Health, Hyogo College of Medicine, 1-1 Mukogawa-cho, Nishinomiya 663-8501, Japan*
[c]*Environmental Health Science Division, National Institute for Environmental Studies, Tsukuba, Japan*
[d]*School of Public Health, China Medical University, Shenyang, China*

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Abstract

To assess the effects of air pollution associated with coal heating in winter on pulmonary function of school children, pulmonary function tests (FVC, $FEV_{1.0}$, PEF, FEF_{75}) of 332 children in Shenyang, located in the northeast of China, were done four times between October 2001 and June 2002. The collected airborne particulate matter (PM) was analyzed for the concentrations of total suspended particles (TSP), PM of less than 7 μm in aerodynamic diameter (PM_7), and PM of less than 2.1 μm ($PM_{2.1}$). All four pulmonary function tests were completed in 244 school children. The airborne PM concentration was higher in April 2002 (end of heating) than in October 2001 (prior to heating). All four pulmonary function indices, adjusted for age and height, were significantly lower in April 2002 than in October 2001; the $FEV_{1.0}$ was lower in boys (0.233 l, 95% CI: 0.167–0.299 l) and girls (0.222 l, 95% CI: 0.165–0.280 l). The decrease continued to be significant in June 2002 compared to October 2001. The decreases in FEV and $FEV_{1.0}$ were also significantly associated with airborne PM concentration, which had a delayed effect on pulmonary function. An increase from the 25th to the 75th percentile of TSP, PM_7 and $PM_{2.1}$ was associated with a delayed decrease in $FEV_{1.0}$; 0.059 l (95% CI: 0.020–0.106 l), 0.095 l (95% CI: 0.057–0.139 l) and 0.110 l (95% CI: 0.072–0.147 l) in boys, and 0.066 l (95% CI: 0.026–0.106 l), 0.101 l (95% CI: 0.063–0.139 l) and 0.114 l (95% CI: 0.080–0.152 l) in girls, respectively. Our findings show that airborne PM might have a subacute effect on pulmonary function in children in Shenyang, and that PM_7 and $PM_{2.1}$ have more adverse effects on pulmonary function than TSP. The effects of airborne PM appear to be prolonged.

Keywords: Air pollution; Particulate matter; Pulmonary function; School children; Subacute effect

Introduction

In recent years, China has achieved rapid economic growth accompanied by increased energy consumption. In China, coal is still used as the main energy source. Coal combustion, along with increased automobile exhausts, accounts for much of the air pollution seen in large cities, (Chen et al., 2004). Concentrations of airborne particulate matter remain higher in China than in the United States, European countries, and Japan. It has been reported that the concentration of airborne particulate matter is higher in the northern part of

*Corresponding author. Tel.: +81 798 45 6565; fax: +81 798 45 6567.
E-mail address: shima-m@hyo-med.ac.jp (M. Shima).

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China than in the southern part (Xu et al., 2000). It has been also reported that the concentration of airborne particulate matter is higher in the winter season due to heating than in the summer season (Chen et al., 2004; Sun et al., 2003; Xu et al., 2000). Thus, elevated air pollutant levels associated with coal heating in the winter season have become a serious problem in the northeast China provinces.

Many studies have dealt with respiratory symptoms and pulmonary function as they relate to the health effects of air pollutants on children. With respect to the acute effects of air pollutants, various researchers have reported that there is a relationship between elevated air pollutant levels and an increased prevalence of respiratory symptoms (Fischer et al., 2002; Jalaludin et al., 2004; Neas et al., 1996; Pershagen et al., 1995; Schwartz et al., 1994; Shima and Adachi, 2000; Van der Zee et al., 1999) and decreased pulmonary function values (Delfino et al., 2004: Gold et al., 1999; Hoek and Brunekreef, 1994; Jalaludin et al., 2000; Peacock et al., 2003; Peters et al., 1999; Pope et al., 1991; Scarlett et al., 1996). Moreover, some reports on the chronic effects of air pollutants have suggested that significant negative effects on pulmonary function development may occur in children exposed to elevated air pollutant levels based on a long-term follow-up study of a cohort of children (Gauderman et al., 2002, 2004; Horak et al., 2002). Many of these studies were done in industrialized countries, including the United States, European countries, and Japan, where oil has been used as the main energy source instead of coal, and pollution control measures have shifted from factory exhausts to automobile exhausts. With respect to the health effects of air pollution in China, there are several reports that have compared the prevalence rate of respiratory symptoms (Quan et al., 2000; Zhang et al., 2002) and pulmonary function values (Wang et al., 1999) among various regions with different air pollution levels. There have also been reports dealing with the relationship between air pollution and daily mortality (Xu et al., 2000; Zhang et al., 2000). However, there are few reports investigating seasonal variation in the effects of air pollution, focusing on the winter heating season.

An assessment of the effects of winter air pollution on children's pulmonary functions in the northeast China provinces may have a significant impact in preventing health problems caused by air pollution resulting from rapid economic development by supporting the healthy development of children. To assess the subacute effects of winter air pollution on pulmonary functions in school children, we did pulmonary function tests four times over 8 months, including the winter heating season, in a cohort of children attending elementary schools in Shenyang, located in the northeast of China. We then investigated the potential relationships between the concentration of airborne particulate matter and pulmonary function values.

Subjects and methods

Subjects

The subjects of this study were children who were in their third grade at the start of the study in three elementary schools located in Shenyang, China. Shenyang is the capital of Liaoning Province, which is located in the northeast of China (Fig. 1). It is a heavy chemical industrial city, whose major industries include steel manufacturing, nonferrous metals, machinery, chemistry, coke-related industries, and electric power generation. In recent years, urbanization has led to a rapid increase in the number of automobiles. The target schools (A, B, and C) were located in a commercial area in the center of the city (A), a residential area around the center of the city (B), and a suburban residential area (C). There were no large-scale factories close to any of the schools.

A total of 322 children (158 boys and 164 girls), aged 8–10 years, participated in the study. The study sample included 109 children from school A (51 boys and 58 girls), 105 children from School B (50 boys and 55 girls), and 108 children from school C (57 boys and 51 girls).

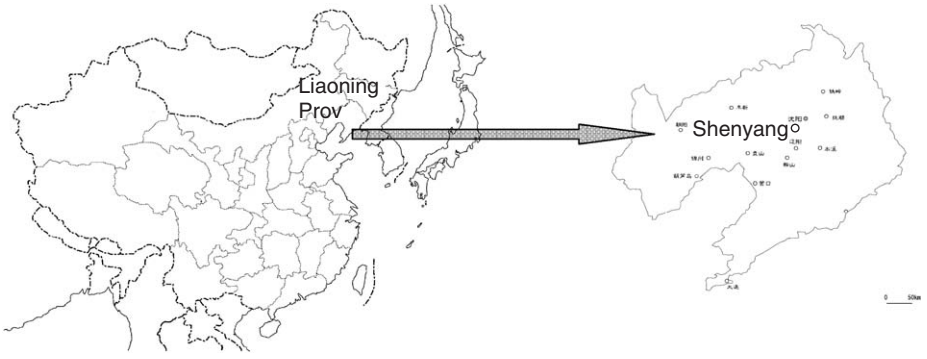

Fig. 1. Location of the study city in China. Shenyang is the capital of Liaoning Province located in the northeast of China.