Short-Term Effects Of Air Pollution Levels On Pulmonary Function Of Young Adults

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Abstract

Sixty-six young healthy persons repeatedly underwent spirometry after having spent five hours at school located close to a polluted environment. Changes in NO_2, CO and black smoke concentrations were found to be negatively associated with FVC, FEV_1 and PEF, but only the associations of NO_2 and CO with PEF, and CO with FEV_1 reached the nominal level of statistical significance. Changes in O_3 concentration were found to be negatively associated only with PEF but not to a statistically significant degree. Thus, an increase 10 g/m3 in NO_2 concentrations was associated with a reduction of 0,04 l/min in PEF and an increase of 1 mg/m3 in CO was associated with a reduction of 0,14 ml/sec in FEV_1 and 0,16 l/min of PEF. These results provide evidence that the increased levels of air pollution in Athens have detectable effects on the pulmonary function tests of healthy young individuals.

INTRODUCTION

For decades, exposure to air pollution has been known to cause short-term and long-term adverse health effects. An important role to this knowledge have played the classic episodes of air pollution in the Meuse Valley in 1930, in Donora, Pennsylvania in 1948 and in London in 1952, during which was demonstrated an increase in morbidity and mortality ([1], [2]).

These episodes happened in the early industrialised countries and were connected with much higher levels of environmental pollutants that are measured today in Europe and North America. The recognition of these adverse health effects led to the legislation of protective measures that resulted in the decrease of air pollution levels ([3]). Thus, during the decades of 70's and 80's it was thought that the current levels of pollution were not seriously harmful ([4]).

In the middle of the 80's studies have started to be published in the scientific medical press from Europe and USA that showed that even these lower levels of pollution have adverse health effects ([5],[6],[7]). Most of the USA studies focused on particulate air pollution ([8]). In the meantime, the city air pollution characteristics changed: from the three main sources of pollution – industry, heating and vehicles – the vehicles are recognised as the most important source and the mixture of pollutants consists mostly of photochemical ones.

Despite the initial sceptisicm of this new epidemiologic studies ([9], [10]), the steadiness and repetitivity of their findings, eventually led in acceptance and review of the Ambient Air Quality Standards of the WHO ([11]), of the limits for the particulates and the ozon of the United States Environmental Protection Agency (USEPA) ([12]) and in the issue of new standards for four pollutants by the European Union ([13], [14]).

In the past, two kinds of air pollution were recognised: the one kind is the London air pollution that is observed when sulfur oxides and particles prevail. The other kind is the photochemical cloud or Los Angeles air pollution that is observed when photochemical pollution prevails, namely nitrogen oxides, hydrocarbonates and photochemical oxidants. However, the real situation is not so simple and the atmospheric air quality is characterised by mixed pollutants. Even though, since the law relies on the control of isolated pollutants, in newer studies, the health effects are combined with each of the pullutants separately ([15]).

METHODS

The study was undertaken in Athens in order to estimate the short-term effects of current levels of urban air pollution and especially the episodes of high pollution, on pulmonary function of health young adults.

Sixty-six young healthy individuals (38 males with mean age of 21 years and 28 females with mean age of 19 years),

non smokers, repeatedly underwent simple spirometry with a portable spirometer, after having spent five hours at a school downtown which is close to a measurement site of an existing air pollution monitoring network. The students, during their studies, were not inhaling any chemical substances, dust or fumes.

All measurements were performed at the school in 10 non-consecutive days within eight months with different air pollution levels.

Nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), carbon monoxide (CO) and black smoke particles (BS) were measured.

Regarding the method of the study, a panel study was performed with repeated measurements. Time series analysis applying random effects models were used to analyse the data.

During the statistic analysis changes in the atmospheric pollutants were associated with FVC, FEV_1, FEV_1% and PEF after controlling for smoking, gender, age, height, month and temperature.

RESULTS

Table (1) shows the mean value, the standard deviation, the median value and the range of the concentration of the pollutants during the days of the study.

Figure 1

Table 1: Levels of air pollutants during the days of the study

Day	NO_2 μg/m^3	O_3 μg/m^3	SO_2 μg/m^3	CO mg/m^3	BS μg/m^3
04/11/98	181	18	39	12,4	108
11/11/98	167	16	30	7,9	130
02/12/98	64	9	25	4,7	27
20/01/99	109	71	31	4,1	45
17/03/99	141	51	27	6,3	113
21/04/99	160	56	27	6,0	108
05/05/99	157	32	25	9,5	157
12/05/99	196	84	23	7,6	150
26/05/99	182	51	17	7,6	150
02/06/99	232	46	15	7,9	157
mean value	158,9	43,4	25,9	7,4	114,5
sd	69,5	19,7	10,7	2,4	45,9
median value	163,5	48,5	26,0	7,6	121,5
range	64-232	9-84	15-39	4,1-12,4	27-157

At the above table is presented a chronological order of the measurements of the air pollutants NO_2, O_3, SO_2, CO and BS, whose levels were recorded on Wednesday during the dated mentiones above at the Patision air pollution monotoring network.

It is observed that the levels of the pollutants are generally lower during the winter period than the summer one exept SO_2, whose levels are higher during the winter period probably due to the use of oil combustion heaters.

Table (2) shows the measured values of FVC, FEV_1, FEV_1% and PEF according to gender. The values are in litres.

Figure 2

Table 2: Values of respiratory indices according to gender.

		Males (38)	Females (28)	Total (66)
FVC	mean	4	3.5	3.8
	sd	0.8	0.6	0.8
	median	4	3.4	3.7
	min	2.4	2.4	2.4
	max	5.9	5.1	5.9
FEV_1	mean	3.7	3.1	3.5
	sd	0.7	0.5	0.7
	median	3.6	3.1	3.4
	min	1.9	2.1	1.9
	max	5.2	4.7	5.2
FEV_1%	mean	0.9	0.9	0.9
	sd	0.06	0.03	0.05
	median	0.9	0.9	0.9
	min	0.8	0.8	0.7
	max	1	1	1
PEF	mean	5.8	4.6	5.3
	sd	0.8	0.5	0.9
	median	6	4.5	5.3
	min	3.4	3.8	3.4
	max	7.1	5.5	7.1

The mean value was calculated in two steps:
A. The mean value per person was calculated.
B. The mean value, the standard deviation and the median value were calculated on the mean value.

As it is seen at the above table the spirometric values of the males are systematically higher than those of the females and this is reconfirmed from the statistical analysis (t-test).

The significance levels (p value) are smaller than 0,005 regarding FVC, FEV_1 and PEF and the males have significant statistical higher values. Especially for FEV_1% (whose values significantly deviated from the normal distribution) the Wilcoxon non parametric index showed significantly higher values for the males with significance level lower than 0,005.

Table (3) shows the regression coefficients between FVC, FEV_1, PEF and values of air pollutants.

Figure 3

Table 3: Regression Coefficients between FVC, FEV, PEF and values of pollutants.

	NO_2	O_3	SO_2	CO	BS
FVC*	-0,001 (0,002)	0,001 (0,002)	0,003 (0,018)	-0,09 (0,070)	-0,002 (0,002)
FEV_1*	-0,002 (0,001)	0,001 (0,002)	0,012 (0,015)	-0,14 (0,059)+	-0,001 (0,001)
PEF**	-0,004 (0,002)+	-0,001 (0,002)	0,005 (0,018)	-0,16 (0,065)+	-0,001 (0,002)

+ $p < 0.05$

* Regarding FVC and FEV_1 the values are regression coefficient in $ml.sec^{-1}.\mu g^{-1}.m^3$ (exept CO where the values are in $ml.sec^{-1}.mg^{-1}.m^3$) and the probable error in parenthesis from random effects models with control regarding gender, age, height, month and temperature.

** Regarding PEF the values are regression coefficients in $L.min^{-1}.\mu g^{-1}.m^3$ (exept CO whose values are in $L.min^{-1}.mg^{-1}.m^3$) and the probable error in parenthesis from random effects models with control regarding gender, age, height, month and temperature.

Changes in NO_2, CO and black smoke concentrations were found to be negatively associated with FVC, FEV_1 and PEF after controlling for smoking, gender, age, height, month and temperature, but only the associations of NO_2 and CO with PEF, and CO with FEV_1 reached the nominal level of statistical significance. Changes in O_3 concentration were found to be negatively associated only with PEF but not to a statistically significant degree. Thus, an increase 10 $\mu g/m^3$ in NO_2 concentrations was associated with a reduction of 0,04 l/min in PEF and an increase of 1 mg/m^3 in CO was associated with a reduction of 0,14 ml/sec in FEV_1 and 0,16 l/min of PEF. These results provide evidence that downtown levels of air pollution in Athens have detectable effects on the pulmonary function of healthy young individuals.

DISCUSSION

The purpose of the study is the investigation of the effect of the acute episodes of pollution on the respiratory function and precisely on certain simple spirometric values. It has to be emphasised that the measurements were done at the area of exposure and not by transferring individuals to a far away respiratory function control laboratory, something that might have affected the results. As a matter of fact the study of the exposure effects by using individual measurements in high concentrations of pollution in a short or relatively short period of time has been carried out only on experimental level. The present study is perspective but in the same time experimental by profiting of the necessary stay of the students at the precise place. The effect of the exposure of healthy young adults to high pollution levels of the real conditions of Athens pollution by using contemporary epidemiological and statistical methods is the object of the present study.

It is known that the population that gets effected by pollution is not homogeneous but consists of people of different ages who are not only healthy but ill as well. Due to this, the results of the precise pollution episodes are different in ill individuals, like those suffering from cardiopulmonary diseases, in young children or old people ([5], [16], [17]).

During the present study, that was done in healthy young individuals, it was found that the values of FVC, FEV_1 and PEF are negatively associated to the concentrations of NO_2, CO and black smoke. The values of PEF are also negatively associated to O_3, but only the associations of PEF with NO_2 and CO and FEV_1 with CO reached the nominal level of statistical significance. There has not been found a statistical significant association with the values of SO_2.

These results show a difference of the spirometric values, before and after a five hours exposure, of healthy young adults at the photochemical pollution and the pollution caused by suspended air particles of Athens at the precise levels. These individuals resided far away from the place where the study was undertaken, so the difference of the spirometric values is explained by their acute exposure to the Athens centre pollution. It is of interest that the respiratory function of people, who theoretically are considered to be resistant to the pollution phenomenon, is affected.

Our results also certify that there is another point of view of the pollution problem besides its effects, namely to vulnerable groups of people like those suffering from COPD. The results of the pollution episodes in patiens with chronic bronchitis and especially the increased mortality that was observed during these episodes have been described for decades at the London pollution ([2]). In addition to this, the effect of air pollution in children that suffer from bronchial asthma has been satisfactory studied ([18], [19]).

Probably the study of respiratory function with more advanced techniques like the flow indexes that estimate the degree of obstruction of the small airways could show the problem to a larger degree. In order to do that, however, the individuals who are being studied have to be transferred to a

respiratory function laboratory that is situated far away from the place of exposure. The contrary could not be done neither. The effect of other pollutants, that exist in the Athens atmosphere and that might play a role in the differences of the spirometric values in young, healthy individuals could also be evaluated.

Lately, it has been found that the small nanogram size particles have important effects and explain phenomena during the pollution episodes like the increased mortality of patients with heart disease ([20]). It is probable that our finding, that is the decrease of the expiratory flow spirometric values, will be better explained through the technology progress and the different evaluation and interpretation of the pollution phenomenon.

Of particular interest could be the study of large groups of people, evaluating also other data that describe the pollution phenomenon from the metereologic point of view. It is also probable that the study of large groups of people will add data that regard individuals who have asymptomatic bronchial asthma. These data may help to explain the universally observed gradual increase of the incidence of bronchial asthma ([21]).

Additionally, particularly useful would be a similar study in healthy individuals that undergo the indoor and the ventilation pollution in contemporary, artifically ventilated buildings. The conditions of pollution of these places could theoretically have the same effects with that of outdoor air pollution ([22]). Thus, the decrease of the respiratory function values that has been studied in this research may have long term effects, like for example increase risk for COPD ([23]).

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