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INFLUENCE OF AIR POLLUTION ON PULMONARY FUNCTION IN HEALTHY YOUNG MEN FROM DIFFERENT REGIONS OF POLAND

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Abstract: The aim of this study was to evaluate the influence of air pollution on pulmonary function parameters in healthy non-smoking young men. The study comprised 1,278 healthy, non-smoking young men (aged 18–23) living in Poland in regions with different levels of air pollution. The examined population was divided into three groups A, B, and C, based on low, moderate and high air pollution levels, respectively. Spirometry and bodyphletysmography at rest were performed by using of mobile lab PNEUMOBIL. Lung function parameters were analyzed and compared with respect to the level of air pollution. The mean values of the pulmonary function parameters were within the limits in all groups, but we observed statistically significant differences between the groups (lowest mean values in group C and the highest in group A). In all groups we found persons with significant airflow limitation in the central and peripheral bronchi, defined as the decrease of FEV_1%FVC ratio <70 and FEV_1<80 % of predicted value (central bronchi), and FEV_1%FVC ratio >70, FEF_{50}<70% predicted (peripheral bronchi). The percentage of persons with airflow limitation in the central bronchi was in group A (0.3%), B (0.4%) and C (1.4%). The incidence of flow limitation in small bronchi was as follows: in group A (1.2%), B (0.5%) and C (6.7%). The majority of factors defining the capacity of lungs as well as the intensity of the airflow showed a negative correlation with the concentrations of the basic air pollution (SO_2, NO_2, PM_{10}). Our study showed, for the first time, the influence of air pollution on pulmonary function parameters in healthy non-smoking young men in the Polish population.

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INTRODUCTION

The air contains several toxic pollutants, mainly sulphur oxides (SOx), nitrogen oxides (NOx) and dust with a diameter of less than 10 um (particular matter PM_{10}) [12, 13, 14, 15]. Each of these factors causes air flow limitation, and increase the prevalence of bronchial hyperreactivity and airways infections. Moreover, it intensifies the symptoms of existing allergic diseases (especially asthma) additionally stimulating the reconstruction of lung tissue and causing its structural changes (remodeling) [2, 17, 18]. The influence of air pollution on pulmonary function has been known for a long time. The increase in the number of deaths as a result of pulmonary diseases, and the increase of exacerbations and hospital admissions in patients with Chronic Obstructive Pulmonary Disease (COPD) or asthma has been reported on days when the concentrations of SO_2, NO_2 and dust [1,

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22] were the highest. Air pollution increases the frequency of symptoms of pulmonary diseases especially in children [5, 18]. In Poland, the highest concentration of air pollution is observed in the south, in the region of Katowice, Kraków and Wałbrzych, which is related to the location of heavy industry [12, 13, 14, 15].

The aim of this study was to evaluate the influence of air pollution on pulmonary function parameters in healthy, non-smoking young men living in regions in Poland with different levels of air pollution.

MATERIALS AND METHODS

In the years 1993-1997, 1278 healthy, never-smoking adults (young healthy men aged 18–23 from military bases) were examined. The population was clinically asymptomatic and composed a homogeneous group being in a good psychophysical condition. All subjects had been in the chosen military bases for more then one year. Each soldier had a physical and chest X-ray examination before inclusion to the study.

The examined population was divided into three groups, A, B, and C, according to the level of air pollution. Group A consisted of men from the regions with the lowest concentration of air pollution - Northern Poland (Giżycko, Hel, Ostróda, Świnoujscie, Ustka). Men in group B were from regions with moderate air pollution - urban agglomerations in Central Poland (Bielsko Biała, Opole, Łódź, Warsaw, Wrocław, Żagań). Group C soldiers from the regions with the highest level of air pollution - big agglomerations and industrial centers in Southern Poland (Katowice, Kraków). Air pollution analysis was performed using State Inspection for Environment Protection and State Sanitary Supervision annual reports [12, 13, 14, 15].

The mean annual concentrations of SO_2 were highest and exceeded the limits – 32 µg/m^3 SO_2 in the south of Poland (Kraków, Katowice). There was a gradual decrease of SO_2 concentrations in southern Poland in 1993–1997 (except for Katowice in 1997) (Tab. 1).

The acceptable mean year concentration of NO_2 (50 µg/m^3) was exceeded in Kraków and Katowice in 1994–1996. In the region of moderate air pollution it exceeded 50 µg/m^3, recorded in Warsaw in 1993 and in Opole in 1997. In the other cities of this region, the concentration was in the range of 7–40 µg/m^3. The mean year concentrations of dust exceeded the limits 50 µg/m^3 for the whole period of study in Katowice. In the region of moderate air pollution, the acceptable values were exceeded only in 1997 in Wrocław (76 µg/m^3). In the other cities of this region, the mean year concentrations were fluctuating from 5–48 µg/m^3. In the region of lowest air pollution, the concentrations were the lowest and fluctuated from 5–34 µg/m^3. Level of air pollution in these regions are presented in Table 1.

Each subject had spirometry and bodyphletysmography performed with a mobile lab equipped by Jaeger. Lung function test was performed according to the ATS reproducibility criteria. All doctors and nurses (4 persons) who took the measurements received identical training. Before starting any measurements the calibration using a 1-litre syringe was carried out. The tests were performed at rest, in the sitting position, before or at least one hour after a meal. Because of circadian, seasonal or weather-dependent variations of lung function, we chose to perform all the tests before noon and in the summer (June–September).

Statistical analysis. All data are presented as mean ± SD. Analysis of variance was used to compare lung function test results between groups (A, B, C) followed by Levene's test when appropriate. To post-hoc analysis Newmana – Keula's test was used.

Table 1. Mean annual concentration of NO_2, SO_2, PM_{10} in the region of low, moderate and high air pollution level

	City	Mean annual concentration														
		NO_2 (mg/m^3) 1993-1997					SO_2 (mg/m^3) 1993-1997					PM_{10} (mg/m^3) 1993-1997				
		'93	'94	'95	'96	'97	'93	'94	'95	'96	'97	'93	'94	'95	'96	'97
highest pollution level	Katowice	45	39	37	40	31	84	53	39	39	30	125	70	67	120	94
	Kraków	47	58	57	52	43	66	42	41	38	35	49	40	43	46	41
moderate pollution level	Bielsko-Biała	35	29	28	33	41	23	27	30	41	27	40	29	37	48	37
	Opole	32	35	32	49	64	21	13	11	10	12	45	18	18	23	24
	Łódź	20	31	24	28	31	24	16	19	21	18	38	29	24	24	23
	Warsaw	61	40	37	23	22	25	18	17	17	13	39	41	42	45	35
	Wrocław	34	27	31	26	24	35	24	19	21	16	76	35	28	32	30
	Żagań	24	18	12	14	16	26	15	18	17	3	35	20	13	6	5
lowest pollution level	Giżycko	12	17	13	16	15	14	14	15	15	8	15	16	18	14	5
	Hel	19	15	21	23	18	9	10	7	11	7	17	15	12	18	15
	Ostróda	27	30	36	40	35	15	23	24	23	13	34	29	33	31	23
	Świnoujście	7	10	11	17	17	23	20	11	13	10	14	10	7	16	10
	Ustka	17	14	9	16	15	7	5	4	7	3	26	15	12	18	12

Table 2. Results of pulmonary function tests (mean ± standard deviation). Asterisks indicate significant differences.

Parameters % predicted	Non Smokers n = 1,278			
	Group A n=329	Group B n=799	Group C N=150	p
TLC	100 ± 14	100 ± 14	98 ± 12	0.06
ITGV	123 ± 26	124 ± 26	126 ± 29	0.07
ITGV%TLC	123 ± 20*	125 ± 22	127 ± 23*	< 0.05
Raw	47 ± 17*	50 ± 19*	53 ± 20*	< 0.05
FVC	106 ± 13*	103 ± 12*	104 ± 11	< 0.05
FEV_1	111 ± 13*	107 ± 12*	103 ± 9*	< 0.05
FEV_1%FVC	106 ± 7*	105 ± 8	103 ± 9*	< 0.05
PEF	104 ± 20*	103 ± 19	96 ± 19*	< 0.05
FEF_{50}	112 ± 25*	107 ± 25*	104 ± 23*	< 0.05

Table 3. Multi correlation and β coefficients between concentration of air pollution and lung function testing. Bold indicates highest values (multiple linear regression analysis).

Parameters	β coefficients			multi-correlation R
	SO_2	NO_2	PM_{10}	
ITGV	0.03	**-0.06**	-0.05	0.07
TLC	**-0.07**	**-0.07**	0.01	0.11
ITGV%TLC	**0.08**	0.00	-0.06	0.04
Raw	-0.08	**0.127**	0.075	0.13
FVC	0.045	**-0.14**	0.045	0.12
FEV_1	-0.08	**-0.12**	0.031	0.15
FEV_1%FVC	**-0.14**	-0.048	0.00	0.13
PEF	0.056	-0.09	**-0.18**	0.19
FEF_{50}	**-0.11**	-0.04	0.031	0.11

Multiple linear regression analysis was performed between lung function test results and the air pollution levels as independent variables (multi-correlation R coefficient and the β coefficient were calculated). Results were consider statistically significant if $p < 0.05$.

RESULTS

The mean values of the pulmonary function parameters were within the limits in all groups, but we observed statistically significant differences between the groups. We noticed lower values of inter thoracic gas volume % total lung capacity (ITGV%TLC) and airflow resistance (Raw) in group C compared to group A. FEV_1 (forced expiratory volume at first second of expiration), FEV_1%FVC (forced expiratory volume at first second of expiration % forced vital capacity), PEF (peak expiratory flow), FEF_{50} (forced expiratory flow) were lower in group C than in group A. Additionally, FEV_1 and FEF_{50} were also lower in the group B (Tab. 2).

In all groups we found subjects with significant airflow limitation in the central and peripheral bronchi defined as the decrease of FEV_1%FVC ratio <70, FEV_1<80% of predicted value (central bronchi) and FEV_1%FVC ratio >70 FEF_{50}<70% (peripheral bronchi). The percentage of subjects with airflow limitation in the central bronchi was 0.3% in group A, 0.4% in B and 1.4% in C. The incidence of small bronchi air flow limitation was 1.2% in group A, 0.5% - B and 6.7% - C.

To test the association of air pollution on the pulmonary function parameters we calculated the multi-correlation R factor (total flow) and the coefficients B factor Table 3. The majority of factors defining the capacity and volumes of lungs and airflow showed a negative correlation with the concentrations of the basic air pollution (PM_{10}, SO_2 and NO_2). The strongest negative correlation was seen between PEF and the concentration of PM_{10}, SO_2 and NO_2. We observed a stronger correlation for the factors describing the airflow than for the factors defining the capacity and volumes of lungs. The ITGV, FVC, FEV_1 and Raw correlated with the concentration of NO_2, PEF with concentration of PM_{10}, and FEF_{50} with concentration of SO_2 (Tab. 3).

DISCUSSION

The study confirmed that the air pollution level is negatively related to pulmonary function parameters in healthy, non-smoking, young men. In results, higher air pollution is associated with a higher prevalence of airflow limitation

The data presented indicate that the concentration of air pollution has gradually decreased in the whole territory of Poland during the last few of years. However, an increase in concentrations of SO_2, NO_2 and dust in the region of Katowice was recorded.

There is not enough data evaluating the influence of air pollution on the respiratory tract in healthy people living in different environmental conditions. Our epidemiological data are associated with a multi-centres study carried out in Europe - PEACE (Pollution Effects on Asthmatic Children in Europe), in which an influence of the short-term changes of basic air pollution on the frequency of asthma symptoms in children was evaluated [20]. In Poland, PEACE was carried out in the south of th country (Katowice and Kraków) only [7, 10]. The investigators did not confirm a correlation between the increase of clinical, lung function testing (decrease of FEV_1) and asthma symptoms (such as cough, dyspnoe, frequency of medication usage) and an increase of SO_2, NO_2 and PM_{10}. Tiittanen *et al.* [16] also did not show such air pollution effect on the severity of asthma symptoms. However, it does not exclude the influence of air pollution on the lung function. It was shown that children and adults living near roads with high traffic density more frequently have symptoms of respiratory tract disturbances. The increased concentrations of NO_2 and ozone O_3 which come from fumes probably have an influence in this case.

Jędrychowski and Flak [9] showed a strong correlation between the amount of coughed-up secretion and the concentration of basic air pollution in children living in different environments (with low or high concentration of

SO_2 and PM_{10}). Children who lived in regions with a high air pollution level had a significant increase of frequency of wheezing. These children did not have allergic diseases and the increase of frequency of the mentioned symptoms was caused by the environmental factor, mostly by air pollution.

The influence of short-term increases of SO_2 and PM_{10} in the air on the number of deaths and hospital admissions in patients with COPD was investigated in an APHEA study (Air pollution on Health: European Approach) [1].

A study was also carried out in Poland by the Insitute of Hygiene-22 in Kraków, Łódź, Poznań and Wrocław. The number of deaths and their reasons were analysed in relation to the concentration of SO_2 and PM_{10}. A strong correlation between the number of deaths and the increase of SO_2 and PM_{10} was shown in Kraków and Łódź. The number of deaths caused by pulmonary diseases correlated positively with the concentration of air pollutions; the correlation, however, was weak. In summary, APHEA results from six European cities (Amsterdam, Barcelona, London, Milan, Paris, Rotterdam), indicated, that the higher the concentration of SO_2, NO_2, PM_{10}, and ozone O3 caused the highest number of hospital admissions in patients with COPD [1].

In a prospective study, Humerfelt *et al.* [8] observed a faster decrease of FEV_1 (5.5 ml per year) in subjects exposed to increasing concentration of SO_2. Influence of air pollution on the drop of FEV_1 was apparent both in non-smokers and smokers. In another prospective study lasting 12 years, van de Lande [19] evaluated the effect of air pollution on pulmonary function in persons living in region of different concentration of basic air pollution. People living in the region with higher concentrations of air pollutions showed more severe disturbances in the pulmonary function tests, which suggests the influence of environmental factors on the development of COPD [6].

CONCLUSIONS

1. The mean values of the pulmonary function parameters were within the limits in all groups but we observed statistically significant differences between the groups (lowest mean values in group C, and the highest in group A)
2. The percentage of persons with airflow limitation in the central bronchi was in group A (0.3%), in B (0.4%) and in C (1.4%). The airflow limitation in the small bronchi was observed in group A (1.2%), B (0.5%) and C (6.7%).
3. The majority of factors defining the capacity of the lungs, as well as the intensity of the airflow, showed a negative correlation with the concentrations of the basic air pollution (SO_2, NO_2, PM_{10}).

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