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 bodyplethysmography at rest were performed by using a 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 FEV₁/%FVC ratio <70 and FEV₁<80 % of predicted value (central bronchi), and FEV₁/%FVC ratio >70, FEF25<75% 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 (SO₂, NO₂, PM₁₀). 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 μm (particulate matter PM₁₀) [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 SO₂, NO₂ and dust [1,
Analysis was performed using State Inspection for Southern Poland (Katowice, Kraków). Air pollution diers from the regions with the highest level of air pollution - Northern Poland (Kraków, Katowice) — to the study. In the chosen military bases for more than one year. Each subject 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, Świnoujście, 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 SO₂ were highest and exceeded the limits — 32 µg/m³ 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/m³). In the other cities of this region, the mean year concentrations were fluctuating from 5–48 µg/m³. In the region of lowest air pollution, the concentrations were the lowest and fluctuated from 5–34 µg/m³. Level of air pollution in these regions are presented in Table 1.

Each subject had spirometry and bodyplethysmography 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).

**Table 1: Mean annual concentration of NO₂, SO₂, PM₁₀ in the region of low, moderate and high air pollution level**

<table>
<thead>
<tr>
<th>City</th>
<th>NO₂ (mg/m³) 1993-1997</th>
<th>SO₂ (mg/m³) 1993-1997</th>
<th>PM₁₀ (mg/m³) 1993-1997</th>
</tr>
</thead>
<tbody>
<tr>
<td>highest pollution level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Katowice</td>
<td>45 39 37 40 31</td>
<td>84 53 39 39 30</td>
<td>125 70 67 120 94</td>
</tr>
<tr>
<td>Kraków</td>
<td>47 58 57 52 43</td>
<td>66 42 41 38 35</td>
<td>49 40 43 46 41</td>
</tr>
<tr>
<td>moderate pollution level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bielsko-Biała</td>
<td>35 29 28 33 41</td>
<td>23 27 30 41 27</td>
<td>40 29 37 48 37</td>
</tr>
<tr>
<td>Opole</td>
<td>32 35 32 49 64</td>
<td>21 13 11 10 12</td>
<td>45 18 18 23 24</td>
</tr>
<tr>
<td>Łódź</td>
<td>20 31 24 28 31</td>
<td>24 16 19 21 18</td>
<td>38 29 24 24 23</td>
</tr>
<tr>
<td>Warsaw</td>
<td>61 40 37 23 22</td>
<td>25 18 17 17 13</td>
<td>39 41 42 45 35</td>
</tr>
<tr>
<td>Wrocław</td>
<td>34 27 31 26 24</td>
<td>35 24 19 21 16</td>
<td>76 35 28 32 30</td>
</tr>
<tr>
<td>Żagań</td>
<td>24 18 12 14 16</td>
<td>26 15 18 17 3</td>
<td>35 20 13 6 5</td>
</tr>
<tr>
<td>lowest pollution level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Giżycko</td>
<td>12 17 13 16 15</td>
<td>14 14 15 15 8</td>
<td>15 16 18 14 5</td>
</tr>
<tr>
<td>Hel</td>
<td>19 15 21 23 18</td>
<td>9 10 7 11 7</td>
<td>17 15 12 18 15</td>
</tr>
<tr>
<td>Ostróda</td>
<td>27 30 36 40 35</td>
<td>15 23 24 23 13</td>
<td>34 29 33 31 23</td>
</tr>
<tr>
<td>Świnoujście</td>
<td>7 10 11 17 17</td>
<td>23 20 11 13 10</td>
<td>14 10 7 16 10</td>
</tr>
<tr>
<td>Ustka</td>
<td>17 14 9 16 15</td>
<td>7 5 4 7 3</td>
<td>26 15 12 18 12</td>
</tr>
</tbody>
</table>

**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 Newman – Keula’s test was used.
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 DISCUSSION section elaborates on the findings, highlighting the impact of air pollution on pulmonary function. The text discusses the results of the 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 the country (Katowice and Kraków) only [7, 10]. The investigators did not confirm a correlation between the increase of clinical, lung function testing (decrease of FEV1) and asthma symptoms in children living near roads with high traffic density more frequently have symptoms of respiratory tract disturbances. The increased concentrations of NO2 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 the country (Katowice and Kraków) only [7, 10]. The investigators did not confirm a correlation between the increase of clinical, lung function testing (decrease of FEV1) and asthma symptoms (such as cough, dyspnoe, frequency of medication usage) and an increase of SO2, NO2 and PM10. 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 NO2 and ozone O3 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 PM10, SO2 and NO2). The strongest negative correlation with the concentrations of NO2 and O3 which come from fumes probably have an influence in this case.
SO\textsubscript{2} and PM\textsubscript{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\textsubscript{2} and PM\textsubscript{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 Institute 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\textsubscript{2} and PM\textsubscript{10}. A strong correlation between the number of deaths and the increase of SO\textsubscript{2} and PM\textsubscript{10} was shown in Kraków and Łódź. The number of deaths caused by pulmonary diseases correlated positively with the concentration of air pollutants; 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\textsubscript{2}, NO\textsubscript{2}, PM\textsubscript{10} and ozone O\textsubscript{3} 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\textsubscript{1} (5.5 ml per year) in subjects exposed to increasing concentration of SO\textsubscript{2}. Influence of air pollution on the drop of FEV\textsubscript{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 pollutants 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\textsubscript{2}, NO\textsubscript{2}, PM\textsubscript{10}).

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