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SHORT COMMUNICATION

THE EFFECT OF AIR POLLUTION ON VENTILATORY FUNCTION IN NONSMOKING WOMEN

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This study investigated disorders of ventilatory function in unemployed nonsmoking women living in areas with different air pollution. Subjects from Bakar and Krasica had lived in areas with large industrial plants in the vicinity. Continuous air quality measurements showed that SO_2 concentrations exceeded the recommended values. The control group had lived in the Viškovo area where measurements showed the air to be clean. Ventilatory functions were measured on two occasions, in 1986 and in 1990. FVC, FEV_1, Tiffeneau index, and $FMF_{25–75}$ were taken and expressed as absolute and relative values. In both 1986 and 1990 measurements, women of Viškovo manifested significantly better values of ventilatory function than the women living in Bakar, except for the Tiffeneau index. The same stands for the 1986 comparison between Viškovo and Krasica women, whereas the second, 1990 measurement showed no difference between the two groups. Decreased ventilatory function in the Bakar women over both measurements and in the Krasica women at the first measurement may be associated with a long-term exposure to an increased air pollution with respect to the Viškovo area.

Key words:
environmental exposure, follow-up, forced expiratory volumes, sulphur dioxide concentrations

Since the 1960s, many studies on health effects of polluted air, especially on the respiratory system, in urban population have been conducted throughout the world. Such studies investigated long-term exposure to lower concentrations of specific pollutants, particularly SO_2, ozone, and airborne particles comparing their impact between those areas where the quality of the ambient air and the health of the population were constantly monitored.

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Numerous World Health Organisation reports stress the importance factors leading to the development of chronic pulmonary disease (1–3).

After World War II, Rijeka and its surroundings swiftly developed into an urbanised and industrialised area. New industrial plants were built exclusively east of Rijeka in Kostrena (oil refinery, thermoelectric power plant), in Bakar (coke plant), and in Omišalj (petrochemical industry).

This paper presents the results of a study on forced expiratory volume in non-smoking, unemployed women living in the Rijeka area contaminated with industrial emissions.

SUBJECTS AND METHODS

The study included 176 women from two settlements (Bakar and Krasica) affected by industrial emissions. The study included exclusively those subjects who were unemployed, had never smoked, and had lived in the two settlements for at least five years. Following the same criteria, a control group consisting of 58 women from Viškovo, a settlement with satisfactory air quality was chosen. The total population of Viškovo (2,769 inhabitants) in the last census was about two times greater than in Bakar (1,665 inhabitants) and Krasica (1,106 inhabitants). Bakar had the highest population density, followed by Viškovo, and then Krasica.

The women were measured forced expiratory volume using a dry Mijnhardt® Vicatest-2 spirometer on two occasions; over five days in March, 1986 and over the same period in 1990. The examination was performed by the same health professional and with the identical device. The best of three measurements of each forced expiratory volume in standing position were taken. The instrument was calibrated daily, on about every 50th measurement.

Relative values of forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and values of FEV_1/FEV ratio, i.e. Tiffeneau index (TT) as absolute and relative in relation to the normal population according to *CECA* norms were analysed (4). The values of maximal expiratory flow between 25% and 75% of expired vital capacity ($FMF_{25–75\%}$) were analysed in relation to the healthy population according to *Morris and co-workers* (5).

Measured concentrations of SO_2 in the studied areas were taken as an index of air quality. The concurrent measurement of dust and black smoke showed comparable results for all three settlements in the study. For that reason they were not particularly analysed. The indirect exposure to cigarette smoke were evaluated within the subjects' families.

The Student's t-test was used to calculate statistical significance of differences between the groups in age, the length of stay in the area of the study, and ventilatory function.

RESULTS

Figure 1 shows the mean annual SO_2 concentrations for the period 1986–1990. The source of the data are Annual Reports issued by the Rijeka Institute for Public Health that span from 1 October of the previous year to 30 September of the following year for the mentioned period (6).

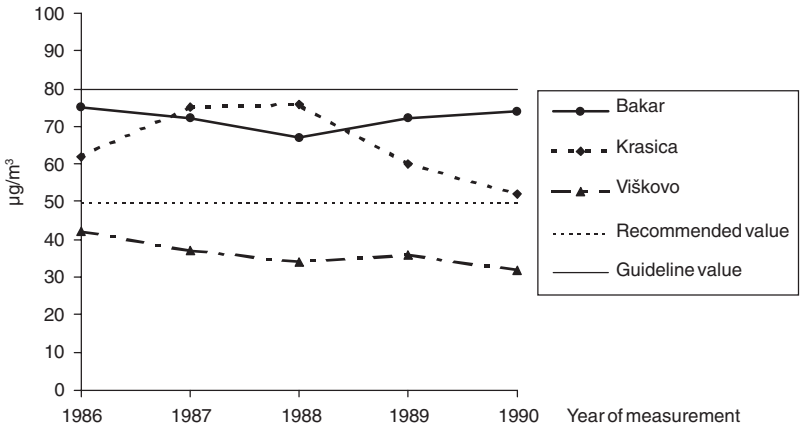

Figure 1 *Mean annual SO_2 concentrations for the period 1986–1990*

During the observed period, the mean annual SO_2 concentrations for polluted areas (Bakar and Krasica) exceeded the WHO recommendations for air quality (2). Mean annual SO_2 concentrations in Bakar ranged from 67–74 $\mu g/m^3$. In Krasica, SO_2 values increased gradually from 1986 to 1988 and then declined eventually to approach mean annual concentration designated as the recommended value by the WHO. In the control area (Viškovo), SO_2 concentrations kept constantly below the WHO recommended values, which suggests that the air quality in the area was quite satisfactory. There were no differences in the distribution of smokers in the subjects' families for all three studied settlements.

Comparison of mean age and the length of stay in the investigated area showed that women from Krasica were older than those in control area (Viškovo), whereas there was no difference in the length of stay (Table 1). The comparison between women from two polluted areas (Bakar and Krasica), and between women from Bakar and the control area (Viškovo) did not show significant differences either in age or in the length of stay.

In the first measurement, subjects from Bakar showed considerably lower values of all ventilatory functions, except for the Tiffeneau index, than did the the controls from Viškovo (Table 2). In the repeated measurement five years later, the values of all

pulmonary functions, except for the Tiffeneau index and relative values of median flow, were again lower in the subjects from Bakar.

Table 1 *Comparison of average values of certain characteristics of subjects relevant to the place of living*

Place of living	Age (years) mean ± SD	Length of stay (years) mean ± SD
Bakar (N = 93)	45.9 ± 10.7	28.2 ± 15.5
Krasica (N = 83)	47.4 ± 9.7	29.2 ± 16.4
Viškovo (N = 58)	43.0 ± 10.2	24.9 ± 16.4
Total (N = 234)	45.7 ± 10.3	27.7 ± 16.1
t-tests:	Age	Length of stay
Bakar:Krasica	t = 0.97; P > 0.05	t = 0.43; P > 0.05
Bakar:Viškovo	t = 1.63; P > 0.05	t = 1.24; P > 0.05
Krasica:Viškovo	t = 2.57; P < 0.02	t = 1.54; P > 0.05

Table 2 *Comparison of ventilatory functions between subjects from Bakar and Viškovo*

Year of investigation	Ventilatory functions	Bakar (N = 93) mean ± SD	Viškovo (N = 58) mean ± SD	t-value	P
1986	FVC	2.89 ± 0.69	3.39 ± 0.68	4.40	< 0.001
	FVC%	99.78 ± 21.25	114.71 ± 20.10	4.28	< 0.001
	FEV_1	2.35 ± 0.66	2.84 ± 0.65	4.39	< 0.001
	FEV_1%	96.71 ± 27.66	132.31 ± 27.60	7.70	< 0.001
	TT	81.38 ± 11.54	83.44 ± 10.18	1.10	–
	FMF_{25-75}	2.74 ± 0.94	3.43 ± 1.13	4.04	< 0.001
	FMF_{25-75}%	55.57 ± 17.47	68.15 ± 17.62	3.63	< 0.001
1990	FVC	3.02 ± 0.61	3.28 ± 0.67	2.45	< 0.02
	FVC%	108.26 ± 18.13	115.41 ± 18.91	2.32	< 0.05
	FEV_1	2.40 ± 0.58	2.64 ± 0.56	2.54	< 0.02
	FEV_1%	118.36 ± 22.85	127.53 ± 22.47	2.41	< 0.02
	TT	79.07 ± 9.48	80.89 ± 10.35	1.11	–
	FMF_{25-75}	2.80 ± 1.10	3.16 ± 0.96	2.05	< 0.05
	FMF_{25-75}%	56.74 ± 19.84	62.52 ± 18.10	1.79	–

Similarly, subjects from Krasica manifested in first measurement significantly lower values of all ventilatory functions, except for the Tiffeneau index, than did the Viškovo controls (Table 3). The repeated measurement five years later, however, revealed no statistically significant differences between the subjects from Krasica and controls from Viškovo.

Table 3 *Comparison of ventilatory functions between subjects from Krasica and Viškovo*

Year of investigation	Ventilatory functions	Krasica (N = 83) mean ± SD	Viškovo (N = 58) mean ± SD	t-value	P
1986	FVC	3.04 ± 0.54	3.39 ± 0.68	3.43	< 0.001
	FVC%	105.59 ± 19.68	114.71 ± 20.10	2.68	< 0.01
	FEV_1	2.40 ± 0.58	2.84 ± 0.66	4.14	< 0.001
	FEV_1%	113.01 ± 26.35	132.21 ± 27.60	4.19	< 0.001
	TT	79.34 ± 14.42	83.44 ± 10.18	1.86	–
	FMF_{25-75}	2.89 ± 0.95	3.43 ± 1.14	3.02	< 0.005
	FMF_{25-75}%	57.40 ± 17.17	68.15 ± 22.62	3.20	< 0.002
1990	FVC	3.14 ± 0.58	3.28 ± 0.67	3.28	–
	FVC%	115.78 ± 18.28	115.41 ± 18.91	0.09	–
	FEV_1	2.50 ± 0.53	2.64 ± 0.60	1.51	–
	FEV_1%	128.69 ± 23.17	127.53 ± 22.47	0.29	–
	TT	79.54 ± 9.17	80.89 ± 10.35	0.82	–
	FMF_{25-75}	2.90 ± 0.92	3.16 ± 0.97	1.70	–
	FMF_{25-75}%	57.64 ± 18.23	62.52 ± 16.10	1.57	–

DISCUSSION

Values of SO_2 as a major indicator of air pollution, which were obtained by continuous measurement of air quality in the Rijeka area, were constantly high and exceeded the recommended values. The fact gave us ground to believe that a long-term exposure in the area was likely to produce adverse health effects on general population (7–15). By choosing exclusively unemployed, nonsmoking women for our study, we tried to exclude the effects occupational exposure (16, 17) and of smoking as the most relevant factor for the occurrence of respiratory diseases (18, 19).

In the first investigation, the mean age of women from Bakar was 45.9 years (ranging from 18 to 62 years), from Krasica 47.4 (ranging from 20 to 63 years), and from Viškovo 45.7 years (ranging from 19 to 61 years). Our study showed that, save for the Tiffeneau index, Bakar women had lower values of ventilatory function than the women living in Viškovo. That was relevant for both measurements over the five-year study period. Female subjects from Krasica compared with the controls from Viškovo, also had lower values of all ventilatory functions, except for the value of Tiffeneau test at the first measurement, while the repeated measurement five years later, showed no significant differences in values of any ventilatory function.

Morris and co-workers studied a group of 988 healthy nonsmokers and found FEV_1 value to be a sensitive indicator for the assessment of obstructive changes in minor airways (5). *Petrilli and co-workers* found greater incidence of respiratory diseases in nonsmoking women living in industrial parts of Genoa than in the control group of women living in areas without sources of air pollution (14). *Yamaguchi and co-workers* conducted extensive studies on the effects of air pollution on the respiratory system and found greater prevalence of obstructive pulmonary diseases in a group of nonsmoking women living in industrial areas. They found significantly lower values of FEV_1 (15).

CONCLUSION

The significantly lower values of ventilatory function in the subjects from settlements affected by industrial emission (Bakar and Krasica) than in the control group from relatively clean area (Viškovo) may indicate the effect of a long-term exposure to air pollution.

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Sažetak

UTJECAJ ONEČIŠĆENJA ZRAKA NA VENTILACIJSKU FUNKCIJU PLUĆA NEPUŠAČICA

Istraživan je poremećaj ventilacijskih funkcija pluća u nezaposlenih nepušačica, nastanjenih na područjima različitim po onečišćenju zraka. Skupine ispitanica iz Bakra i Krasice nastanjene su u područjima u čijoj su blizini izgrađena velika industrijska postrojenja. Kontinuirano mjerenje kakvoće zraka pokazalo je da koncentracije SO_2 prelaze preporučene vrijednosti kakvoće zraka. Kontrolna skupina ispitanica nastanjena je u Viškovu, području gdje su mjerenja pokazala da je zrak čist. Mjerenje ventilacijskih funkcija pluća učinjeno je u dva navrata, 1986. i 1990. godine. Tražene su vrijednosti FVC, FEV_1, Tiffeneauov indeks i FMF_{25-75} koje su izražene kao apsolutne i relativne vrijednosti. Prilikom obaju mjerenja nađene su značajno više vrijednosti ventilacijskih funkcija pluća, osim Tiffeneauova indeksa, u žena Viškova nego u žena nastanjenih u Bakru. Pri usporedbi mjerenih ventilacijskih funkcija pluća između žena s područja Viškova i žena s područja Krasice, sve vrijednosti osim Tiffeneauova indeksa su pri prvom mjerenju bolje u žena iz Viškova nego u žena iz Krasice. Pri drugom mjerenju razlike nisu utvrđene. Na temelju dobivenih rezultata može se pretpostaviti da su lošije vrijednosti ventilacijskih funkcija pluća u ispitanica iz Bakra nego u ispitanica iz Viškova u obim mjerenjima, a ispitanica iz Krasice u prvom mjerenju posljedica dugotrajne izloženosti većem onečišćenju zraka.

Ključne riječi:
forsirani ekspiracijski volumeni, izloženost u okolišu, koncentracije sumpornog dioksida, praćenje

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