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Research paper

Spirometry in the prophylaxis of respiratory system diseases – a retrospective study

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Abstract

Introduction: Diseases of the respiratory system are the third cause of mortality worldwide in terms of incidence. A spirometry test enables early detection of changes in the respiratory tract of persons with minor ailments, as well as the diagnosis of a fairly advanced illness whose symptoms have been neglected by the patient.

Aim: The aim of this study has been to identify any irregularities in spirometry tests in the population of the province of Warmia and Mazury.

Material and methods: The study covered 1061 persons living in the province of Warmia and Mazury, of which 637 patients (188 women and 249 men) were included in the analysis. The participants provided their basic demographic and medical data through a survey. Each participant underwent a spirometry test according to the European Respiratory Society and American Thoracic Society 2005 guidelines. Statistical analysis was carried out in a Statistica software package.

Results and discussion: The study showed that women smoke significantly less than men – the average pack years for women and men were 4.02 (SD 9.33) and 8.11 (SD 17.19) ($P < 0.001$), respectively. A higher number of pack years contributed to a higher incidence of the respiratory tract symptoms (cough, wheeze, breathlessness) ($P < 0.05$). Compared to men, women were more often observed to suffer from grade 1 or 2 degree dyspnoea on the mMRC scale.

Conclusions: Pulmonary function tests play an important role in the diagnosis of respiratory system diseases. Promotion of prophylactic measures in streets of cities helps to improve patients' awareness of the condition of their health.

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1. INTRODUCTION

A growing number of cases of so-called civilisation diseases draws attention to the need for promoting broadly understood health prophylactic measures.[1] The prophylactic programmes in Poland now cover selected diseases within the set age categories. These include a program composed of the prevention measures regarding tobacco-related illnesses, addressed to people aged 40 to 60 years who have not had spirometry tests made under this programme in the past 36 months. The persons qualified for the tests are the ones who have not been diagnosed with chronic obstructive pulmonary disease (COPD), chronic bronchitis or ectasis and have not had any changes detected in a spirometry test. Due to the limited access to this type of prophylaxis, many non-profit organisations, local governments and hospitals increasingly often hold health promoting events which are intended to support this form of disease prevention. During such pro-health initiatives, some basic medical tests, like blood pressure measurements, the measurement of incidental glycaemia or spirometry tests, are carried out.

A spirometry test enables early detection of changes in the respiratory systems of patients with minor ailments and often leads to the diagnosis of a considerable advanced illness whose symptoms have been neglected by the patient.

Diseases of the respiratory system are the third cause of mortality worldwide in terms of incidence, after the cardiovascular and neoplastic diseases.[2] The data published by the Olsztyn Branch of Statistics Poland (former Central Statistical Office GUS) from the province of Warmia and Mazury, situated in the north-eastern part of Poland, and pertaining to the years 2000–2019 show that the mortality among both women and men due to respiratory system diseases (ICD-10 numbers J00–J99) in Warmia and Mazury is higher than in the remaining parts of Poland, 7.7% v. 6.7% in Poland.[3]

Spirometry is a tool which facilitates making a diagnosis of obstructive-type ventilation disorders in patients with different pulmonary and non-pulmonary disorders interfering with the respiratory system.[4] A correctly performed spirometry test enables the reliable interpretation of its results. Spirometry test standards had been developed for many years until the Snowbird workshop carried out in 1979 led to the first announcement issued by the American Thoracic Society (ATS) concerning the standardisation of spirometry.[5] These standards were updated in 1987 and once more in 1994.[6,7] The first European standardisation document was issued in 1983.[8] It was published in 1993 as an official document of the European Respiratory Society (ERS).[9] The latest document issued jointly by the ATS and ERS regarding the standardisation of spirometry appeared in 2005.[10]

COPD is characterised by chronic inflammation of the main (central) airways as well as small (peripheral) bronchioles and progressive destruction of lung parenchyma.[11] A functional consequence of these pathological changes is the reduced expiratory flow, which is manifested by obstruction in a spirometry test.[12]

According to the guidelines of the Polish Pulmonary Diseases Society, obstruction is diagnosed when the forced expiratory volume in 1 s (FEV1) to vital capacity (VC) ratio is below the 5th percentile relative to the required value and the flow-volume curve is concave in shape.[13] In line with the GOLD standards, the criterion for a positive diagnosis of COPD in a spirometry test is the FEV1 to FVC ratio value after the bronchodilator test of less 0.7.[14]

Based on the results of a spirometry test, certain restrictive-type ventilation disorders can be suspected. In terms of pathophysiology, restriction is a decrease in the total lung capacity (TLC) below the lower limit of normal (LLN).[15] When the VC declines below the LLN at the correct value of the FEV1 to FVC ratio, this can implicate the presence of restrictive changes.[16] The reference method for the diagnosis of such restrictive changes is the plethysmographic method for measuring the total lung capacity (LLN= –1.645 RSD, that is relative standard deviation).

2. AIM

The aim of this study has been to detect any abnormalities in the spirometry tests conducted in the population of inhabitants of the province of Warmia and Mazury.

3. MATERIAL AND METHODS

The research covered 1061 persons, of which 637 patients were included for further analysis. The study participants provided basic demographic and medical data through a survey. The participation in the study was completely voluntary and anonymous, and any volunteer could refuse to answer any question throughout the entire study without providing any justification. The study was carried out under the framework of prophylactic activities, without using any personal data. Prior to a spirometry test, each patient was informed about the procedure, and received the test results and recommendations after the test.

3.1. Spirometry

The measurements of the VC and flow-volume curve were made by qualified medical staff with many years of experience in making spirometry tests, in line with the ERS/ATS 2005 standards. Each test was made with a Microlab MK8 Care Fusion spirometer (MicroMedical; UK). The device was calibrated every day prior to the tests. Only the results of spirometry tests that satisfied the criteria of a correctly performed spirometry test according to the ATS/ERS were taken for the subsequent statistical analysis.

3.2. Statistical analysis

Statistical analysis was carried out using Statistica v. 10 software (TIBCO Software, California, USA). The minimum, maximum, standard deviation (SD), 95% confidence interval for the mean and the median were calculated for every variable. The *W* Shapiro-Wilk test was applied to test the normality of distribution. Homogeneity of variance within the groups was

Table 1. Age groups including division into sexes, *n*(%).

Age	Women	Men	Total
18–29 years	88(22.68)	77(30.92)	165(25.90)
30–39 years	50(12.89)	44(17.67)	94(14.76)
40–49 years	41(10.57)	24(9.64)	65(10.20)
50–64 years	99(25.52)	60(24.10)	159(24.96)
≥65 years	110(28.35)	44(17.67)	154(24.18)
Total	388(100.00)	249(100.00)	637(100.00)

Table 2. Descriptive data on the grade of dyspnoea, *n*(%).

Grade of dyspnoea	Women	Men	Total
0	331(85.31)	236(94.78)	567(89.01)
1	36(9.28)	4(1.61)	40(6.28)
2	15(3.87)	3(1.20)	18(2.83)
3	5(1.29)	4(1.61)	9(1.41)
4	1(0.26)	2(0.80)	3(0.47)
Total	388(100.00)	249(100.00)	637(100.00)

tested with the Levene's test. The threshold value of the acceptable level of error was assumed to be the significance level of 0.05. For the variables satisfying the assumptions of parametric tests, *t*-Student test (when two groups were compared) or ANOVA (when more than two groups were compared) were employed. When variables did not meet the assumptions of normal distribution or equality of variance, the *U* Mann-Whitney test or the Kruskal–Wallis test were applied, respectively.

4. RESULTS

The research covered 1061 volunteers. 637 patients living in the province of Warmia and Mazury were distinguished from this group to be submitted to further analyses. Most were women, i.e. 388 persons (60.91%) while men made up a group of 249 persons (39.09%).

The patients were divided into 5 age groups: 18–29, 30–39, 40–49, 50–64 and 65 and older patients (Table 1).

Most patients, 516 (81%), lived in cities with a population of over 100 000, while 74 persons inhabited towns with less than 100 000 residents, and 47 persons (7.38%) lived in the countryside.

The presence of dyspnoea on the mMRC (modified Medical Research Council) was determined. Most study participants, 567 (89.01%), declared grade 0 breathlessness, and 40 persons (6.28%) reported grade 1 shortness of breath. More detailed description of the intensity of dyspnoea including the division between men and women is presented in Table 2. Grade 2 dyspnoea was identified in 3 patients (0.47%). Women significantly more often than men were observed to have grade 1 and 2 dyspnoea ($P < 0.05$). Moreover, it was shown that overweight patients significantly more often reported breathlessness ($P < 0.05$).

Based on the performed spirometry tests, the incidence of respiratory obstruction (in total 14.29%) was determined in every age category (Figure 1).

It has been demonstrated that the occurrence of obstruction was not correlated with the place of residence – town/village, distance to a busy road, type of the house heating system (gas/oil/coal/timber stove), nor was it dependent on the position of windows in the house (facing a road or the backyard). However, it was observed that obstruction was more common in the age group of 18–29 years, 50–64 years and 65 years and more. The frequency of obstruction also depended on the number of pack years, as the group of patients with diagnosed obstruction presented a higher number of pack years, namely 8.12 (SD 17.09) compared to 5.20 (SD 12.31) ($P < 0.05$).

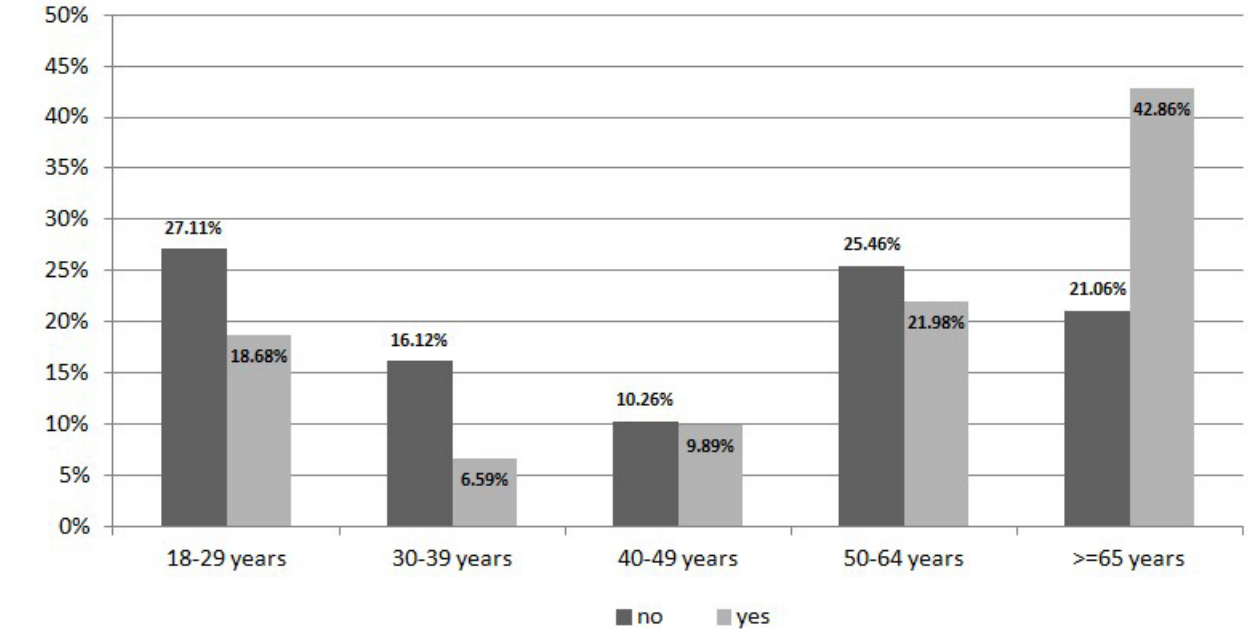

Figure 1. Distribution of the incidence of obstruction including division into age groups.

The average number of pack years in the analysed population was 5.62 (SD 12.13). The average number of pack years in the group of patients without obstruction was 5.2 (SD 12.31) compared to 8.12 (SD 17.09) among the patients who were diagnosed by spirometry to suffer from pulmonary obstruction ($P < 0.05$). The statistical analysis did not reveal any significant difference in the average number of pack years for the distinguished grades of pulmonary obstruction ($P < 0.45$).

The research showed that women smoke less than men do, and the average number of pack years for women was 4.02 (SD 9.33), compared to 8.11 (SD 17.19) for men ($P < 0.001$). It was also noted that the general population with a higher number of pack years most often presented such symptoms as dyspnoea ($P = 0.03$), productive cough ($P = 0.002$) or wheeze ($P = 0.001$). These data were confirmed for women patients (productive cough $P = 0.001$; wheeze $P = 0.02$) (Table 3). In the oldest group of patients, aged 65 years and more, dyspnoea and wheeze were observed significantly more often than among younger patients ($P < 0.001$; $P < 0.006$).

The study also demonstrated that the patients who had never taken up any sport activity reported breathlessness more often ($P < 0.05$). These data were confirmed in the subpopulation of men ($P < 0.01$). Patients who had never done any sports were significantly more often at risk of productive cough than the remaining population ($P < 0.03$).

5. DISCUSSION

Based on the spirometry tests performed, we were able to observe a significantly more frequent incidence of pulmonary obstruction in patients aged 65 years and older (Figure 1). These patients were exposed to a higher risk of COPD than the persons in the other age categories. These results are in agreement with the literature references and the nature of chronic diseases.[17–20] More severe presentation of COPD in elderly patients occurs more often and implicates a worse prognosis. This is undeniably connected with the modification of pulmonary tissue that progresses with age and entails lesser elasticity of pulmonary tissue and its higher vulnerability. The collapse of tiny bronchioles during inhalation may lead to the reduced flow of air through the respiratory tract.[21] Eventually, this results in more frequent hospital admissions and higher mortality.[22] COPD is most often diagnosed in elderly patients, although there are certain genetic traits which in predisposed persons can result in the development of COPD in younger age. An example of the deficiency of alpha-1-antitripsin.[23]

The data we analysed demonstrate that obstruction occurred quite as frequently in the subpopulation of patients aged 18–29 years. In this group, grade 1 obstruction (low-grade obstruction, FEV1 > 80%) was diagnosed in as many as 116 out of 160 patients (72.5%) (Figure 1). The presence of obstruction in the population of young people might be associated with asthma. The data we were able to collect and present in Figure 1 show an evident increasing tendency in the incidence of obstruction in the subsequent age categories. The 18–29-year-olds are a distinct exception. The prevention programmes included the basic spirometry test without a bronchodilator test or any preparation prior to the test.

This research demonstrated a significant relationship between the number of pack years and the detection of pulmonary obstruction in smokers. The result obtained in this study correlates with the aetiology of COPD, where tobacco smoking is considered to be the main factor in the development of obstructive disorder.[24] Tobacco smoking is one of the chief risk factors of six of the eight main causes of death worldwide, including diseases of the respiratory system and of the cardiovascular system, stroke and a few neoplastic diseases.[25] In this study, we demonstrated that women smoke less than men ($P < 0.0001$). Previously, COPD was considered to be an illness mostly affecting elderly men, which was associated with the fact that men were more often addicted to smoking. Unfortunately, this situation has changed and a worrying tendency is now being observed for an increasing number of women smokers. The higher morbidity and mortality due to COPD in recent decades is partly explained by the higher number of women who smoke. In many developed countries, COPD is diagnosed in women more often than in men.[26,27] On the other hand, Sorheim et al. demonstrated in their study that women still smoke less than men, which might suggest they are more sensitive to tobacco smoke and more likely to develop COPD.

This study showed that the number of pack years correlates with such reported symptoms as wheeze, productive cough or dyspnoea (Table 3). The available population research data seem to confirm that long-term smoking is connected with respiratory tract symptoms, COPD and a higher risk of developing respiratory tract infections.[28,29] There is

Table 3. Number of pack years versus the presence of dyspnoea, dry cough, wet cough and wheeze in total and in the subpopulations of women and men.

Pack years	Not present		Present		*P*
	x	SD	x	SD	
In total					
Dyspnoea	5.06	11.91	7.99	17.22	0.03
Dry cough	5.61	13.15	5.62	13.05	1.00
Productive cough	4.88	12.21	9.27	16.52	0.002
Wheeze	5.06	12.25	11.22	19.18	0.001
Women					
Dyspnoea	3.98	9.48	4.12	8.80	0.91
Dry cough	4.13	9.60	3.64	8.41	0.67
Productive cough	3.33	8.37	7.29	12.54	0.001
Wheeze	3.64	8.60	7.28	13.89	0.02
Men					
Dyspnoea	6.56	14.56	17.51	26.86	0.0004
Dry cough	7.70	16.72	10.55	19.84	0.36
Productive cough	7.25	16.19	12.59	21.39	0.07
Wheeze	7.20	16.05	20.48	26.22	0.002

evidence now that most smokers suffer from breathing disorders before being diagnosed to have developed COPD.[30] In one of the recent studies addressing this issue, it was concluded that 50% of smokers eventually develop COPD.[31,32] However, many patients remain undiagnosed.[33]

COPD is characterised by the occurrence of such symptoms as dyspnoea, cough, spitting out of phlegm, wheezing breath or chest tightness.[34,35] Koo et al. demonstrated that cough is an independent risk factor of lower FEV1 and diffusion lung capacity for carbon monoxide (DLCO), more severe dyspnoea, worse quality of life and future aggravation of the condition. Moreover, the presence of cough is associated with the severity of COPD.[36] Chronic cough is linked to the neutrophilic inflammation of the airways and the release of such pro-inflammatory cytokines as tumour-alpha necrosis factor or interleukin-8.[37,38]

The ATS defines dyspnoea as 'a subjective experience of breathing discomfort that consists of qualitatively distinct sensations that vary in intensity.' In our study, we were able to observe high incidence of dyspnoea in the whole population, in men and in the group of patients aged 65 years and over (Table 2). According to the data from the Clinical Practice Research Datalink, 82% patients with COPD presented dyspnoea of any grade, assessed by the Medical Research Council (MRC) on the severity scale of 1 to 5, where 46% had moderate to severe dyspnoea (MRC $\geq$ 3).[38] Dyspnoea is more frequent in elderly patients ($\geq$70 years of age), women, obese patients (BMI $\geq$ 30 kg/m^2), and with concurrent mental issues, such as depression or anxiety.[40]

The statistical analysis concerning the place of residence of the patients and the occurrence of pulmonary obstruction of different grade showed that the place of residence, as a socioeconomic parameter, did not correlate with any significant differences in the incidence of pulmonary obstruction nor did it contribute to a specific severity of this health problem.

The results presented in this paper originate from sets of data collected during some prophylactic events, such as Days of Spirometry or Health Check, carried out on specific occasions in streets of Olsztyn. It is obvious, therefore, that the analysis of these data made during our study is burdened with a certain marginal error, mostly arising from the way the data were collected. The spirometry tests were conducted without any prior preparation of patients. Patients may have eaten before the test or may have taken some inhalation medications prior to tests that could have affected the degree of obstruction. However, we made every effort to ensure that each spirometry test was carried out in compliance with the ERS/ATS standard. The spirometry tests selected to be analysed were conducted on residents of the same province, the province of Warmia and Mazury. All persons who declared in the survey that they lived in another province were excluded from the study. This, in our opinion, creates a reliable population-based evaluation of the pulmonary function among the population living in one province.

6. CONCLUSIONS

Lung function tests, and particularly a spirometry test, play an important role in the diagnosis of respiratory system diseases, especially asthma and COPD. Prophylactic events carried out in streets of cities contribute to a better understanding among patients regarding the harmfulness of tobacco smoking. They are also a valuable source of data that enable one to assess the function of the respiratory system in the analysed population.

Conflict of interest
None declared.

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