



# BMJ Open Prevalence, symptom burden and under-diagnosis of chronic obstructive pulmonary disease in Polish lung cancer screening population: a cohort observational study

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## ABSTRACT

**Objectives** Lung cancer screening using low-dose CT may be not effective without considering the presence of comorbidities related to chronic smoking. The aim of the study was to establish the prevalence of chronic obstructive pulmonary disease (COPD) in group of highlight the potential benefits atients participating in the largest Polish lung cancer screening programme MOLTEST-BIS and attempt to confirm the necessity of combined lung cancer and COPD screening.

**Design** Cohort, prospective study.

**Setting** Medical University of Gdańsk, Poland

**Participants** The study included 754 participants in lung cancer screening trial from the Pomeranian region, aged 50–70 years old, current and former smokers with a smoking history  $\geq 30$  pack-years.

### Primary and secondary outcome

**measures** Questionnaire, physical examination, anthropometric measurements, spirometry test before and after inhaled bronchodilator (400  $\mu$ g of salbutamol)

**Results** Obstructive disorders were diagnosed in 186 cases (103 male and 83 female). In the case of 144 participants (19.73%), COPD was diagnosed. Only 13.3% of participants with COPD were known about the disease earlier. According to classification of airflow limitation 55.6% of diagnosed COPD were in Global Initiative for Chronic Obstructive Lung Disease (GOLD) 1 (mild), 38.9% in GOLD 2 (moderate), 4.9% in GOLD 3 (severe) and 0.7% in GOLD 4 (very severe) stage. Women with recognition of COPD were younger than men (63.7 vs 66.3 age) and they smoked less cigarettes (41.1 vs 51.9 pack-years).

**Conclusions** Prevalence of COPD in Polish lung cancer screening cohort is significant. The COPD in this group is remarkably under-diagnosed. Most diagnosed COPD cases were in the initial stage of advancement. This early detection of airflow limitation highlights the potential benefits arising from combined oncological-pulmonary screening.

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## INTRODUCTION

Screening for lung cancer became the standard of care in the USA, being piloted in

## Strengths and limitations of this study

- The largest Polish lung cancer screening programme with additional diagnostic procedures to assess the prevalence of most common comorbidities.
- One of few low-dose computed tomography (LDCT) trials in Europe in which the prevalence of chronic obstructive pulmonary disease was established according to all respiratory guidelines by performing full spirometry with the bronchodilator reversibility test.
- The lack of randomisation resulting from the specificity of screening tests, which are designed for volunteers.

Europe increasingly.<sup>1 2</sup> In many countries studies have been conducted to assess the benefits of screening for this cancer and to determine the optimal eligibility criteria for screening tests.<sup>3</sup>

Based on the data obtained from multi-centre studies covering the smoking population, it has been proven that lung cancer screening using low-dose CT (LDCT) in people at high risk of this cancer may significantly reduce mortality in this group of patients.<sup>4 5</sup> Ten-year follow-up of people who had undergone lung cancer screening as part of the European Netherlands-Leuven Longkanker Screenings Onderzoek study showed a reduction in cancer deaths by 26% in men and by 61% in women.<sup>1</sup> However, researchers agree that appropriate group selection, taking into account comorbidities that may reduce the effectiveness of tests, is crucial for lung cancer screening to become the standard of care, reduce mortality and be cost-effective.<sup>6–8</sup>

Smoking is not only responsible for the development of lung cancer but is also involved in the aetiology of over 80% of

chronic obstructive pulmonary disease (COPD) cases.<sup>9</sup> The most recent analyses of the WHO indicate that 251 million people worldwide suffer from COPD and it is the third cause of death.<sup>10 11</sup>

Given the high prevalence of COPD in the general population, the ever-increasing mortality from this disease, and its close relationship with smoking, the presence of COPD should be an important factor in qualifying patients for lung cancer screening. People with COPD have been shown to have twice the risk of developing lung cancer than smokers without COPD.<sup>7 8 11–14</sup> Moreover, in this group of patients there are more complications related to the diagnostic procedures and treatment of the diagnosed lung cancer. These patients are more likely to develop complications after biopsy, such as pneumothorax and bleeding requiring transfusion of blood products.<sup>15</sup> In the perioperative period, patients with COPD are more likely to develop respiratory failure, stay in hospital longer after surgery, and have an increased risk of 30-day mortality.<sup>7 16</sup>

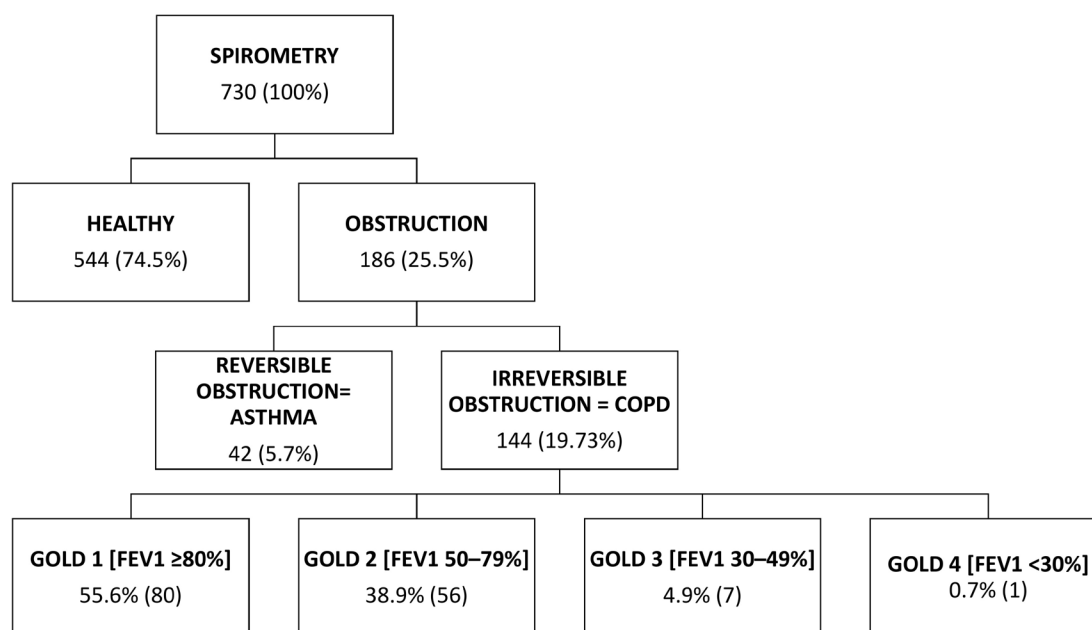
Therefore, the aim of this study is to establish the prevalence and clinical characteristics of COPD in a cohort of adult Poles who underwent screening for lung cancer.

## MATERIALS AND METHODS

Screening of patients for the diagnosis of COPD was carried out as part of the MOLTEST-BIS programme, which is one of the first Polish screening programmes dedicated to the early diagnosis of lung cancer in the group of long-term tobacco smokers.<sup>17</sup> The project was implemented in 2016–2018 by the Medical University of Gdańsk. People aged 50–79 years, inhabitants of the Pomeranian Voivodeship, with a smoking history of over 30 pack-years were eligible for the study. Both current

smokers and those who quit smoking no later than 15 years prior to the study enrolment date were included in the study. The study was aimed at a comprehensive health assessment of the population undergoing screening for comorbidities, and in particular COPD.

All participants in the study were interviewed using a standardised questionnaire. The questionnaire included questions about the patient's medical history, with particular emphasis on chronic diseases, medications, respiratory and cardiovascular symptoms, smoking history, sociodemographic data, healthy behaviours and physical activity. Then physical examination, anthropometric measurements, electrocardiographic examination, three measurements of blood pressure according to the European Society of Hypertension/European Society of Cardiology recommendations, and heart rate assessment were examined.<sup>18 19</sup> Each participant underwent a spirometry test using a Jaeger Masterscreen Pneumo (Germany) spirometer. Pulmonary function tests were performed by an experienced spirometry technician. The results were analysed by a pulmonologist. Spirometry was performed in accordance with the current European Respiratory Society/American Thoracic Society standards.<sup>20</sup> Both static (Vital Capacity (VC), Inspiratory Capacity (IC), Inspiratory Reserve Volume (IRV), Expiratory Reserve Volume (ERV)) and dynamic (forced vital capacity (FVC), forced expiratory volume in 1 s (FEV<sub>1</sub>)) lung volumes were measured. If obstructive disorders were found, spirometry was repeated 20 min after the administration of 400 µg of salbutamol from a pressurised inhaler (figure 1). The COPD Assessment Test (CAT) was performed on people diagnosed with COPD and the incidence of dyspnoea was assessed according to the mMRC (modified Medical Research Council) scale. The



**Figure 1** Diagnostic diagram. COPD, chronic obstructive pulmonary disease; FEV<sub>1</sub>, forced expiratory volume in 1 s; GOLD, Global Initiative for Chronic Obstructive Lung Disease.

spirometric assessment and classification of the disease severity were carried out based on the guidelines of the Global Initiative for Chronic Obstructive Lung Disease (GOLD).<sup>21</sup> Primarily the diagnosis of obstruction was evaluated using the absolute value of FEV<sub>1</sub>/FVC ratio. The FEV<sub>1</sub>/FVC cut-off point was considered to be less than 0.7. Furthermore, in case of uncertain results, we assessed if this value was lower than lower limit of normal. In the study besides from GOLD criterion, reference values from the Global Lungs Initiative were used.<sup>22 23</sup> Before the spirometry test, when participants were contacted by phone to arrange the test date, everyone was instructed on how to properly prepare for the test. After a comprehensive cardiovascular and pulmonary assessment, participants received feedback on their health. People whose tests revealed significant abnormalities were referred to specialists in order to extend the diagnosis or initiate appropriate treatment (eg, COPD).

In addition, each tobacco smoker underwent smoking cessation intervention (5 A's to help patients quit tobacco).<sup>24</sup>

The whole results from MOLTES-BIS about lung cancer prevalence will be presented in a separate publication. Predicted incidence of lung cancer screening in our study varies between 1% and 2%, the data are still under revision.

In the statistical analyses carried out in the study, quantitative variables were described with mean values, SD and medians, and qualitative variables were presented as percentages with counts. The assumption of distribution normality was verified with the Shapiro-Wilk test. The quantitative variables of the two groups were compared using the Mann-Whitney test. The significance of differences between the qualitative variables was tested using the Fisher test. The hypotheses were verified with two-sided tests. The level of significance was taken as  $p < 0.05$ .

### Patient and public involvement

No patient involved

## RESULTS

The inclusion criteria for the study were met by 754 people. The analysis included the results of 730 screened participants (335 women and 396 men) who had no contraindications to perform spirometry and whose test results were without technical errors (figure 1). The mean age of men and women participating in the study did not differ significantly and was 63 and 63.5 years, respectively.

As shown in table 1, obstructive disorders were found in 186 patients (103 men and 83 women). Bronchodilator test showed irreversible obstruction in 144 patients (86 men and 58 women). COPD was diagnosed in 19.7% of the study participants.

There was no difference in the incidence of COPD between women and men. Only 13.3% of the subjects diagnosed with COPD based on spirometry were aware of the disease—11.6% of men and 15.8% of women; the difference was not statistically significant ( $p = 0.641$ ).

Fourteen of 144 responders with COPD reported having asthma in their medical history. The age of the first asthma diagnosis in these cases ranged from 40 to 70 years.

The mean FEV<sub>1</sub> in the entire cohort was 97.8% (mean SD 37.527, median (Q1, Q3) 97.500 (86.300, 109.100)). In people without COPD, FEV<sub>1</sub> was 103% (mean SD 39.215, median (Q1, Q3) 100.900 (92.300, 112.000)), and in those with diagnosed COPD, the value of this parameter was 75.6% (mean SD 16.342, median (Q1, Q3) 75.350 (67.075, 85.800)). The most important spirometric parameters before and after administration of a bronchodilator in case of group diagnosed with COPD are presented in table 2.

Table 3 presents data on the severity of the diagnosed COPD cases. In our analysis, according to the GOLD criteria for airflow-limitation severity, 55.6% of patients had mild obstruction, 38.9% moderate, 4.9% severe and 0.7% had very severe airflow obstruction. After assigning the diagnosed COPD cases to the appropriate category according to GOLD 'ABCD' classification, most patients were in group B (63.9%) with more symptoms and a low risk of disease exacerbation, 29% were in group A, 1.4% in group C and 5.5% in group D.

Screened patients with and without COPD were compared in terms of age, symptoms and hospitalisation rates (table 4). The mean age of people diagnosed with COPD was 65.2 years and was significantly higher than that of people without the disease, 62.7 years. The mean age of men was 66.3 years in those with COPD and 62.6 years in those without COPD ( $p < 0.001$ ). For women, it was 63.7 years and 62.7 years, respectively ( $p = 0.212$ ).

People with COPD significantly more often reported chronic cough, defined as a cough lasting more than 8 weeks (39% vs 29.9%) and dyspnoea (51% vs 33.7%). There was no difference in the reporting rate of dyspnoea between women without COPD and women with COPD.

**Table 1** Proportion of patients with pulmonary function abnormalities in spirometry

	Overall (N=730)	Men (M) (N=395)	Women (W) (N=335)	P value, M vs W
Obstruction	25.5% (186)	26.1% (103)	24.8% (83)	0.752
Irreversible obstruction (COPD)	19.7% (144)	21.7% (86)	17.3% (58)	0.157
Reversible obstruction (ASTHMA)	5.7% (42)	4.3% (17)	7.4% (25)	0.096

COPD, chronic obstructive pulmonary disease.

**Table 2** Spirometric parameters in group with chronic obstructive pulmonary disease

	Overall (N=144)	Men (M) (N=86)	Women (W) (N=58)	P value, M vs W
Spirometric parameters before bronchodilator				
FEV <sub>1</sub> (% predicted value)—mean (SD)	75.60 (16.34)	73.40 (14.67)	78.80 (18.19)	0.048
FVC (L)—mean (SD)	3.60 (0.91)	4.10 (0.83)	2.90 (0.59)	<0.001
FEV <sub>1</sub> /FVC (%)—mean (SD)	56.40 (8.48)	55.80 (8.32)	57.40 (8.70)	0.269
Spirometric parameters after bronchodilator				
FEV <sub>1</sub> (% predicted value)—mean (SD)	80.81 (17.05)	78.55 (15.35)	84.17 (18.94)	0.027
FVC (L)—mean (SD)	3.85 (1.00)	4.34 (0.92)	3.12 (0.59)	<0.001
FEV <sub>1</sub> %/FVC (%)—mean (SD)	57.69 (8.82)	56.79 (8.47)	59.03 (9.23)	0.024

FEV<sub>1</sub>, forced expiratory volume in 1 s; FVC, forced vital capacity.

The subjects were asked about hospitalisation for coughing, breathlessness or shortness of breath. Respondents diagnosed with COPD reported it more often than people without the disease (6.9% vs 1.7%).

In the CAT assessing the impact of COPD on the quality of life of patients, the mean score achieved by people diagnosed with COPD was 13.7 points out of maximum achievable score of 40 and it did not differ significantly by gender.

Data on smoking, education and type of work are presented in table 5. The number of cigarettes smoked was significantly higher in people with COPD compared with those without COPD. Among men with COPD, the average number of pack-years was 51.9 and was significantly higher than in women diagnosed with COPD (41.1 pack-years). People diagnosed with COPD were significantly more often blue-collar than white-collar workers. There were also statistically significant differences in education between men diagnosed with COPD and men without the disease. Among men diagnosed with COPD, 39.5% had primary education, 39.5% had secondary education and only 20.9% had higher education. In men without COPD, secondary education was the most frequent—42.4%, and only 26.9% had primary education. No significant differences in the level of education between the groups were found in women.

There were no differences in the mean values of height, weight, waist circumference and body mass index (BMI) in the groups of women and men with and without COPD. There was a difference in the distribution of BMI between patients with COPD and those without COPD (table 6).

## DISCUSSION

Our study shows the prevalence and characteristics of chronic obstructive pulmonary disease in the group of people participating in one of the first lung cancer screening studies in Poland. In our study, almost one-fifth (19.73%) of the participants were diagnosed with COPD.

According to epidemiological studies conducted both in Europe and around the world, the prevalence of COPD in people subjected to lung cancer screening is high; this disease was detected in up to two-thirds of the examined subjects.<sup>2 25</sup> However, there is a large discrepancy in the results, which may suggest significant differences in the populations participating in the screening, and may result from different eligibility criteria for the study and adopted diagnostic criteria. It is noteworthy that in many of the studies conducted, only basic spirometry was assessed, without the bronchodilator reversibility test, which raises methodological doubts and might cause the obtained results to be overestimated. In one of the largest American lung cancer screening studies, the National

**Table 3** Classification of severity of diagnosed COPD cases

	Overall (N=144)	Men (M) (N=86)	Women (W) (N=58)	P value (M vs W)
GOLD classification of severity of airflow obstruction				
Mild GOLD 1 (FEV <sub>1</sub> ≥80%)	55.6% (80)	50.0% (43)	63.8% (37)	0.137
Moderate GOLD 2 (FEV <sub>1</sub> 50%–79%)	38.9% (56)	45.3% (39)	29.3% (17)	
Severe GOLD 3 (FEV <sub>1</sub> 30%–49%)	4.9% (7)	4.7% (4)	5.2% (3)	
Very severe GOLD 4 (FEV <sub>1</sub> <30%)	0.7% (1)	0% (0)	1.7% (1)	
GOLD classification of COPD severity				
A (less symptoms and low risk of exacerbations)	29.2% (42)	27.9% (24)	31% (18)	0.959
B (more symptoms; low risk of exacerbations)	63.9% (92)	66.3% (57)	60.3% (35)	
C (less symptoms, but high risk of exacerbations)	1.4% (2)	1.2% (1)	1.7% (1)	
D (more symptoms; high risk of exacerbations)	5.5% (8)	5.8% (5)	5.1% (3)	

COPD, chronic obstructive pulmonary disease; FEV<sub>1</sub>, forced expiratory volume in 1 s; GOLD, Global Initiative for Chronic Obstructive Lung Disease.



Table 4 Symptomatology

	Men (N=395)			Women (N=335)			Overall (N=730)		
	COPD (N=86)	Non-COPD (N=309)	P value	COPD (N=58)	Non-COPD (N=277)	P value	COPD (N=144)	Non-COPD (N=586)	P value
Age—mean (SD)	66.3 (6.98)	62.6 (6.44)	<0.001	63.7 (6.23)	62.7 (5.77)	0.212	65.2 (6.78)	62.7 (6.13)	<0.001
Cough	37.2% (32)	24.9% (77)	0.034	43.1% (25)	28.5% (79)	0.042	39% (57)	29.9% (175)	0.032
Dyspnoea	50.6% (43)	26.3% (81)	<0.001	51.7% (30)	42% (116)	0.176	51% (73)	33.7% (197)	<0.001
Dyspnoea severity according to the mMRC scale			0.08			0.159			0.022
0	14% (6)	33.8% (27)		6.7% (2)	23.3% (27)		11% (8)	27.6% (54)	0.033
1	53.5% (23)	46.2% (37)		53.3% (16)	49.1% (57)		53.4% (39)	48% (94)	0.49
2	25.6% (11)	15% (12)		26.7% (8)	20.7% (24)		26% (19)	18.4% (36)	0.17
3	7% (3)	5% (4)		13.3% (4)	6% (7)		9.6% (7)	5.6% (11)	0.06
4	0% (0)	0% (0)		0 (0%)	0.9% (1)		0% (0)	0.5% (1)	<1
Hospitalisations	7% (6)	1.3% (4)	0.003	6.9% (4)	2.2% (6)	0.054	6.9% (10)	1.7% (10)	<0.001

COPD, chronic obstructive pulmonary disease; mMRC, modified Medical Research Council.

Lung Screening Trial, the prevalence of COPD was 34.4%.<sup>2</sup> However, the bronchodilator test was not performed in this study, which could have an impact on the final result. In the British Lung Screen Uptake Trial (LSUT), the prevalence of COPD among people participating in lung cancer screening was as high as 57%; however, also in this study, analyses included only basic spirometry without the bronchodilator test.<sup>26</sup> In addition, people aged 60–75 were eligible for the LSUT study, which means that the participants were older than in most other lung cancer screening tests. The prevalence of COPD found in our study may appear lower than in most countries; however, the diagnosis of this disorder was carried out in accordance with the GOLD and the Polish Society of Lung Diseases guidelines,<sup>9 21</sup> using a complete diagnostic scheme including the bronchodilator reversibility test in every person with airflow obstruction. Additionally, the severity of COPD symptoms was assessed using the tools recommended in the guidelines: CAT and mMRC scale. Such analyses reliably refine the diagnosis of COPD. Unfortunately, it seems that the prevalence of COPD, as assessed in our study, may be underestimated. It should be emphasised that it was the second stage of the pilot screening study carried out in a big city, which was attended by people who were more interested in their health condition, with a higher socio-economic status, better education and higher awareness of diseases. It is a characteristic feature of the population participating in each screening test, but nevertheless, this effect in the Polish population seems to be particularly pronounced. Compared with the above-mentioned multi-centre studies, this could have resulted in the lower accessibility of the study for volunteers from more distant parts of the voivodeship, especially from small towns and villages, where the prevalence of COPD may be higher than in large cities.

Another important aspect that should be highlighted is the number of newly diagnosed COPD cases. Analysing the respondents' answers regarding their knowledge about the earlier diagnosis of COPD and considering the medications taken by the respondents, only 13.3% of people diagnosed with COPD during the visit knew about the disease beforehand. For example, in the previously mentioned British study,<sup>26</sup> 33% participants were aware of COPD, and in the American study this proportion was almost 60%.<sup>2</sup> These data highlight how underdiagnosed the Polish population is in terms of lung diseases. Considering the importance of the presence of COPD in the diagnostic and therapeutic process and in the stratification of the benefits and risks of lung cancer screening, as well as the low awareness of the disease, it should be considered that the diagnosis of this disorder during screening should become a standard of care.

According to the above analyses, it seems that women are the group that should receive special attention when diagnosing COPD. Our results show that not only do women suffer from COPD at a younger age than men, but also with significantly less exposure to tobacco smoke. The frequency of the individual symptoms reported by the women was the same, regardless of whether they had COPD or not. In this

**Table 5** Sociodemographic data and smoking history

	Men (N=395)			Women (N=335)		
	COPD (N=86)	Non-COPD (N=309)	P value	COPD (N=58)	Non-COPD (N=277)	P value
<b>Smoking status</b>						
Pack-years—mean (SD)	51.9 (17.31)	45.40 (17.35)	0.002	41.15 (11.06)	31.91 (12.51)	<0.001
Current smoker	69.8% (60)	60.5% (187)	0.149	72.5% (42)	70.1% (194)	0.839
Former smokers	30.2% (26)	39.5% (122)		27.5% (16)	29.9% (83)	
<b>Type of job</b>						
Blue-collar workers	63.9% (53)	58.2% (166)	0.36	46.6% (27)	34.1% (88)	0.075
White-collar workers	36.1% (30)	41.8% (119)		53.4% (31)	65.9% (170)	
<b>Education level</b>						
Primary	39.5% (34)	26.9% (83)	0.49	22.4% (13)	21.3% (59)	0.85
Secondary	39.5% (34)	42.4% (131)		46.6% (27)	50.5% (140)	
Higher	20.9% (18)	30.7% (95)		31.0% (18)	28.2% (78)	

COPD, chronic obstructive pulmonary disease.

group, the inclusion of early screening for COPD in lung cancer diagnostic testing may be particularly important.

Although the benefits of lung cancer screening have been proven in long-term observational studies, the financial burden on healthcare systems due to the high cost of the study remains under discussion. Research is ongoing in many countries on the potential introduction of a combined lung cancer screening and comorbidities, which could contribute to greater cost-effectiveness of the study and lower mortality associated with comorbidities in long-term smokers.<sup>1 4 27</sup> Most of the COPD cases diagnosed in our study were classified as low-stage disease (the most common were mild obstruction and COPD stages A and B). Studies show that in the early stages of the disease, patients die more often from lung cancer than from respiratory failure, the latter predominating at higher disease severity categories.<sup>28</sup> Therefore, people with early-stage COPD are optimal candidates for lung cancer screening, as the benefits of potential diagnosis and treatment for this cancer may outweigh the risk of possible adverse effects. Currently, analyses are

also conducted on the feasibility and cost-effectiveness of a combined screening for lung cancer and COPD by assessing the presence of emphysema in low-dose CT.<sup>6 29 30</sup> Determining the prevalence of COPD by means of spirometry in the Polish population undergoing screening for lung cancer and the possible correlation of our results with the assessment of the severity of emphysema and symptoms of chronic bronchitis in LDCT, may contribute in the future to broadening the scope of diagnostic imaging examinations to assess the functioning of the respiratory system, which would make the screening applied cost-effective.

The limitations of our study include the lack of randomisation resulting from the specificity of screening tests, which are aimed at people willing to participate. Moreover, the study, due to time constraints, did not include the entire cohort of lung cancer screening participants, but only a part of the group. Due to easier access to the study of people from a big city, this group constituted the majority of participants, which could also have influenced the results obtained.

**Table 6** Anthropometric data

	Men (N=395)			Women (N=335)		
	COPD (N=86)	Non-COPD (N=309)	P value	COPD (N=58)	Non-COPD (N=277)	P value
<b>Body weight, kg</b>						
Mean (SD)	86.26 (15.17)	89.15 (14.99)	0.116	70.2 (12.38)	71.7 (14.05)	0.437
Median (Q1, Q3)	84.30 (75.38, 98.50)	87.50 (77.70, 98.15)		69.00 (60.95, 75.90)	69.50 (61.40, 79.50)	
BMI, kg/m <sup>2</sup> —mean (SD)	28.43 (4.54)	29.2 (4.81)	0.170	27.2 (4.3)	27.8 (7.45)	0.499
<b>BMI category</b>						
Underweight (BMI <18.5)	0 (0%)	1 (0.3%)	<1	0% (0)	0.4% (1)	0.442
Normal weight (BMI 18.5–24.99)	26.7% (23)	14.6% (45)	0.0259	37.9% (22)	31.8% (88)	
Overweight (BMI 25.0–29.99)	33.7% (29)	47.7% (147)	0.061	32.8% (19)	38.6% (107)	
Obesity (BMI ≥30)	39.5% (34)	37.2% (115)	<1	20.3% (17)	29.2% (81)	

BMI, body mass index; COPD, chronic obstructive pulmonary disease.

## CONCLUSIONS

Our study showed a significant prevalence of COPD in a cohort of Polish smokers participating in the lung cancer screening test. Awareness of the disease in this group is very low and amounts to approximately 13%. Most people diagnosed with COPD are in the early clinical stage, which allows for effective prevention and means that they may be potential beneficiaries of lung cancer screening. Further studies are needed to assess the effectiveness of COPD diagnosis and prevention in this group in order to assess the effectiveness of combined oncological-pulmonary screening.

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**Contributors** AU, KK, WR, TZ designed the study. AU, PK, AR performed literature search and conduct the study, AU and KK analyse spirometry results, AU, KK, TZ, WR, PK contributed to data analysis. AU wrote the first draft and all authors contributed to producing the final text of the manuscript. AU acting as guarantor.

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**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

**Patient consent for publication** Consent obtained directly from patient(s).

**Ethics approval** This study involves human participants and was approved by Independent Bioethics Committee for Scientific Research at the Medical University of Gdańsk (No. NKBBN/173/2016). The participants were informed about all procedures and signed the agreement to participate in the trial. The researchers informed participants about the results by email or phone. Participants gave informed consent to participate in the study before taking part.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data are available upon reasonable request.

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