ORIGINAL RESEARCH

The use of microspirometry in detecting lowered FEV$_1$ values in current or former cigarette smokers

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Abstract

Aims: COPD is an underdiagnosed disease. This study was undertaken to assess the value of microspirometry in detecting reduced FEV$_1$ values in cigarette smokers i.e. subjects at high risk for COPD.

Methods: A total of 611 smokers or ex-smokers with a smoking history >20 years and no previously-diagnosed lung disease were recruited (389 male, age 27-83 years, mean age 56 years, mean smoking history 35 pack years, 19% ex-smokers).

Results: An FEV$_1$ < 80% predicted on microspirometry was found in 44.6% of cases. The mean FEV$_1$ was 2.8 litres (80.6% predicted, range 26-121%). This correlated well with values obtained from full spirometry (R=0.965, p<0.0001). Detailed questionnaire responses revealed that almost half of the subjects (48.2%) reported chronic cough and sputum production and 39.8% reported breathlessness during exercise.

Conclusions: Microspirometry finds a considerable number of smokers or ex-smokers with reduced FEV$_1$ values. Microspirometry is quick to perform. All smokers with reduced microspirometry FEV$_1$ values would benefit from smoking cessation, and all patients with reduced FEV$_1$ values need to be considered for full spirometry to confirm if they actually have COPD.

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Introduction

The prevalence of chronic obstructive pulmonary disease (COPD) is increasing worldwide, but the disease is underdiagnosed.[1,2] Spirometry can be very useful in identifying new undiagnosed COPD cases.[3-8] However, since there is no medication which can slow the progression of COPD,[9] the only way to affect the prognosis and control the current COPD epidemic is early detection of the disease combined with effective anti-smoking counselling and smoking cessation.[10-13]

There are several problems with conducting spirometry in primary care – for example, the difficulty of implementing spirometry as a routine procedure in the community, and the interpretation of spirometric results.[14,15] In Finland, doctors and nurses in all health centres have participated in the national asthma and COPD programmes which include the teaching of spirometry. Education of general practitioners (GPs) and nurses who perform spirometric tests in the primary care setting has been shown to be beneficial, but there are contradictory results.[4,14-19] Once patients are informed of their results, full spirometry may lead to significant smoking quit rates especially in patients shown to have airway obstruction, but not all studies have reported such favourable outcomes.[20-23] In addition, conducting full spirometry in primary care is costly, and it requires time, expertise and extensive training. Recent guidelines do not suggest using spirometry in order to screen for COPD.[24]

An alternative method for the preliminary assessment of lung function values and the provisional diagnosis of COPD in primary care is microspirometry. Hand-held office spirometers

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have already been studied in general practice.[25] Microspirometry is easy to perform in daily practice, and special focus can be directed to smoking cessation in the same setting. If abnormal values are obtained by microspirometry, full spirometry with bronchodilatation testing can then be performed by an experienced lung function technician either in the health care centre or the hospital.

This study was undertaken to assess the potential value of microspirometry in screening for reduced forced expiratory volume in one second (FEV_1) values – i.e. possible new COPD cases – in primary health care.

Methods

This was a cross-sectional study. Inclusion criteria were: smokers or ex-smokers with a smoking history of 20 pack years or more; no previously diagnosed lung disease; and no respiratory infection in the four weeks before the study. Subjects were recruited by 100 physicians from 23 Finnish health care centres (four or five health centres from each of the five University Hospital Districts in the country) from June 2005 to March 2006. Patients who had previously been treated with inhaled medications were excluded. A careful clinical history was obtained to exclude any patients with a previous diagnosis of asthma or COPD. The study protocol recommended smoking cessation, and health care centres offered organised smoking cessation courses for each subject.

Primary health care physicians who recruited the subjects enquired about chronic respiratory symptoms at rest, during exercise, and during the night. The following symptoms were asked about: prolonged cough; shortness of breath; breathlessness on exertion; and any breathing symptoms at night.

Three microspirometry values (using the One flow tester screen manufactured by Clement Clarke International Ltd, Edinburgh Way, Harlow, Essex CM20 2TT, England) were obtained according to the manufacturer's instructions. All physicians were trained to use the microspirometer before the start of the study, and microspirometers were provided for the whole study period. Training was given by an experienced chest physician.

Pilot testing on 32 subjects with normal lung function parameters recruited from a pulmonary consultant outpatient clinic assessed the correlation between FEV_1 values obtained from microspirometry and those obtained by full spirometry (Spirostar DX Spi-rometer M921, program used Software 1.5.2, manufactured by Medikro Ltd, Kuopio, Finland). In the pilot study, there was excellent correlation between the values obtained by microspirometry and full spirometry (r=0.965, p<0.0001). In the current study, subjects who had an FEV_1 < 80% predicted were advised to undergo full spirometry with bronchodilatation testing. However, only a subset of investigators (26 different physicians in 15 heath care centres)

participated in a sub-study collecting data for full spirometry according to international guidelines (n=50).[26] The microspirometry values were correlated with values obtained from full spirometry. The percent (%) predicted FEV_1 values are based on Finnish reference values described in more detail by Viljanen.[27] These same reference values are used in all lung function laboratories in Finland and they specifically reflect the Finnish population.

All statistical analyses were done using SAS® System for Windows, version 8.2 (SAS Institute Inc., Cary, NC, USA). A two-sided p-value less than 0.05 was considered to be statistically significant. Pearson's correlation coefficients were calculated and compared to zero using t-distribution. Linear regression modelling was used to estimate the FEV_1 (%) as a function of age, gender, the presence of the COPD symptoms, and pack years. Bland-Altman plot was used to describe the agreement between microspirometry and full spirometry FEV_1 values.

This study was approved by the Ethics Committee of Helsinki University Hospital with written consent being obtained from every subject.

Results

A total of 611 smokers or ex-smokers were recruited; 389 were male (64.2%) and 103 (19.0%) were ex-smokers. Patient characteristics are shown in Table 1. The mean age

Table 1. Patient characteristics.

	Age (years)	Height (cm)	Weight (kg)	BMI (kg/m²)	Age when started smoking	Pack years
Mean	55.7	171.8	79.9	26.9	18.1	35.1
5% percentile	39	157	53	19.8	12	20
95% percentile	73	186	114	36.9	28	59

Figure 1. Distribution of FEV_1 values (% of predicted).

FEV_1 (% of predicted)
- 25-44%
- 45-64%
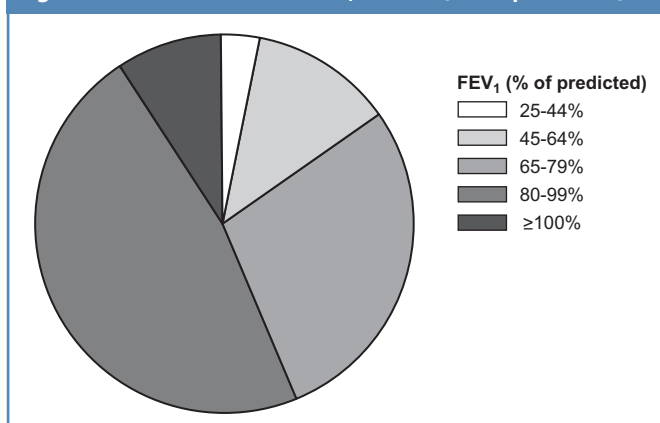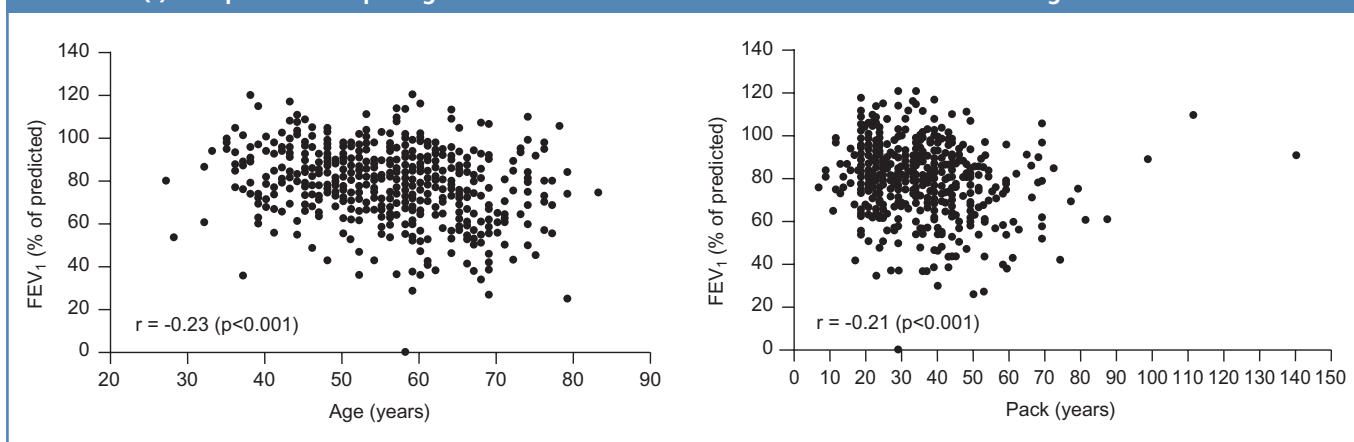- 65-79%
- 80-99%
- ≥100%

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Figure 2A and 2B. Correlation between FEV₁ (% predicted) versus age (years) and pack years. Pearson's correlation coefficient (r) and p-value comparing the correlation coefficient to zero are shown in the figure.

r = -0.23 (p<0.001)

r = -0.21 (p<0.001)

was 56 years and mean smoking history was 35 pack years. The mean (range) FEV_1 measured by microspirometry was 2.8 (0.8-6.0) litres which is 80.6% (26-121%) of predicted values (Finnish reference values).[27] An abnormal FEV_1 (below 80% predicted) was found in 270 smokers (44.6%).

The frequency distribution of FEV_1 values (% predicted) can be seen in Figure 1. Of the subjects who had an FEV_1 < 80% predicted, 50% had an FEV_1 between 70-80% predicted, 40% an FEV_1 between 50-70% predicted, and 10% an FEV_1 < 50% predicted. In all, 294 subjects (48.2%) reported chronic cough and sputum production, 231 subjects (37.9%) complained of shortness of breath, 242 subjects (39.8%) exhibited breathlessness with exercise, and 107 (17.6%) experienced symptoms at night.

There was a significant negative correlation between age and FEV_1 % predicted (r=-0.23, p<0.001, Figure 2a) and between pack years and FEV_1 % predicted (r=-0.21, p<0.001, Figure 2b). The linear regression analysis showed that higher age and presence of breathlessness on exercise, shortness of breath and chronic cough were explanatory factors for lowered FEV_1 values. Furthermore, as expected, female subjects had lower FEV_1 values than male subjects (Table 2).

In addition to the pilot study on healthy subjects with normal lung function values, a sub-set of patients (n=50) with FEV_1 < 80% predicted had full spirometry conducted after microspirometry. A very good correlation was again found between the FEV_1 values and the two measurements (r=0.87, p<0.001, Figure 3) even though microspirometry in general was found to associated with lower values than full spirometry. Of the 50 subjects who had an FEV_1 < 80% predicted, 47 (94.0%) had an FEV_1/forced vital capacity (FVC) ratio below 88% predicted – the ratio used normally in Finland.[27,28]

Discussion

Our study shows that primary health care microspirometry

Table 2. Linear regression analysis of FEV₁ (% of predicted.

Explanatory factor	Estimate of regression coefficient	P-value*
Age (years)	-0.378	<0.001
Gender (male vs. female)	4.803	<0.001
Breathlessness in exercise (yes vs.no)	-4.458	0.002
Shortness of breath (yes vs. no)	-4.462	0.002
Chronic cough, sputum production (yes vs. no)	-3.210	0.018
Pack years	-0.081	0.113
Symptoms at night (yes vs. no)	-0.754	0.672

* P-value is comparing the estimate of regression coefficient to zero.

Figure 3. Bland-Altman plot comparing FEV₁ (L) measured using microspirometry with office spirometry. The office spirometry was perfomed after microspirometry in a subset of 50 patients.

Mean + 2xSD

Mean difference -0.24 L

Mean - 2xSD
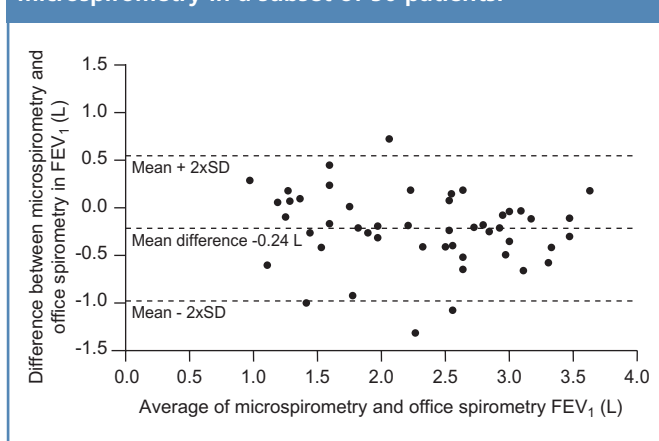
screening of smokers or ex-smokers with a smoking history > 20 pack years can identify a large group of subjects with low FEV_1 values. Even though no bronchodilator reversibility testing had been performed, the FEV_1 values obtained from microspirometry correlated well with values obtained from full spirometry.

Smokers with reduced lung function tended to be older than smokers with better lung function and there was a significant negative correlation between FEV_1 % predicted and age. Similarly, there was a negative correlation between lung function and smoking history. The risk of developing COPD increases with age and smoking history,[29] and it has been proposed that screening for COPD should be limited to older age groups.[30] However, in a recent European study, a high number of younger smokers (aged 20 to 40 years) had COPD, and even mild disease was associated with more extensive use of health care resources.[31] In the current study there were several cases of low FEV_1 among younger smokers. Many Europeans smoke at an even younger age[32] and therefore it is not uncommon to find COPD in young smokers; they tend to have less nicotine dependence and a higher potential for successful quitting.[20] Therefore, based on these findings, screening for COPD and especially smoking cessation efforts should not be restricted to older smokers. Furthermore, normal lung function can also be used as a motivational tool for quitting: it is never too late to stop smoking …

It is difficult to determine the target group of smokers who should be directed to full spirometry since many smokers are symptom-free, and there may be symptoms without the presence of airway obstruction. Our study showed that smokers with reduced lung function experience more symptoms than smokers with normal lung function – as would be expected – and that symptomatic smokers have lower FEV_1 values than non-symptomatic smokers. In a Dutch study,[33] spirometry needed to be conducted in four patients with prolonged cough to find one at-risk patient with an FEV_1 < 80% predicted; however, in their sub-group of symptomatic smokers over 60 years old, obstruction was found in 45%. In another study from Poland, 31% of smokers with more than 10 years' smoking history (over the age of 40 years) exhibited obstruction whereas only 8.3% of smokers < 40 years old and with a smoking history < 10 pack years had obstruction.[6] The latter percentage was less than in older never-smokers.

It is known that symptoms alone are poor indicators of COPD and that spirometry is mandatory if one wishes to detect COPD.[13] To avoid these caveats, the exact target group for COPD screening should perhaps not be limited only to symptomatic smokers. Most new cases found by screening spirometry represent mild/moderate disease, and often do not require any therapy. It is, however, of the utmost importance that all smokers, regardless of how long they have smoked, should be given appropriate advice and help to quit smoking.

All current guidelines state that COPD diagnosis and staging requires spirometry and a bronchodilatation test.[9,34] However, there is controversy about the use of spirometry in COPD case-finding.[35,36] Recent recommendations commissioned by the United States Agency for Health Research and Quality[37] and the USA Preventive Services Task Force (USPSTF)[24] found little if any justification for conducting spirometry in primary care for the screening of COPD. These conclusions were based on the cost and poor prognostic value of spirometry to predict future respiratory impairment, and on the inability of current medical therapies available for mild COPD to reduce disease progression and exacerbation rates. These recommendations did not include any studies on microspirometry. There are data showing that detection of bronchial obstruction by spirometry can lead to both smoking cessation and to a reduction in the numbers of cigarettes smoked per day[20-22] even though opposite results have been reported as well.[23] Recent studies from Poland[20,21] suggest that simple smoking cessation advice combined with spirometry can result in good one-year cessation rates of 16.3%, especially in those subjects with airway obstruction.[20] In this Polish study, the validated smoking cessation rate in those with *normal* spirometric parameters was relatively good (12.0%). Similar findings were found in a recent Swedish study where annual spirometry and brief cessation advice by a nurse showed high smoking cessation rates (25-29%) in smokers with COPD.[22] These results are also in agreement with an older study in which quit rates improved to 22% when spirometry was combined with education and nicotine replacement therapy.[38] Overall, it appears that spirometry combined with an efficient antismoking campaign can improve smoking cessation – and therefore microspirometry may be a practical way to start this screening.

Microspirometry is quick to perform, does not take longer than measuring blood pressure, and the measurements can also be performed by a clinical nurse specialist in the community.[39] This is no more difficult than using peak expiratory flow (PEF) meters, with which there has been excellent experience in Finland within the National Asthma and COPD Programmes.[16,18] Peak flow values, however, have several weaknesses compared to FEV_1 measurements, one of which is their effort dependence.

One important aspect about screening is whether it is cost effective.[19,40] Full spirometry generally requires another visit to a lung function laboratory, while microspirometry can be successfully performed during the visit to the GP or experienced nurse with a low cost device (around 110€) – as compared to spirometry which requires more personnel. Moreover, many primary care facilities have a shortage of qualified staff and limited financial resources. Even though the values obtained by

full spirometry and microspirometry correlated very well, values obtained by microspirometry were generally lower than those obtained by full spirometry. The optimal cut-off value obtained by the ROC analyses (not shown) in order to distinguish between normal values was below 70% for microspirometry instead of 80% for full spirometry.

One limitation of our study was that we did not systemically determine the impact of microspirometry screening on patient follow-up. Only in a sub-set of patients was full spirometry conducted in order to assess reproducibility. Nevertheless, microspirometry measurements were accurate and the correlation with full spirometry was excellent both in the pilot study in normal controls and smokers, and in subjects with reduced FEV_1 values, as has been shown previously.[41] Our impression is that the awareness of COPD among the primary care physicians involved was greatly improved. The patients were directed to smoking cessation programs, but this cross-sectional study was not designed to quantify these parameters. Our study was done in a relatively short period of time over nine months. Previous data has shown that unless there is continuous re-inforcement by using spirometry for the screening of smokers, the enthusiasm fades.[14] This emphasises the importance of national programmes for COPD and on-going education.[17] Other potential diagnoses for symptomatic smokers with a low FEV_1 are restrictive lung diseases and asthma. They should be excluded by means of a chest X-ray, spirometry and bronchodilatation test and PEF follow-up measurements. It can also be argued that subjects with normal FEV_1 values might have a reduced FEV_1/FVC ratio and risk of developing COPD. This is certainly possible, but resources in order to perform full spirometry for all smokers are often limited in primary care.

In conclusion, our study has shown that it is feasible to screen for abnormally low FEV_1 values – i.e. probable COPD – with microspirometry in primary health care, and that the accuracy of measurements when compared to full spirometry is excellent. Microspirometry identifies a large population of smokers or ex-smokers with lowered FEV_1 values who have no previous diagnosis of lung disease. Its use is not only feasible but also cost-effective, and the availability of this technique improves COPD awareness among both primary health care physicians and smokers. Individuals with abnormal microspirometry values need to be investigated further by full spirometry and reversibility testing. In addition, all smokers with either normal or abnormal FEV_1 values shown on microspirometry would benefit from smoking cessation.

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