SPIROMETRY VALUES IN ADULTS IN NORTHERN FINLAND

ABSTRACT

Objectives. If reference values do not accurately reflect the distribution of lung function in the population, the interpretation of spirometry results may be incorrect. Differences in lung function exist between populations, which supports the use of local reference values. In Finland, the national reference values for spirometry are currently in use. The aim of this study was to assess the correlation between measured spirometric values from healthy adults and the reference values used in Finland.

Methods. In the present population-based study, spirometry results were assessed in healthy adults aged 21 to 70 years in northern Finland. After exclusions for any chronic pulmonary disease or symptom, 206 men and 215 women remained in the group. We calculated regression equations for spirometric reference values in adults and compared these with European recommendations, and with the reference values currently used in Finland.

Results. These comparisons revealed large differences. The linear models do not take into account the physiological changes in both young and old adults and, thus, the reference values calculated according to the European recommendations differed from the real measured results at both ends of the 20- to 70-year age scale. Moreover, values from the logarithmic Finnish reference equations also diverged from our measurements; the differences were largest in subjects younger than 30, and in elderly men.

Conclusion. Differences between populations and reference equations make international comparisons difficult, and divergence between reference values and real results may lead to incorrect clinical interpretation. (Int J Circumpolar Health 2004;63(2):129-139)

Key words: epidemiology, lung function, reference values
INTRODUCTION

Spirometry is the most important means for detecting changes and disturbances in lung function, both in screening and diagnosis, and also in following treatment effects of pulmonary conditions. The interpretation of spirometry results depends on both the actual measurement and the reference values. Common lung function reference values for the adult populations in Europe have been recommended by the European Respiratory Society (ERS) (1, 2), and similarly in the US by the American Thoracic Society (ATS) (3).

The fact that recent studies have shown differences in lung function between populations or ethnic groups, supports the use of ethnic, or local reference values (4-10). In Finland as well, the national reference values for adults are recommended by the Finnish Association of Clinical Physiology and the Finnish Association of Chest Physicians (11-13). The Finnish reference values were calculated in late 1970s from spirometric measurements of healthy non-smokers, including 296 men and 257 women, all employees of the State Railway company, Helsinki district (14). Since these values differ considerably from the European reference values (13), difficulties may ensue when pulmonary function results are compared internationally. It may also be asked whether a selected worker group is truly representative of the whole Finnish adult population. Another question is whether these Finnish reference values (14), developed more than 20 years ago from measurements with a dry-rolling seal spirometer, are still relevant. Nowadays most spirometers use either a pneumotachograph, or a mass-flow sensor as the measuring device.

Our population-based clinical study (15) gave us the opportunity to assess spirometry results in northern Finland in healthy adults aged 21 to 70 years, and to evaluate how the results fit into the Finnish reference values (14).

The aim of this study was, firstly, to calculate regression equations for spirometric reference values and, secondly, to compare these equations with the European Community for Steel and Coal (ECSC), or ERS, recommendations (1, 2), and with the reference values currently used in Finland (14).
METHODS

Study area and population
During the winter 1995-96, a postal questionnaire study was conducted in the central and southern part of the Finnish Lapland. A random sample of 7937 subjects, in the age group 20 to 69 years, was invited to participate in a postal questionnaire study; 6633 of them (83.6%) responded. Of the respondents (n=3420) in the southern part of the study area, a random sample of 959 subjects was invited for clinical studies at the out-patient clinic of Länsipohja Central Hospital. That study included a structured interview, skin-prick tests, pulmonary function measurements and serum samples. At the time of the clinical study, the participants were 21 to 70 years of age. From this clinical study material, the prevalence of chronic obstructive pulmonary disease (COPD) in Finland has been analysed (15).

Structured interview
The FinEsS interview questionnaire, developed from the Obstructive Lung Disease in Northern Sweden Study (OLIN) questionnaire (16), includes 162 questions to assess respiratory symptoms (cough, sputum production, wheezing and shortness of breath) and respiratory symptom-provoking factors. Data about asthma, chronic bronchitis, use of medicines against allergy, asthma or respiratory symptoms, other chronic diseases, other medications, heredity, need for health services, socio-economic factors, profession, and smoking habits, was also obtained. Amount of smoking was calculated as cumulative pack-years. The interviews were performed by specially trained nurses.

Lung function tests
Tests included flow-volume spirometry, a broncho-dilatation test and slow vital capacity. At least three successive spirometric measurements were performed with a flow-volume spirometer (SensorMedics VMAX-22, mass-flow sensor) according to the ATS standards, employing the best curve method (17). The spirometer was calibrated daily. The measurements were performed with the subjects in a sitting position, with nose clips and standard bacterial filters. Broncho-dilatation was assessed 10 minu-
tes after inhalation of salbutamol 2 x 200 μg (Ventoline MDI 200 μg/puff with Volumatic, Glaxo Pharmaceuticals, UK).

Selection of the reference population
All those with acute respiratory disease, or with a history of chronic lung disease, or with chronic pulmonary symptoms, or those who had been treated by a doctor for a pulmonary problem, were excluded.

Mathematical and statistical methods
Smokers were not excluded, but a mathematical correction was calculated for the effect of smoking. The reference equations presented show results when the effect of smoking is fully compensated. The accuracy of lung function equations in young adults was increased by adding to the data spirometric measurements from a randomly selected group of 7 healthy males and 12 healthy females 12 to 18 years of age. Our own normal values were obtained by a linear step-wise regression analysis (a program from the IBM-1130 library from early 1960ies). Exponential functions were calculated by the same measures as in the Finnish standards (14); age, log(age) and 1/H (H=height). Linear functions were calculated with age and height as the explaining variables, following the ERS (1) recommendations. Means and standard deviations were calculated when appropriate.

RESULTS

Participation and smoking habits
A total of 959 subjects were invited to the clinical study; 695 attended. Complete data with pulmonary function measurements were obtained from 683 subjects (71% of invited). Men in the youngest age group had the lowest participation rate both, for the questionnaire and in the clinical study. After exclusions for any chronic pulmonary disease or symptom, 206 men and 215 women remained in the group (Table I). The mean amount of smoking was 10 pack-years for ex-smokers and 15 pack-years for current smokers.
Normal values for spirometry calculated from the study group

The following regression equations for non-smokers were calculated from the spirometry results of the 213 men (m) and 227 women (f) (Table II).

**Comparison with European and Finnish reference values**

These equations were compared with the Finnish (14) and ECSC/ERS (1, 2) reference values in the measured 206 men and 215 women aged 21 to 70 years. The measured FVC, FEV₁, and MEF₅₀
values for each subject are shown as scatter plots against results calculated for each individual from the Finnish reference equations in Figures 1a-f.

A direct comparison showed that FVC, FEV₁ and PEF values calculated according to the ECSC equations were lower than those measured in our study subjects. The mean difference for men was
8% in FVC, 5% in FEV₁ and 10% in PEF and, for women, the values were 13%, 8%, and 6%, respectively (Table III). However, according to the ECSC, MEF₅₀ was 10% higher in both men and women than was the measured result (Table III). Results calculated from the Finnish logarithmic equations were higher than measured in our population: for men the mean difference in FVC was 3%, in FEV₁ 6%, in PEF 6% and in MEF₅₀ 21%; for women, the values were 3%, 4%, 6%, and 21%, respectively. As our model curves show, the differences were much larger in subjects aged 20 to 30 years, and in men aged over 50 (Figure 2a-h). As a clinical consequence, compared to our population, the Finnish reference values give a FEV₁/FVC ratio that is too high for elderly men.
Figure 2 a-h. The model curves for FVC, FEV1, PEF and MEF50 for mean height men (175 cm), and women (162 cm), according to our current linear and logarithmic, ECSC linear and the Finnish logarithmic reference value equations.

\[ x = \text{current lin}; \quad \square = \text{current log}; \quad \Delta = \text{ECSC}; \quad \bullet = \text{Finnish} \]
DISCUSSION

The comparison between our results and the Finnish reference values and the European recommendations (ECSC/ERS) reveal large differences. Obviously, the linear models do not take into account the accelerated physiological changes in both young and very old adults, and thus the results according to the European recommendations differ at both ends of the 20- to 70-years age scale. Linear regression equations calculated from our population show higher lung volumes than those in ECSC recommendations. This supports the findings that Finns have larger lungs than do Europeans in general (13), but the difference between our measurements and ECSC values was smaller than the difference between the ECSC and Finnish reference values.

Surprisingly, the values from the logarithmic Finnish reference values also diverged markedly from our measurements: according to the scatter plot comparison, the differences were especially striking in subjects younger than 30 and in men older than 50. The Finnish reference values for FEV₁ in elderly men might be too high and, as a consequence, may lead to over-diagnosis of pulmonary obstruction. A selection bias in the Finnish reference values might be possible: all tested subjects were from the Finnish State Railway Company (healthy-worker effect?). Moreover, in the age group 60 or older (60 to 65 years), the Finnish reference study (14) had only 9 men and 13 women. Our measurements were obtained with a mass-flow sensor, while the current Finnish reference values were established with a dry-rolling seal spirometer. In our opinion, this methodological difference does not explain the divergent results: theoretically, a rolling seal could give lower end expiratory flow values, but the results show the opposite.

It may be argued that our population sample was too small. Obviously, a larger group size should increase accuracy. Our study was neither designed, nor aimed, to create new reference values for adults in Finland, but on the other hand, population sizes in several reference value studies have been in the same range (3,4,6,14,18,19). Due to the low number of subjects aged 21 to 30 years in our study, measurements from 19 healthy teenagers were added. The regression equations calculated with this addition followed the physiologic changes in lung function of teenagers and young adults better.

Another weakness in our study might be that 57 % of our subjects were, or had been, smokers. Usually, smokers have been excluded from reference populations (3-10,14). However, in two Swedish studies published in 1985-1986, employing a similar method to ours, smokers were not excluded, but the effect of smoking on lung functions was calculated, and the re-
results were corrected for the effect of smoking (18,19). Lung function equations from these studies are still in use in Sweden. In our study, the mean amount of smoking was low and smoking had only a modest effect on FEV₁, MEF₅₀ and FVC, but not on PEF. The effect of smoking was mathematically corrected. After this correction, the mean values and the distribution of the results from subjects with a smoking history were similar to those obtained from non-smokers. Thus, the effect of smoking does not explain the difference between our results and the Finnish reference values and the European recommendations.

Many studies have reported spirometry results to deviate from the common reference values (4-10), and most of these reports found better correlation with non-linear than with linear equations (4-8). Similar to our findings, the European Community Respiratory Health Survey (ECRHS) found that ECSC equations lead to an "under-estimation of both predicted FVC and predicted FEV₁". An ECRHS report concluded "that the use of ECSC equations…may provoke significant under-estimation of spirometric results" (20). Our results are in agreement with these findings; logarithmic equations gave better accuracy than linear models.

Our study subjects were taken as a random sample from the general adult population of 21 to 70 years of age. All subjects with acute respiratory problems or with a history of chronic respiratory disease, or chronic respiratory symptoms, were excluded. It can thus be assumed that the subjects measured in this study represent healthy adults in this age range in the study area; and taking into account the homogeneity of the population in Finland, these results may also apply in other parts of the country.

In conclusion, spirometric measurements of our population-based study material show that neither the ECSC, nor the Finnish reference values accurately reflect the distribution of measured spirometric values in healthy adults of 20 to 70 years of age in northern Finland. Although real differences in lung function between northern and southern Finland seem unlikely, the difference between our results and European reference values might reflect an adaptation: a northern population has larger lung volumes than does a southern one. Consequently, local reference values should be available for northern populations.

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