Original Article

Spirometry Reference Values and Equations in North Indian Geriatric Population

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Abstract

Background. Spirometry or pulmonary function test (PFT) is the most common test used to assess pulmonary functions; though its reference values are variable in different populations. Limited data are available regarding the reference values of pulmonary function tests in north Indian elderly population and prediction equations to assess these values.

Methods. A prospective study of 366 non-smoker north Indian subjects of both gender above the age of 60 years was conducted in our institution. The subjects performed spirometry as per American Thoracic Society (ATS) guidelines. The spirometry values for forced expiratory volume in one second (FEV_1), forced vital capcity (FVC) and peak expiratory flow rate (PEFR) were measured.

Results. There were 243 males (66.4%) and 123 females (33.6%). The males had higher mean age, height, weight and body surface area. The body mass index was lower in male subjects as compared to female subjects. Mean FEV_1, FVC and PEFR were higher in males. Reference values were derived using multiple regression analysis. Observed and predicted spirometry values were compared.

Conclusion. Our results highlight the importance of using prediction equations appropriate for the ethnicity, age and height characteristics of the patient population being evaluated with PFT. **[Indian J Chest Dis Allied Sci 2017;59:125-130]**

Key words: Spirometry, Asthma, COPD, Geriatric population.

Introduction

Spirometry is the most readily available, safe, cost-effective and valuable pulmonary function test (PFT) measuring the volume of air exhaled at specific time points during a forceful and complete expiration after a maximal inspiration. It is a key diagnostic test for diagnosis of asthma and chronic obstructive pulmonary disease (COPD). The principal spirometric parameters, forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and peak expiratory flow rate (PEFR) were measured and compared with reference values, which are calculated from regression equations derived from previous studies on healthy people.

The reference values play an important role in establishing whether the volumes measured in an individual fall within a range to be expected in a healthy person of the same gender, height, age. Ideally, pulmonary function laboratories should use reference equations derived from the subjects with a similar ethnic background to the patients being evaluated.[1,2]

There is evidence of considerable variations in normal values of pulmonary functions in different ethnic groups and across different age-groups.[3-5] Racially, Indians are not only smaller in body habitus as compared to white populaiton; but also pursue more sedentary occupations than those living in Europe and America. These factors combined with poor nutrition and repeated childhood respiratory infections perhaps are reasons for impaired lung functions in the Indian populaiton.[6,7] In India also, it is generally accepted that North Indian populaiton has larger lung volumes than their South Indian brethren.[8] Several factors, such as differences in body proportions, chest wall anatomy, parenchymal lung development and mechanical properties of the thorax may account for these variations.[9-14]

Normal lung function values are known to change with age. After an initial increase in first two decades of life, these begin to decline at about 20-30 years of age.[15,16] This physiological decline is attributed to age-related reduction in elastic recoil of the lungs and early closure of the airways. Therefore, reference lung function values for the geriatric subjects cannot be extrapolated from the equations generated for the adults. The current international guidelines also recommend that spirometry reference equations

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should, in general, not be extrapolated for different age groups or heights which were not included in the initial study population.[17]

Studies from different regions of the world have tried to derive predictive equations that are in agreement with the lung functions of their native populations.[18-24] Age group specific spirometry reference values for subjects up to 80 years old and in the age range of 65–85 years have been generated by using data from representative samples of the Caucasian population in North America.[25,26] However these values cannot be used to predict baseline values for Indian population.[27]

There is paucity of studies on deriving reliable prediction equations for lung functions reference values which are applicable to Indian subjects, especially in the geriatric population.[28,29] Inclusion of smokers and narrow age range of subjects have limited the strength of earlier studies.[28] The present study has been undertaken to generate predictive normal reference PFT values and to deduce a predictive equation for the reference values in geriatric population in north Indian city of Chandigarh.

Material and Method

In the present study, subjects of both genders above 60 years of age were randomly selected from the general population in the Chandigarh city. Chandigarh is a Union Territory roughly divided in to 63 sectors with varied distribution of population in each sector. A total of 25 sectors were chosen by simple random sampling and 20-30 subjects were enrolled from each selected sector. A total of 641 subjects were enrolled in the study, however, only 366 subjects met the inclusion criteria. The subjects were contacted using phone calls, mail, displaying study information at the public places, visiting the senior citizens congregation points etc. Inclusion criteria for the subjects were absence of any intensive athletic training; non-smoker status; no evidence of any cardio-respiratory dysfunction on physical examination, chest radiograph and electrocardiogram; and absence of any symptom of rhinitis, common cold, dyspnoea or cough. The subjects with history of any lung disease, inability to walk, communicate or give informed consent were not included in the study.

A subset of the standardised American Thoracic Society Division of Lung Disease Questionnaire-78 (ATS DLD-78) was administered to each subject. In addition to detailed clinical examination, a chest radiograph and electrocardiogram (ECG) was taken. Bare foot height and weight was recorded and body mass index (BMI) was calculated. Each subject was explained about the purpose and methodology of the test before conducting the test. The test manoeuvre was explained as well as demonstrated to the subjects. The test was carried out in sitting posture. All tests were performed according to ATS guidelines.[20] The test was carried out between 10 AM and noon after full night rest and light breakfast in the morning. The subjects were allowed to take one hour rest before performing the test. Pulmonary function tests were performed using Spiro Analyzer, Model ST-90, Fakuda Sangyo Co. Ltd. Tokyo, Japan after volume calibration at 6 litres and temperature calibration at room temperature to give values at British Temperature Pressure Standard (BTPS). The subjects were encouraged continuously during the procedure for maximal effort. Three readings were taken and best one was chosen for the final analysis as per ATS guidelines. Only those test values were taken as the best acceptable values which were without false start and back extrapolated volume less than 5% of FVC or 150mL whichever was more.

The ICMR guidelines-2000 for biomedical research on human subjects and all the basic principles contained in Declaration of Helsinki for biomedical research involving human subjects were strictly adhered to in the study.

Statistical Analysis

Statistical analysis was carried out using Statistical Package for the Social Sciences (SPSS; version 20.0) (SPSS Inc. Chicago, USA). Data of male and female subjects were analysed separately and are presented as mean with standard deviation (95% confidence interval), range and percentages as required. Pearson's correlation analysis and univariate regression were carried out to identify the significant predictor variables from amongst age, height, weight, body surface area (BSA) and BMI for each of the dependent variables. Prediction equations were derived using multiple regression analysis. Analysis of variance was carried out for each model to evaluate significance of the regression equation and standard errors of the estimate (SEE) were calculated. Estimates of regression coefficients for predictor variables were obtained and their significance was determined by student's t-test.

Results

A total of 366 elderly subjects were randomly selected from the general population; out of which 243 (66.4%) subjects were males and 123 (33.6%) subjects were females. The mean age for male population (70.9±6.6 years) was higher than the female group (67.2±6.1 years). The mean height, weight and BSA were higher in the male group as compared to those of female group (Table 1). However, BMI was higher among the females (Table 1).

Table 1. Mean values in the male, female and total subjects

Parameter	Males (n=243)	Females (n=123)	Total (N=366)
Mean age (years)	70.9±6.6	67.2±6.1	69.7±6.6
Mean height (cm)	167.7±6.5	156.7±6.9	164.0±8.4
Mean weight (kg)	72.2±11.6	65.6±11.9	69.9±12.1
Mean BMI (kg/m²)	25.6±3.8	26.7±4.4	26.0±4.00
Mean BSA (m²)	1.8±0.2	1.6±0.2	1.7±0.2

Definition of abbreviations: BMI=Body mass index; BSA=Body surface area

Out of the total subjects, 64 (17.5%) had diabetes mellitus (DM) and 151 (41.3%) subjects suffered from hypertension; but they did not have any history of coronary heart disease. The mean spirometry values for FVC, FEV_1, and PEFR are depicted in table 2.

Predictive equations were calculated for the spirometry values separately for male and female subjects using multiple linear regression analysis (Table 3).

Table 2. Spirometry values in both the groups

Spirometry Values	Males (n=243)	Females (n=123)	Total (n=366)
FVC (L)			
Mean	2.7±0.6	2.1±0.9	2.5±0.8
Range	1.2 to 5.8	0.9 to 9.6	0.9 to 9.6
FEV_1 (L)			
Mean	2.2±0.5	0.7 to 3.6	2.0±0.7
Range	0.7 to 3.6	0.6 to 9.0	0.6 to 9.0
PEFR (L/sec)			
Mean	7.2±2.1	5.0±1.7	6.5±2.3
Range	1.1 to 12.8	1.2 to 10.2	1.1 to 12.8

Definition of abbreviations: FVC=Forced vital capacity; FEV_1=Forced expiratory volume in one second and PEER=Peak expiratory flow rate

Discussion

In the present study, an endeavour has been made to derive a predictive equation of pulmonary function tests in the elderly Northern Indian population. Chandigarh city is the capital of two North Indian states, namely Haryana and Punjab, and is inhabited by population from these two states along with population from another neighbouring state of Himachal Pradesh.

Therefore, prediction equations derived from this city are very likely to give a close picture of the elderly North Indian population. In the current study a correlation between lung functions with age, gender, height, weight, BMI and BSA has also been derived. This study included healthy subjects of both genders of age greater than 60 years. Spirometry was performed by a trained technician adhering ATS standards after taking due consent from the volunteer subjects.[17] The predictive equation for FVC, FEV_1 and PEFR was derived using multiple linear regression and this was found to be most dependent on age and height of the subjects. These predictive equations were derived separately for male and female subjects.

The equation derived in the present study is similar to that derived by Ostrowski *et al*.[19] Reference values of FVC and FEV_1 for female and male subjects in both studies have been calculated by linear multiple regressions with age and height used as predictors.

The study conducted in central India by Phatak and co-workers had variable results.[29] The authors documented that the correlation of age with FEV_1 was highly significant ($p < 0.01$); but the correlation was not significant with FVC ($p > 0.05$). The authors further observed that the correlation of height, weight and BSA was not significant for any other lung function value ($p > 0.05$). However, in the present study a clear-cut negative correlation with age and positive correlation with height for each parameter, i.e. FVC, FEV_1, PEFR has been observed. In male subjects, FVC, FEV_1 and PEFR had positive correlation with body

Table 3. Prediction equation for FVC, FEV_1 and PEFR in both male and female groups along with R square (R^2) and the standard error of estimate (SEE)

	Prediction Equation	R^2	SEE
Males	FVC = -3.982 + height (cm) × 0.049 – age (years) × 0.021	0.262	0.556
	FEV_1 = -3.129 + height (cm) × 0.042 – age (years) × 0.024	0.316	0.425
	PEFR = -10.817 + height (cm) × 0.134 – age (years) × 0.062	0.184	1.93
Females	FVC = -3.186 + height (cm) × 0.047 – age (years) × 0.032	0.126	0.849
	FEV_1 = -0.938 + height (cm) × 0.033 – age (years) × 0.037	0.075	0.782
	PEFR = -10.214 + height (cm) × 0.125 - age (years) × 0.066	0.296	1.42

Definition of abbreviations: FVC=Forced vital capacity; FEV_1=Forced expiratory volume in one second and PEER=Peak expiratory flow rate weight and BSA; but there was no correlation with BMI. However, in female subjects, weight and BMI also had no correlation with FVC, FEV_1 and PEFR.

It is important to appreciate that there are wide variations in the lung function values amongst different subjects all over the world. These variations are not only limited to racial differences but can also be present among different geographical regions. As India is a vast country, this variation among different regions is more obvious and every region should have an established standard to prevent misdiagnosis of ailments in the patients.

A comparison of the values for FVC and FEV_1 observed in the present study with other available studies worldwide is given in figures 1 to 4.[20,22,29,30]

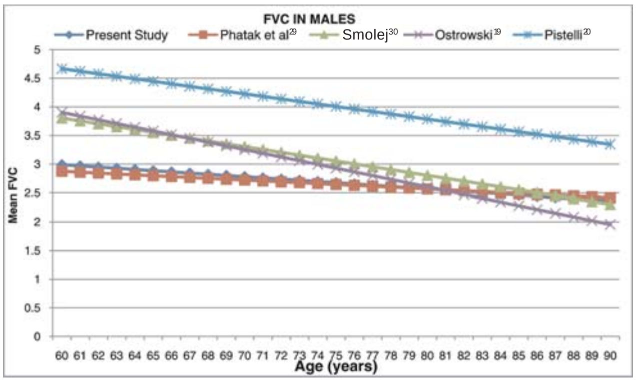

Figure 1. Comparison of mean FVC values in males in the present study with other studies.

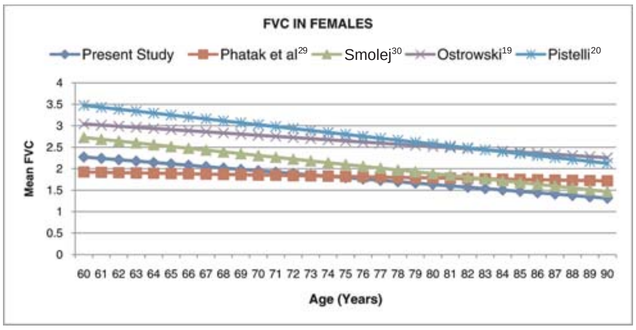

Figure 2. Comparison of mean FVC values in females in the present study with other studies.

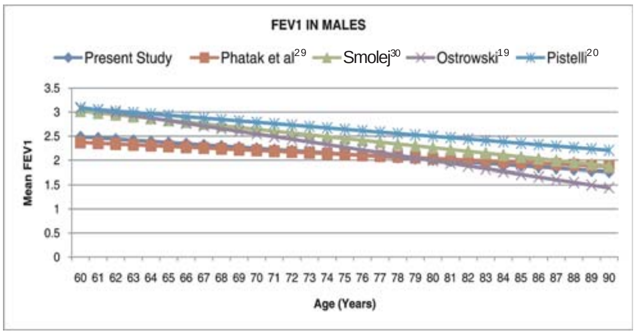

Figure 3. Comparison of mean FEV_1 values in males in the present study with other studies.

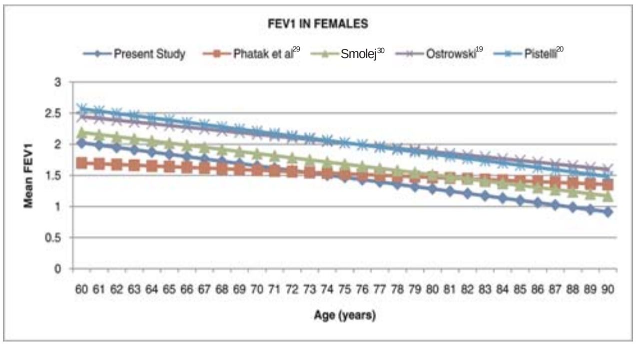

Figure 4. Comparison of mean FEV_1 values in females in the present study with other studies.

The comparison of the present study PEFR data with other studies was not done as most of the previous studies lacked PEFR data measurement. The plausible explanations for the differences amongst various groups may be due to variation in age and height, selection procedures, exclusion criteria, choice of the instruments used and cumulative environmental exposures. The aim of Global Lung Initiative (GLI) 2012 was to establish improved international spirometry reference equations. The resultant equation is global multi ethnic reference equation that covers all ages and is dependent on the patient profile, such as age, height and race. The GLI-2012 did not include the data from few south-east Asian countries including India as the datasets from such centres were too small to be combined with other data sets.

The GLI-2012 recommended that more studies are required in non-Caucasians, particularly Arab, Indian, Polynesian, African and Latin American subjects, including ethnic minorities and to ensure selection of a representative sample of healthy reference subjects aged between 3–95 years. In fact, GLI-2012 clarified that values calculated for the South-east Asian female subjects are not valid for Indian female population; but are derived for the female population of mongoloid ethnicity.[31] This further adds to the importance of the current study as it helps to predict spirometry values of geriatric population in the Indian context.

The limitation of the present study includes an element of selection bias as few subjects of geriatric population included in the study were institutionalised in old age homes where they are more prone to develop respiratory infection. However, caution was taken not to include the subjects who had history of any recent infection. India is a developing country where biomass fuel is still used as domestic fuel for cooking. Exposure to biomass fumes in the present or past was not ruled out which could be another limitation of the study.

Moreover, the exact socio-economic status of the subjects was not recorded, and hence, its effect on the spirometry values could not be investigated. However, an attempt was made to include subjects from a wide socio-economic strata of the society. Even though smoking history was well elicited; the possibility that few subjects concealed this variable cannot be ruled out.

The equation derived through the present study is in the format: "Predicted value = a + height (cm) x b – age (years) x c", where a, b and c are constants varying for both males and females. The authors are of the opinion that ongoing research is vital to refine the pulmonary function standards and keep them updated in our country.

Other studies have also supported the need for update of pulmonary function reference values due to the change in factors such as nutrition, environmental exposures, childhood infections and lifestyle over a period of time.[32] Updated standards of reference values will enable clinicians and researchers to correctly recognise the influence of a disease on the respiratory system, and the influence of environmental factors on lung functions.

Conclusions

Spirometry is an important tool for determining lung pathology. However, it does not have any absolute cut-off values applicable to all subjects which can label a patient to have obstructive or restrictive lung disease. The interpretation of spirometry parameters in a subject largely depends upon the available reference values. These reference values are variable depending upon age, height, gender and ethnicity. India being a vast country has a wide variation in the PFT values depending upon the geographical location of the population. The present study is an attempt to determine the predictive equation for North Indian geriatric population. The derived predictive equations are realistic to calculate predicted PFT values in elderly subjects. The current study enables clinicians to use reference PFT values calculated through the evidence-based predictive equations in arriving at accurate diagnosis to improve the management in elderly patients in North India. However, the equation needs to be further validated in an independent set of subjects for a more robust reference data for our country.

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