Original Article

Spirometric reference values in healthy, non-smoking, urban Pakistani population

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Abstract

Objective: To estimate the lung function prediction equation and to calculate appropriate normal reference values for the Pakistani adults living in Karachi.

Methods: Predicted equations for normal lung functions were derived from 504 healthy non-smoking subjects including 321 males and 183 females aged 15-65 years. The subjects underwent measurement of spirometric flow and volume. The following variables were measured: forced vital capacity (FVC), forced expiratory volume in one second (FEV1), maximal mid expiratory flow (MMEF) and peak expiratory flow (PEF). Regression analysis using height and age as independent variables were applied to provide predicted values for both sexes.

Results: There was negative correlation between each pulmonary function and age. All parameters correlate positively with height. The largest negative correlation was found for FEV1 and FVC in males, while the largest positive correlation was observed for FVC in females.

Conclusion: In this study set of PFT reference values and prediction equations for both sexes have been derived using healthy, non-smoking urban Pakistani population which was different from several other prediction equations (JPMA 57:193;2007).

Introduction

Pulmonary function variable depends on height, age and gender. There is evidence of considerable variation in pulmonary functions in different ethnic groups and across generations.[1] Reference equations are used to determine a normal range of spirometry results. Reference values play an important role in establishing whether the volume measured in an individual fall within a range to be expected in a healthy person of the same gender, height and age. Several studies have examined the development of lung function in young adults and reported continued growth of lung functions into early adult hood, followed by decline beginning at 35 years of age.[2] This has been described as a steady state period where there is little or no growth occurring and called plateau phase of lung function development.[3,4] The American Thoracic Society acknowledges the presence of documented racial and ethnic differences such differences must be considered when interpreting pulmonary function tests.[5]

Interpretation of pulmonary function measurements is complicated by the fact that the predicted values from different published studies vary in different individuals.[6,7] Another study has demonstrated, however that ethnic groups differ in pulmonary function[8], and therefore reference equation based on European population may not be accurate for all subjects.[4]

The objective of this study was to estimate the lung function prediction equations and to identify appropriate normal reference values for the Pakistani adults living in Karachi.

Methods

The study was conducted in Karachi, the largest city of Pakistan with a population of approximately 13 million belonging to different ethnicities.[9]

A total of 601 healthy non-smokers who met the inclusion criteria participated in the study. Participants belonged to various walks of life, either students or employees of different organizations. Few of the participants were workers or shopkeepers from different areas of the city. All the participants were called in Ziauddin Medical College, Physiology laboratory for the measurement of pulmonary function tests. The participants completed a questionnaire that gathered the information on age, sex, health and smoking habit. Body measurements were taken, including the standing height and weight. All subjects were non smokers with no history of symptoms of cardiovascular or respiratory diseases that required treatment. Subjects who had recovered from common cold at least one month prior to the study were allowed to participate.

Forced expiratory maneuvers were recorded using micromedical, microloop and microrint (airway resistant) in conjunction with spida 5 PC software. The spirometer was calibrated daily with a 3L calibrating syringe. After explanation the procedure, every subject was asked to perform the test. A minimum of 3 acceptable and reproducible maneuvers were obtained, according to the standards recommended by the American Thoracic Society.

The data was entered in computer programme "Microsoft Excel" and analyzed using the Statistical Package for Social Science (SPSS) version 11 for window software. Results from participants whose spirometry test session did not meet the ATS standard for acceptability and reproducibility were excluded from analysis. The data for age, weight, height and pulmonary function parameters were

expressed as mean and standard deviation. A graph of pulmonary function variables against height and age were initially examined for each gender. Means and standard deviation of all quantitative variables (age, height and weight) were compared according to gender by student's t-test. Multiple linear regression analysis was applied to observe lung function values as a function of standing height and age. The FEV1, FVC, etc were dependent variables, while height and age were independent variables. Correlation coefficient (r), r2 and SEM were also calculated.

In all statistical analysis, only p-values <0.05 were considered significant and correlation coefficient of > 0.4 or < - 0.4 were regarded significant.

Results

Out of 601, only 504 subjects, (321 males and 183 females) were analyzed as they completed the pulmonary function measurements. The age of the subjects was 15 to 65 years and they were divided into three age groups on the basis of the different phases of lung development and the pulmonary function tests: group A ranging from 15 - 34 years, group B from 35 - 54 years, and group C were 55 years and above

The total number of male subjects in the three groups was 172, 100 and 49 respectively while the number of female subjects in the three groups was 80, 70 and 33 respectively. The mean age, height, FEV1, FVC, PEF and FEF25-75 of all subjects were 37 years, 164.2 cm, 2.86 $\pm$ 0.7 L, 3.35 $\pm$ 0.81 L, 399 $\pm$ 136 L/min and 3.38 $\pm$ 1L respectively.

There was negative correlation between pulmonary function and age. All parameters correlated positively with height. The greaters negative correlation was found for FEV1 and FVC in males, whereas the gratest positive correlation was observed for FVC in females. FEV1, FVC, PEF and FEF25-75 values were obtained in all 504 subjects. Multiple linear regression yielded prediction equations for each parameter based on age and height. Prediction equation using multiple regression analysis formula derived for men and women subjects, interpreting age and height as independent variables are shown in Table 1 and 2.

A comparison of PFT derived from prediction equations obtained in present study with those calculated from some previously published equations revealed significant differences for most of the PFT (Table 3).

Table 1. Prediction Equation for males living in Karachi.

Variables	Regression Equation	R^2	St Error of Estimate (SEE)
FVC	-0.848+[0.032 x Ht] + [-0.020 x Age]	0.429	0.508
FEV1	-1.440+[0.030 x Ht] + [-0.020 x Age]	0.478	0.427
*PEF	-61.8+[3.665 x Ht] + [-2.699 x Age]	0.172	113.8
**FEF25-75	-1.746 + [0.37 x Ht] + [0.024 x Age]	0.204	0.969

* Peak expiratory flow
**Forced expiratory flow in the midportion of FVC

Table 2. Prediction Equation for females living in Karachi.

Variables	Regression Equation	R^2	St Error of Estimate (SEE)
FVC	-3.072 + [0.042 x Ht] + [-0.020 x Age]	0.422	0.611
FEV1	-1.866 + [0.032 x Ht] + [-0.019 x Age]	0.467	0.480
PEF	-44.5 + [3.468 x Ht] + [-2.712 x Age]	0.285	111.8
FEF25-75	-0.097 + [0.025 x Ht] + [0.028 x Age]	0.301	0.822

Table 3. FEV1, FVC values calculated for a 40 years old male with a height of 175 cm and a 45-year-old female with height of 175 cm.

	Year	Subjects	FEV_1 (L)	FVC (L)	FEV_1/FVC
Male					
Current Study	2005	504	3.0 1	3.95	0.81
NHANES III	1999	7429	3.93	4.9	0.78
Ashok	1997	363	3.02	3.69	-
Falaschetti[3]	2004	2479	5.0	5.2	-
Enright et al[14]	1993	5201	3.6	4.6	0.84
Chattarjee [19]	1988	334	3.23	3.97	0.80
Crapo et al[5]	1988	506	3.96	4.89	0.83
Knudson et al[20]	1983	290	3.81	4.64	0.85
Female					
Current Study	2005	504	2.88	3.38	0.79
NHANES III	1999	7429	3.39	4.24	0.80
Ashok	1997	363	2.12	2.55	-
Falaschetti[3]	2004	3556	5.2	5.5	-
Enright et al[14]	1993	5201	3.3	4.2	0.83
Chattarjee[19]	1988	334	2.0	2.42	0.80
Crapo et al[5]	1988	506	2.92	3.54	0.81
Knudson et al[20]	1983	290	2.79	3.36	0.82

Discussion

Standard reference values for PFT are important for clinical practice and also for screening and epidemiological research.[2] This study provided an opportunity to develop such equations for Pakistani population. This study has generated PFT variables and derived prediction equation from 504 healthy, non-smoking males and females from urban area in the city of Karachi. The subjects representing a wide range of heights and ages, were drawn from various social classes, had no history of cardio respiratory disease, and there was a normal distribution of height and age among the study population.

Most of the PFT studies performed in non-European population have shown greatly reduced lung volumes when compared to published European reference values, a finding which is usually interpreted as real and indication greatly lower values in non-European-American populations.[9,10]

As shown in Table 3 the results of present study revealed that there are significant differences in pulmonary function variables in Pakistani population compared with those derived from most international studies, although some variables were higher, most PFT were lower than those calculated using other equations.

Many previous studies have averaged the two best values for any variables or have taken FEV1 and FVC reading from the same manoeuvre. The current guidelines of the ATS6,[11,12] and the European Community for Steel and Coal (ECSC) recommended the best values be taken independently from at least three technically acceptable maximum efforts. These standards may yield slightly higher results than those used in some earlier test.

Hankinson et al[9], shows significant differences in PFT between race / ethnic groups of Caucasians, African-Americans and Mexican-Americans. However reference equations from their studies were similar to those of other studies. They concluded that lower values for FEV1 seen for Mexican-Americans could be attributed to their short height compared with Caucasian of similar age. However African-Americans similar height for a particular age had lower values of FEV1 than both Caucasians and Mexican-Americans. Other recent studies have also observed a lower FEV1 in African-Americans. The ATS statement also concluded that compared with Caucasians of European descent, most other races usually show small static and dynamic lung volumes.[13,14] Although statistically significant the differences between the PFT values derived from the prediction equations obtained in present study and those of other studies were small.

The results of present study, partially support the statement of ECSC working party[15] that FVC and FEV1 for the population of our region (India and Pakistan) are 88-90% of those derived from prediction equation of ECSC study for the Caucasian population. This result is supported by two studies, one in urban and rural areas of northern Pakistan on highlanders[16] and another study on immigrants from India.[17] Both studies gave the same results as our study. But the limitation of this study is that we cannot divide the participants in different multiethnic groups on the basis of Pathan highlanders, Potoharian, Punjabi plain dwellers, Sindhis, Balochis and the migrants of India because of the small number of the participants in each group. There is a negative correlation between PFT and the age while the correlation is positive between PFT and height. In conclusion the result of this study provide PFT prediction equation derived from relatively large, healthy, non-smoking urban Pakistani population with a wide range of height and ages. The significant differences between prediction equations obtained in the present study compared with those of other studies indicate that it is preferable to use PFT equations based on local data, and this is supported by ATS.[11]

Acknowledgement

I am very thankful to Dr. Amin Suria and Dr Ghulam Ali for their help in sample collection and Mr. Ejaz Alam and Dr. Amir Omair for statistical analysis.

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