Research Article

Reference models of lung function parameters from FVC maneuver for south Indian male early adolescent population

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Abstract

Background: Usefulness of any test is determined by the availability of suitable standards. Lung function parameters are dependent on multiple anthropometric, genetic, and environmental factors. Some of these effects can be transient; hence, updating of normative standards for pulmonary function test (PFT) parameters on a regular basis in every ethnically distinct society is of overriding importance. **Aims and Objective:** To correlate lung function parameters [obtained from forced vital capacity (FVC) maneuver] with anthropometric variables and age, and to derive normative data for these parameters using the best possible combination of independent variables. **Materials and Methods:** This is a cross-sectional study of lung function in a non-hospital-based early adolescent male population. It included 91 male children in the age group of 10–15 years. Lung function parameters were obtained using a computerized spirometer with Fleisch-type pneumotachograph, which were subjected to correlational analysis with height, weight, and age. Regression analyses were performed for PFT parameters by introducing age/anthropometric data as independent variables. **Results:** All PFT parameters except forced expiratory volume in 1 s (FEV_1)/FVC showed positive correlation with height, weight and age. Regression analysis yielded that height alone (FEV_1 and MEF25), age alone (MEF50, MEF75, MMEF, and PEF), and age with height (FVC) contributed for the variance in these PFT parameters. **Conclusion:** A population-, age-, and sex-specific linear prediction equations are presented for various PFT parameters based on the cross-sectional study conducted in an early adolescent male population from south India.

KEY WORDS: Ethnicity; Pulmonary Function; Reference Standards

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Introduction

Measurement of ventilatory function in common diagnostic use consists of quantification of the gas volume contained in the lungs under certain circumstances and the rate at which gas is expelled from the lungs.[1] Because these lung function parameters are known to vary significantly with respect to racial origin,[2,3] ambient air pollution levels,[4,5] socioeconomic status,[6] nutrition,[7–10] and so forth, hence there is a necessity for building population-specific prediction equations, rather than blindly depending on prediction equations built-in commercial computerized spirolysors. In fact, variations have been found existing between the people living in different regions of the same continent.[11] Several methods have been used to overcome these ethnic differences, but these fade in comparison to population-specific equations.[2]

These problems are further compounded in certain age groups such as children, adolescents, and elderly because of the unique growth-related variations introduced in the lung function parameters. Hence, the best way to make lung function parameters as a better clinical tool is by standardizing them, which is done by considering the major determinants of lung function. The most appropriate approach for getting a normative value for pulmonary function test (PFT) parameters for a particular patient is to use his/her own value when he/she was normal. Because this is not always practical, the normative values are obtained on the basis of data obtained from large numbers of normal nonsmoking individuals without evidence of lung disease.

Some of these determinants that affect PFT values are also known to evolve with time.[12] Hence, the changing circumstances in living conditions of people preclude the acceptance of any “standard” pattern as a permanent reference.[13] Such time-related changes in PFT parameters have been observed in many places such as Japan,[14] Taiwan,[15] and even in India.[16] Therefore, a predetermined timetable for periodic updating of reference standards is essential.

Hence, the objectives of this study were to study the direction and extent of correlations of various lung function parameters with anthropometric variables (such as height and weight) and also age, and to arrive at multiple regression equations for these lung function parameters with relevant independent variables that would permit prediction of these lung function variables.

Materials and Methods

This study was conducted at institute’s Department of Physiology on 10- to 15-year-old male schoolchildren selected from local government schools. Ethical clearance was obtained from the institute’s ethical committee before commencement of the study. Written informed consent was obtained from the parents/guardian after the detailed procedure and purpose of the study was explained to them. All the children were naive to spirometry. They were subjected to detailed clinical examination to rule out the presence of any underlying diseases that could affect the results of PFTs. Healthy boys aged 10–15 years, nonsmokers, not having any disease that could affect the lung function, and not involved in any physical activity (beyond the normal level) were included in the study. Those with history of upper/lower respiratory tract infections in the past 3 weeks, present/history of cardiac disease, history of bronchial asthma, who had physical/mental disability, and smokers were excluded from the purview of the study. In all, 91 children met the inclusion criteria and were able to perform acceptable spirometric maneuvers. Height and weight were measured using accepted standard procedures. Age was calculated based on the date of birth provided in the school register.

The instrument used in this study was Spirolysor SPL-95 (France International Medical, Lyon). The instrument was calibrated with a 3-L syringe on a regular basis to maintain the reliability of the equipment. The procedures were conducted in the morning hours with the subject standing and with the nose clip in place. The subject was asked to loosen tight clothing, if any. All the procedures were carried out in the school itself to provide a familiar environment to the children. Each child was taught about the performance of forced vital capacity (FVC) maneuver for about 5 min and then was allowed to do some practice blows. Sufficient rest was provided between the procedures. The subjects were asked to perform the FVC maneuver and at the culmination of a satisfactory test session, the disposable mouthpiece was discarded and new one was put in its place.

The results of the PFT parameters obtained from the FVC maneuver were subjected to correlation analysis with height, weight, and age. A two-tailed significance test was applied to the correlation analysis results. Then step-wise linear regression analysis was performed for all PFT parameters. The independent variables introduced were height, weight, and age. Statistical analyses were performed using MedCalc, version 12.4.0.

Results

The anthropometric data of different age subgroups within the subjects are presented in Table 1. Height, weight, and body surface area showed a progressive increase over the age range studied, whereas body mass index did not show any consistent increase or decrease. Pearson’s correlation analyses of various PFT parameters with variables (height, age, and weight) are shown in Table 2. Details of regression analysis of PFT

Table 1: Anthropometric data in different age groups (mean ± SD)

Age group (years)	Height (cm)	Weight (kg)	BSA (m^2)	BMI
10.1–11.0 (*n* = 27)	108.30 ± 4.20	23.20 ± 3.07	0.82 ± 0.06	19.7 ± 1.58
11.1–12.0 (*n* = 12)	119.40 ± 2.64	31.10 ± 1.82	1.00 ± 0.03	21.8 ± 1.31
12.1–13.0 (*n* = 21)	129.90 ± 4.18	36.30 ± 1.71	1.13 ± 0.04	21.5 ± 1.35
13.1–14.0 (*n* = 13)	142.20 ± 3.09	41.20 ± 1.59	1.28 ± 0.04	20.4 ± 0.58
14.1–15.0 (*n* = 18)	153.60 ± 3.44	45.70 ± 6.90	1.41 ± 0.11	19.4 ± 2.80

BSA, body surface area; BMI, body mass index.

Table 2: Pearson's correlation analyses of PFT parameters with variables (height, age, and weight)

PFT parameter	Height (*r*-value)	Age (*r*-value)	Weight (*r*-value)
FVC	0.9795**	0.9678**	0.9089**
FEV_1	0.9722**	0.9639**	0.9068**
FEV_1/FVC	0.1344*	0.1539*	0.1566*
MEF25	0.8553**	0.8552**	0.7879**
MEF50	0.8949**	0.8988**	0.8277**
MEF75	0.8335**	0.8416**	0.7877**
MMEF	0.8971**	0.9002**	0.8292**
PEF	0.9004**	0.9040**	0.8524**

*, Not significant ($p > 0.05$); **, very highly significant ($p < 0.001$).

Table 3: Regression analysis of PFT parameters with height, age, and weight as independent variables

PFT parameter	Adjusted R^2	Constant	Height coefficient	Age coefficient	Weight coefficient
FVC	0.9637	−1.4754	0.0420	-0.2019	Not included
FEV_1	0.9445	−1.6870	0.0238	Not included	Not included
FEV_1/FVC	–	–	Not included	Not included	Not included
MEF25	0.7286	−3.0058	0.0354	Not included	Not included
MEF50	0.8057	−4.1172	Not included	0.5132	Not included
MEF75	0.7050	−4.1489	Not included	0.5262	Not included
MMEF	0.8082	−4.3363	Not included	0.5197	Not included
PEF	0.8152	−4.1523	Not included	0.5501	Not included

parameters with height, age, and weight as independent variables are shown in Table 3.

The prediction equations for the various PFT parameters obtained from the FVC maneuver based on the regression analysis are as follows:

$$\begin{aligned} \text{FVC} &= -1.4754 + 0.0420\ (\text{height in cm}) \\ &\quad - 0.2019\ (\text{age in years}) \\ \text{FEV}_1 &= -1.6870 + 0.0238\ (\text{height in cm}) \\ \text{MEF25} &= -3.0058 + 0.0354\ (\text{height in cm}) \\ \text{MEF50} &= -4.1172 + 0.5132\ (\text{age in years}) \\ \text{MEF75} &= -4.1489 + 0.5262\ (\text{age in years}) \\ \text{MMEF} &= -4.3363 + 0.5197\ (\text{age in years}) \\ \text{PEF} &= -4.1523 + 0.5501\ (\text{age in years}) \end{aligned}$$

Discussion

Spirometry is a useful clinical tool in respiratory medicine and a proper use of it requires clear-cut standards regarding the way in which the test is performed, how it is interpreted, and on what basis it is interpreted. The last objective can be achieved by having proper reference standards for various PFT parameters pertaining to the population under study. There is a paucity of such reference standards for PFT parameters in south India, especially in children. This study was intended to serve the purpose of having reference standards for PFT parameters (from FVC maneuver) in the local population based on which proper clinical interpretation of spirometry results can be made. The population specifically targeted was male children in the age group of 10–15 years.

Our study was limited to a small age span and to a single sex because the human lung growth and thereby the lung function parameter values are not uniform throughout life, and hence, it is better to present as split equations targeting specific age groups, and also there are real sex differences, especially during maturation phase, and therefore providing sex-based reference standards would be an appropriate approach.[13]

Most PFT parameters showed a positive linear correlation with height, weight, and age. The ratio FEV_1/FVC changed very little over the different age groups, probably because both FEV_1 and FVC changed proportionately. This finding is echoed by many studies.[15,17–20]

Step-wise regression analysis of the PFT parameters with the independent variables (height, age, and weight) showed that height alone contributed the maximum variance in the PFT parameters FEV_1 and MEF25, whereas age alone contributed for MEF50, MEF75, MMEF, and PEF. In case of FVC, both height and age contributed.

We have gone for a linear form of prediction equation to make computations easier. Linear regression is the most common type adopted by many studies.[18,21,22]

Conclusion

The PFT parameters (except for FEV_1/FVC) showed a linear increase with increase in height, age, and weight. Linear form of prediction equations are given because of their simplicity in clinical use. A note of caution though is that these prediction equations be used only for those it is intended for, that is, male children in the age group of 10–15 years. Also, before applying these equations, a study using a larger sample size would add more credibility and this is the limitation of this study.

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