Pulmonary Function Studies of Healthy Non-smoking Male University Students of Kolkata, India — Revisited

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Abstract

Background: Pulmonary function tests (PFTs) need to be revisited in light of rapid economic growth and industrial development. Questions have been raised about the validity of existing population-specific norms for predicting PFTs, and therefore, the present study aimed to determine the applicability of existing norms for PFTs in young healthy non-smoking male university students of Kolkata.

Methods: PFTs were carried out for 87 non-smoking male university students who were randomly sampled from the University of Calcutta, Kolkata, India.

Results: The PFTs data obtained in this study did not show a significant variation with that obtained in a previous study. Significant ($P < 0.001$) differences in the forced expiratory volume in 1 s ($FEV_{1\%}$) and peak expiratory flow rate (PEFR) between the two studies may be attributed to differences in the age and body height, which exhibited significant correlations with the vital capacity (VC), forced vital capacity (FVC), FEV_1, $FEV_{1\%}$, and PEFR. Regression equations have been computed to predict PFTs parameters from age and body height.

Conclusion: Pulmonary function in the university students of Kolkata was found to have remained mostly unchanged in the last 24 years. The equations computed in this study are considered preferable owing to their substantially smaller standard error of estimate (SEE) than those proposed in the previous study.

Keywords: $FEV_{1\%}$, FVC, Indian, PEFR, Pulmonary function

Introduction

Pulmonary function tests (PFTs) have evolved from tools for conducting physiological studies to clinical tools for the diagnosis, management, and follow-up of respiratory diseases because they can be used to provide objective information about the status of an individual's respiratory system (1). Spirometric tests are useful not only for estimating the severity of airway obstruction but also for assessing the functional degradation of the pulmonary system and evaluating the results of various therapeutic regimens. Reference values for spirometry tests have been reported for European (2–6), North American (7–9), Indian subcontinent (1,10–19), Chinese (20–22), Malaysian (23–27), and other non-Caucasian (28,29) populations.

PFTs are affected by factors including diet, obesity, air pollution, and physical activity level (30). In the last two decades, rapid economic growth and development worldwide has resulted in an improvement in people's nutritional status.

At the same time, air pollution levels have increased and people's physical activity levels have decreased. As such, lung function norms need to be revisited to account for socioeconomic development, environmental factors, and lifestyle changes that influence the normative values even within a single generation within an ethnic group living in the same geographical region (30). However, in the last five decades, the anthropometric data of young adults have changed significantly owing to factors such as increasing body height and body mass index; therefore, whether previously reported population-specific norms for the prediction of PFTs remain valid is a commonly asked question (31).

Chatterjee et al., (14) studied the pulmonary function of healthy non-smoking men (age: 20–59 years) in Kolkata, India, more than two decades back. The present study has the following objectives.

a. Determine the lung function parameters of normal young healthy non-smoking male university students in Kolkata, India.

b. Compare the lung function measurements with previously reported data for similar and different populations.

c. Derive equations for predicting the lung volumes of the currently studied population and compare these equations with the norms reported previously by Chatterjee et al., (14).

Methods

Selection of subjects

Eighty seven non-smoking male university students (age: 19–24 years) with similar socioeconomic background were randomly sampled from the post-graduate section of the University of Calcutta, Kolkata, India to conduct this cross-sectional study. The sample size was calculated according to Dupont and Plummer's method (32), and the confidence interval (CI) was set as 95%. The study was conducted with 87 subjects, which was greater than the computed sample size of 62. According to Jones et al.'s proposal (30), the data collection was limited to young male university students over a restricted time frame to limit inter-individual differences due to age and time of year.

Each subject filled up one questionnaire (33) to record their personal demographic data and health status, and to give consent to participate in this study. Students who exercised regularly or who had a history of or currently had obstructive or restrictive types of respiratory diseases and were taking treatment for the same were excluded from this study. The experimental protocol was explained and demonstrated to all the volunteers to allay their apprehensions. Each subject signed the written informed consent form. Ethical clearance was obtained from the Human Ethics Committee, Department of Physiology, University of Calcutta.

Preparation of subjects

The age of each subject was calculated to the nearest year from the date of birth as obtained from the University records. The body height was measured with the subject standing barefoot with an accuracy of +0.50 cm, and the body mass was measured to an accuracy of +0.1 kg by using a weight measuring instrument fitted with a height measuring rod (Avery India Ltd., India) with the subject wearing minimum clothing. The body surface area (BSA) was calculated using DuBois and DuBois's equation (34).

Determination of dynamic pulmonary function measurements

The dynamic pulmonary functions were recorded on a 9-L closed-circuit-type expirograph (Toshniwal Technologies Pvt. Ltd., India). The parameters measured were the tidal volume (TV), vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in 1 s (FEV_1), FEV_1 as a percentage of FVC ($FEV_{1\%}$), mid expiratory flow rate ($FEF_{25-75\%}$), and forced expiratory time (FET). The peak expiratory flow rate (PEFR) was recorded using a Wright peak flow meter. The expirograph was calibrated daily using a Palmer respiratory hand pump. All the measurements were conducted according to Chatterjee et al., (14). The subjects were encouraged and motivated to attain the maximum possible effort. These tests were recorded at noon before lunch because the expiratory flow rates are highest at noon (35). For each volunteer, three satisfactory efforts were recorded with at least 3–5 minutes rest between the consecutive trials as per the standard norm (15). After a couple of practice runs, at least three trials were conducted, and the highest value among these was accepted (14,36). All pulmonary function measurements were performed at body temperature and pressure saturated with water vapour (BTPS). In one subject, all the records, i.e. anthropometric measurements and recording of pulmonary function measurements, were conducted in one sitting on the same day.

Statistical analysis

Data were expressed as mean (SD). Student's one-sample t test was adopted to compare the pulmonary function measurements and physical parameters of the subjects with the mean values of similar parameters reported by Chatterjee et al., (14). Pearson's product-moment correlation coefficient (r) was computed to test the significant relationship between two parameters. Regression analysis was adopted to compute the prediction norms for predicting pulmonary function measurements from different physical parameters. The level of significance was set at $P < 0.05$.

Results

The mean (SD) age of the subjects in the present study is 21.74 years (SD 2.14). The values of other pulmonary function measurements recorded in the present study and reported in an earlier investigation conducted in a similar population by Chatterjee et al., (14) are tabulated

in Table 1. A similar finding was observed when the values obtained in the present investigation were compared with the computed values from the regression norms proposed by Chatterjee et al., (14). Table 1 shows that $FEV_{1\%}$ and PEFR (l.min^{-1}) were significantly ($P < 0.01$) different than those reported by Chatterjee et al., (14).

The body mass exhibited an insignificant correlation with pulmonary function measurements although age and body height were significantly correlated with VC, FVC, FEV_1, $FEV_{1\%}$, and PEFR in the present study (Table 2). Simple and multiple regression equations have been computed for predicting the pulmonary functions in the studied population (Tables 3 and 4).

Table 1: Values of physical parameters and pulmonary function measurements

	Body Mass (kg)	Body Height (cm)	BSA (m²)	BMI (kg/m²)	TV (ml)	VC (l)	FVC (l)	FEV_1 (l)	$FEV_{1\%}$ (%)	$FEF_{25-75\%}$ (l.min^{-1})	$FEF_{75-85\%}$ (l.min^{-1})	PEFR (l.min^{-1})
Present study (N = 87)	58.34 (9.92)	173.23 (5.96)	1.65 (0.13)	20.86 (2.18)	587.24 (71.27)	4.12 (0.58)	3.87 (0.55)	3.53 (0.66)	90.68 (7.38)	280.25 (82.19)	80.58 (31.53)	678.39 (69.37)
Chatterjee et al. (14) (N = 45)	56.0 (5.34)	167.40 (4.54)**	1.626 (0.08)			4.07 (0.50)	4.05 (0.50)	3.50 (0.46)	86.70 (6.23)*	290.00 (76.00)	88.70 (27.40)	607.00 (57.17)**

Values are Mean (SD), $*P < 0.01$ and $**P < 0.001$ using student's one-sample t test.

Table 2: Values of correlation coefficients between pulmonary function measurements and physical parameters in male university students

	Age (years)	Body height (cm)	Body mass (kg)
VC (l)	0.75*	0.89*	0.17
FVC (l)	0.69*	0.84*	0.18
FEV_1 (l)	0.71*	0.87*	−0.08
$FEV_{1\%}$ (%)	0.42*	0.57*	0.12
$FEF_{25-75\%}$ (l/min)	0.12	0.26	0.08
$FEF_{75-85\%}$ (l/min)	0.08	0.17	0.02
PEFR (l/min)	0.60*	0.88*	0.18

$*P < 0.001$.

Table 3: Simple regression norms for the prediction of pulmonary function measurements from age and body height in the studied population

Pulmonary Function Measurement	Regression Equation	R	R²	SEE
VC (l)	VC = 0.206 A − 0.3558	0.75	0.56	0.38
FVC (l)	FVC = 0.179 A − 0.0186	0.69	0.48	0.39
FEV_1 (l)	FEV_1 = 0.219 A − 1.2328	0.71	0.50	0.46
$FEV_{1\%}$ (%)	$FEV_{1\%}$ = 1.452 A + 59.106	0.42	0.18	6.74
PEFR (l.min^{-1})	PEFR = 19.57 A + 252.78	0.60	0.36	55.61
VC (l)	VC = 0.087 H − 10.45	0.89	0.79	0.27
FVC (l)	FVC = 0.077 H − 9.03	0.84	0.70	0.30
FEV_1 (l)	FEV_1 = 0.096 H − 12.48	0.87	0.76	0.33
$FEV_{1\%}$ (%)	$FEV_{1\%}$ = 0.702 H − 26.78	0.57	0.32	6.12
PEFR (l.min^{-1})	PEFR = 10.287 H − 1142.10	0.88	0.77	32.63

Abbreviation: A = Age, H = Body height, SEE = standard error of estimate.

Table 4: Multiple regression norms for the prediction of pulmonary function measurements in the studied population

Pulmonary Function Measurement	Regression Equation	R	R²	SEE
VC (l)	VC = 0.0511 A + 0.0728 H − 9.1652	0.90	0.81	0.262
FVC (l)	FVC = 0.0352 A + 0.068 H − 8.2668	0.84	0.71	0.293
FEV_1 (l)	FEV_1 = 0.0405 A + 0.0854 H − 11.6318	0.87	0.76	0.321
$FEV_{1\%}$ (%)	$FEV_{1\%}$ = − 0.0586 A + 0.7216 H − 28.7192	0.57	0.32	0.323
PEFR (l.min⁻¹)	PEFR = − 4.4409 A + 11.4414 H − 1138.4102	0.88	0.78	32.53

Abbreviation: A = Age, H = Body height, SEE = standard error of estimate.

Discussion

The values of the different pulmonary function parameters considered in this study are within the normal range. A comparison of the pulmonary function measurements of the present study with those of a foreign population is quite difficult owing to variations in anthropometric profiles that largely affect the lung function measurements [27]. Therefore, according to Bandyopadhyay [27], the values of pulmonary function measurements reported in other studies were standardized age and height for a valid comparison.

$FEV_{1\%}$ and PEFR recorded in the present investigation were significantly different from those reported by Chatterjee et al., [14], whereas the remaining parameters of pulmonary function measurements did not show any significant variation. The variation in $FEV_{1\%}$ and PEFR was indicative of the changes in those parameters in university students of Kolkata over the last 24 years. The influence of instrumentation, standardization, and testing procedures does not arise in the present context because both studies have been conducted in the same laboratory using the same instruments and experimental protocol. However, one explanation might be that the age range was higher in Chatterjee et al.'s study [14], that showed a significant negative correlation between age and pulmonary function measurement parameters. Another probable explanation is that pulmonary function variables are directly proportional to a subject's body height [37], which is significantly higher in the present study than in Chatterjee et al.'s study [14]. Perhaps, the deleterious effects of increased industrialization and urbanization on pulmonary health outweighed the cumulative beneficial effects of physical activity and nutrition in the present population, who in turn exhibited significantly higher values of a few indices of pulmonary function (i.e., $FEV_{1\%}$ and PEFR) than in Chatterjee et al.'s study [14]. Furthermore, with the improvement in socioeconomic status as well as continuous health promotion campaigns organized by the governmental and non-governmental sectors, it may be expected that the health status of the studied population has improved in the last 24 years.

The pulmonary function measurements showed higher values than those in the case of the male populations of South India [38], Eastern India [14], Nepal [39], and West Pakistani workers in the UK [40]. However, FVC was lower than that of age-matched Europeans [4,5], Americans [41], and Senegalese [29]. The precise reason for these inter-ethnic differences is uncertain although it has been attributed to both genetic and environmental factors [14]. Anthropometric variations might explain some of these differences considering the fact that the physical stature of Westerners on average is somewhat larger than that of Asians [23]. The specific reason for the existence of differences in pulmonary function variables in different healthy populations is uncertain, although they may be attributable to sociodemographic factors, e.g. ethnicity, habitat, and anthropometric characteristics. [27]. FVC and FEV1 values were higher than previously reported values among Malaysians [23,24]. Such a difference might be attributed to the variation in habitat, ethnicity, and sociodemographic nature [15].

VC, FVC, FEV_1, $FEV_{1\%}$, and PEFR exhibited significant correlation with age and body height. In other studies [14,19,23,24,42], age showed

a significant negative correlation with pulmonary function measurements whereas in the present investigation, age showed a significant positive correlation with VC, FVC, FEV_1, and $FEV_{1\%}$. This might be attributed to the smaller age range in the present investigation, as also reported by (27). The regression equations for predicting the pulmonary function measurements from physical parameters in the studied population have been computed on the basis of the existence of significant positive correlation between physical parameters and pulmonary function measurements; these regression lines have been plotted in Figures 1, 2, and 3.

$FEV_{1\%}$ was within the normal range, indicating that subjects do not have obstructive pulmonary diseases. The value of $FEV_{1\%}$ was in agreement with that of previous findings from different Indian and overseas populations. $FEF_{25-75\%}$ did not show any significant correlation with physical parameters although PEFR, which is considered one of the most significant parameters indicating one's pulmonary function

status (19), showed significant positive correlation with age and body height.

Simple and multiple regression equations have been computed to use as norms for predicting FVC, FEV_1, and PEFR from the age and body height in the studied population. The standard errors of estimate (SEE) of the computed equations are sufficiently small to recommend these norms for practical use in epidemiological studies and also in clinical settings. The prediction of different lung volumes from currently derived equations and Chatterjee et al.'s equations (14) have been plotted in Figures 4, 5, 6, and 7.

The SEE of the simple and multiple regression equations computed from the present observation were almost 50% smaller than the earlier reported norms computed by Chatterjee et al., (14). This finding indicated that the regression equations computed from the present investigation would predict pulmonary function measurements more precisely and accurately in the studied population.
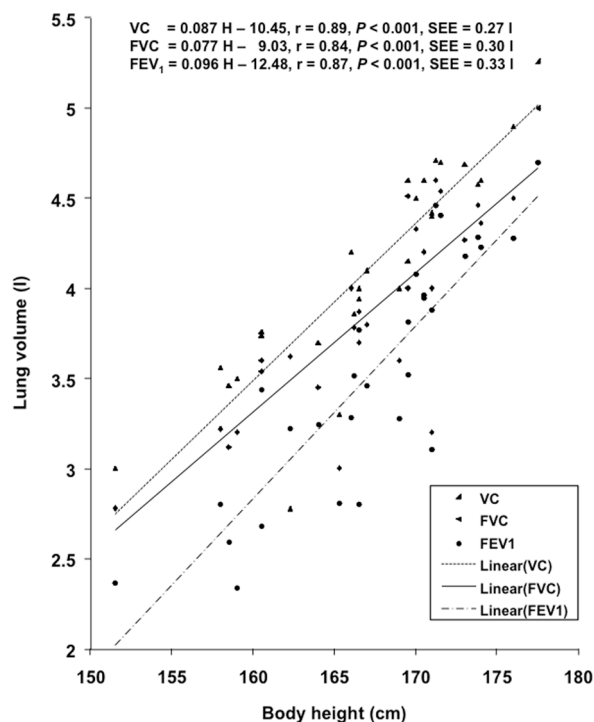

Figure 1: Relationship of body height with VC, FVC, and FEV_1 in the studied population.
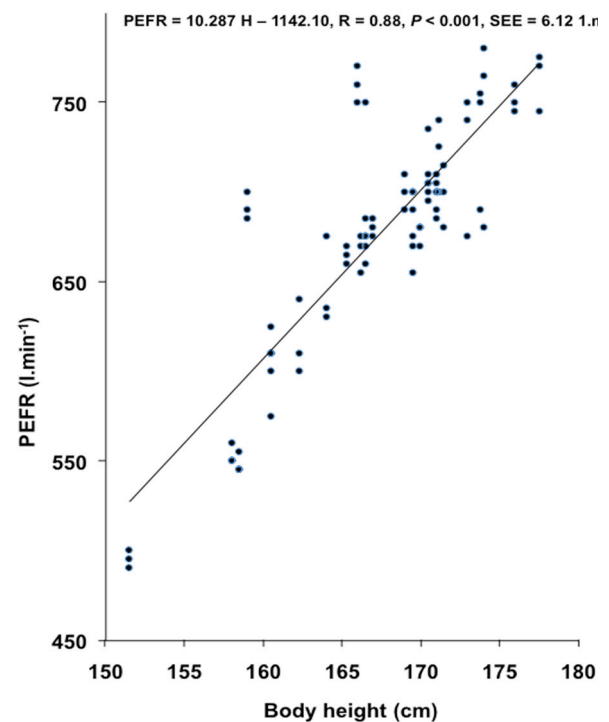

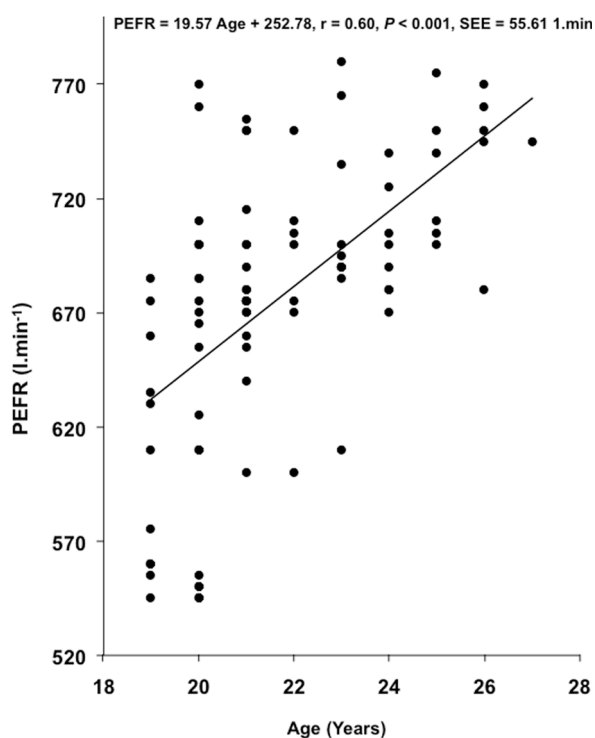**Figure 2**: Relationship of body height with PEFR in the studied population.

Figure 3: Relationship of age with PEFR in the studied population.
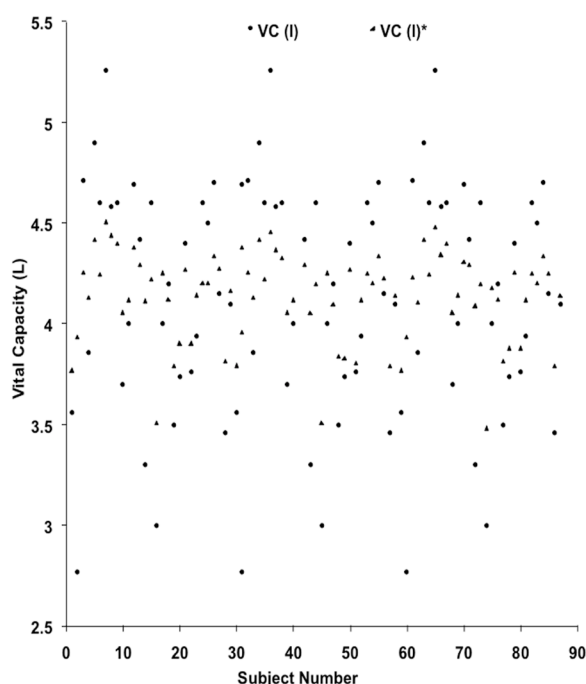

Figure 4: Plotting of vital capacity – comparison with the values predicted from currently derived equation and the standard norms proposed by Chatterjee et al., (1988).
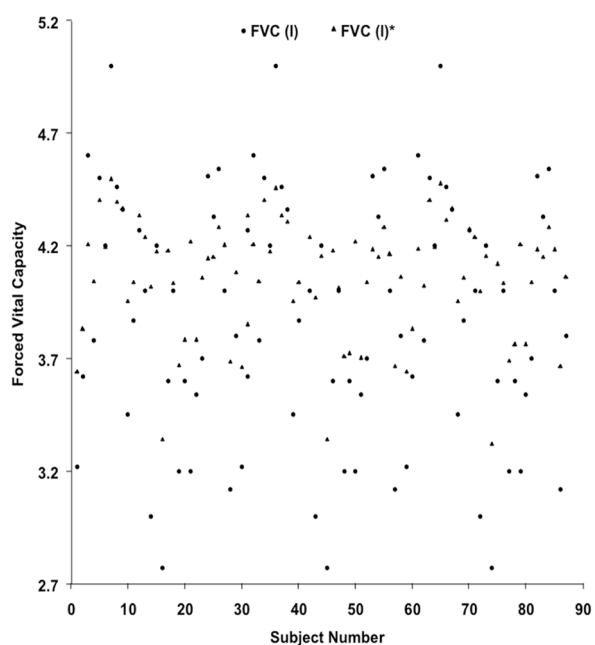

Figure 5: Plotting of forced vital capacity – comparison with the values predicted from currently derived equation and the standard norms proposed by Chatterjee et al., (1988).
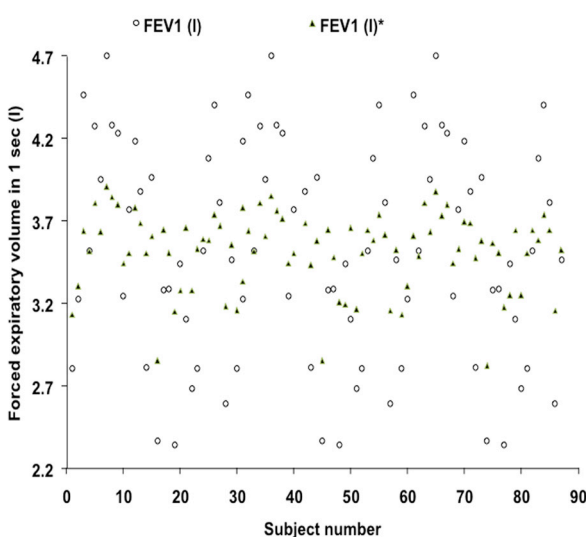

Figure 6: Plotting of forced expiratory volume in 1 sec – comparison with the values predicted from currently derived equation and the standard norms proposed by Chatterjee et al., (1988).
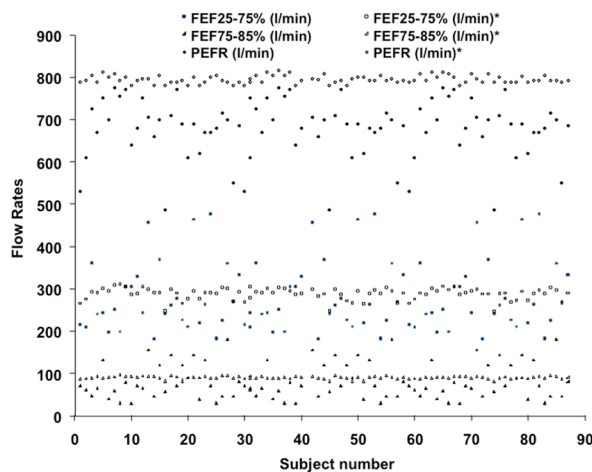
Figure 7: Plotting of FEF$_{25-75\%}$, FEF$_{75-85\%}$ and PEFR – comparison with the values predicted from the standard norms prescribed by Chatterjee et al. (1988).

Conclusion

From the present investigation, it can be concluded that the pulmonary function of the university students of Kolkata, India, is within the normal range. FEV$_1$% and PEFR have improved in this population relative to those in the previous study conducted by Chatterjee et al., (14) in 1988; i.e., 24 years back. The percentage of change in these two parameters was 4.6% and 11.7%, respectively. The remaining parameters did not show any significant change between the two studies. The SEE of the presently computed norms were substantially smaller than those reported by Chatterjee et al., (14), and therefore, these equations are considered suitable for a more precise and accurate prediction of pulmonary function measurements in the studied population.

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Conflict of interest

Authors do not have any conflict of interest.

Authors' Contributions

Conception and design, critical revision of the article for the important intellectual content and final approval of the article: AB,RD, SP
Analysis and interpretation of the data:AB, IB
Drafting of the article: AB, IB, RD, SP
Administrative, technical or logistic support: AB, IB, SP
Obtaining of funding:SP
Statistical expertise and collection and assembly of data: AB

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