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Predicted Equations of Pulmonary Function Indices for East Indian Adolescent Girls

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Abstract: *The prevalence of childhood pulmonary diseases is increasing worldwide. Reference standard for pulmonary function that is reported for Indian children and adolescent is mainly from Northern and Western part of the country. We already established reference standard for pulmonary function of Eastern Indian adolescent boys. There is a paucity of data on pulmonary function of normal Eastern Indian adolescent girls. Therefore this study was planned to establish reference standard for pulmonary function of Eastern Indian adolescent's girls. Pulmonary function test was carried out on 1143 school girls aged 10-18 years in six schools in Hooghly District of west Bengal state. Subjects were grouped into three: early adolescent (10-13 years), mid adolescent (14-15 years) and late adolescent l (16-18 years). Anthropometric parameters such as height and weight were measured and body mass index (BMI) and body surface area (BSA) were derived. The lung function parameters studied were forced vital capacity (FVC), forced expiratory volume in one second (FEV1), peak expiratory flow rate (PEFR) and forced expiratory flow 25-75% (FEF25-75%). Correlation coefficients between pulmonary function parameters and anthropometric parameters were derived. Both simple and multiple regression equations were developed for pulmonary function. In adolescent girls aged 10-18 years positive correlation was noted between pulmonary function and age, height, weight, BSA and BMI. Maximum correlation was obtained with height followed by BSA and minimum with BMI. Both simple and multiple regression equations were predicted for every pulmonary function parameter. In view of the large sample size equations of the present study can be used largely to calculate lung functions in Indian adolescent girls particularly for Eastern Indian adolescent girls.*

***Keywords**: Spirometry, FVC, FEV1, FEF25-75%, PEFR, Predicted equations for lung function*

I. Introduction

The prevalence of childhood pulmonary diseases especially bronchial asthma is increasing worldwide (1). Spirometry is an invaluable tool for the assessment of lung function. It can be comparable to the ECG of heart (2). It is used to identify the underline cause of respiratory symptoms in children and adolescents and to monitor the status of those with chronic pulmonary diseases. The predictive normal values are essential for meaningful clinical interpretation of pulmonary function test (PFT).

Pulmonary functions were known to vary with age, sex, height, weight, race and geographic locations (3,4). India, being a subcontinent, changes in pulmonary functions can occur between children of East Indian Origin and children of other region (5-7). Reference standards for pulmonary function that are reported for Indian children are mainly from Northern and Western part of the country (5-7) and there is paucity of data on pulmonary function in normal East Indian children.

Adolescent people constitute 25% of the world population of which 85% are in developing countries. In India the adolescent population is 243 million (8). Pulmonary function study of adolescent is very limited (9). The prevalence of childhood pulmonary diseases is increasing worldwide and this necessitates the need for establishing regression equations for predicting pulmonary functions in children. Thus it is essential to have normal pulmonary function data for East Indian adolescents to interpret accurately the result of PFT. We have already developed prediction equations for PFT of East Indian adolescent boys (10). A study was therefore designed to obtain reference values for force vital capacity (FVC), Forced expiratory volume in one second (FEV1), peak expiratory flow rate (PEFR) and forced expiratory flow 25-75% (FEF25-75%) among adolescent girls aged 10-18 years in Eastern region of India.

II. Materials And Methods

Subject: The present study was conducted among normal healthy school girls of 10-18 years studying in six schools (three from rural area and three from suburban areas) in Hooghly district of West Bengal state during their school hours. The subjects of this study were chosen at random irrespective of socioeconomic status and religion so that in can reflect an overall picture pulmonary health status of study region. The prior written permission of school authority was taken. Written consent from the parents of the students experimented in the study was obtained. The girls were eligible for this study if they were ethnic East Indian and were free from respiratory symptoms at least three months before testing. We excluded the students who did not complete the lung function test correctly, who reported being active smoker, who had allergic diseases and who had been hospitalized with respiratory or cardio vascular complaint. Every girl in this study was given a predesigned questionnaire which was to be recorded by parents to obtain the information regarding age, food habit family history of asthma and COPD and physical activity. A total of 1314 students were selected first, out of which 167 children were debarred either due to exclusion criteria or due to unsatisfactory expiratory effort during the procedure. Adolescents were divided into three categories: early adolescent age group: 10-13 years; mid adolescent age group; 14-15 years and late adolescent age group: 16-18 years by considering classification process of Kumar, 2012 (11).

Anthropometric measurement: Body weight was measured using bathroom scale and standing height was measured using anthropometric rod.Body mass index (BMI*)* was calculated from the height and weight using following equation: BMI (kg/m^2) = weight (kg) / height^2(m). Body surface area (BSA) was calculated from height and weight using Mosteller formula [12].

Spirometry: It was done using a portable spirometer and print outs were obtained from a computer. The subject was asked to loosen tight clothing and was seated comfortably. The subjects were instructed to take a full breath in, then close the lips around the mouth piece and blow out as hard and fast possible in standing upright posture. Inspiration should be full and unhurried and expiration once begins should be continued without a pause. Three consecutive spirometric measurements were carried out. The highest values were recorded. FVC, FEV1, PEFR and FEF25-75% (mid expiratory flow) were the spirometric function tests that carried out.

Statistical analysis: Data obtained from the study were given as mean ± SD. The statistical significance was determined by student's t test. Two tailed p values were used throughout. p value less than 0.05 were judged as significant andp value less than 0.01 were taken as highly significant. Pearson correlation was used to find the significant relationship between pulmonary function indices and anthropometric parameters. Prediction equations by regression analysis were carried out.

III. Results

Age wise distribution and physical characteristics of selected adolescent girls were as given in table-1. The height and weight consistently increased with age of the subjects. The relationship of height and weight with age was almost linear. Rate of increment of height and weight were more in early part of adolescent life and also from pre-adolescent to mid adolescent stage.

Table-1: Anthropometric measurement values by age of adolescent girls

Age (years)	Number of subjects	Height (cm)	Weight(kg)	BMI (kg/ m^2)	BSA (m^2)
10	107	136.44 ± 7.96	31.30 ± 8.38	16.60 ± 3.21	1.083 ± 0.168
11	124	142.63 ± 7.15	35.12 ± 8.18	17.12 ± 3.17	1.174± 0.155
12	165	146.21 ± 7.45	39.08 ± 10.00	18.11 ± 3.60	1.252± 0.180
13	193	147.87 ± 7.58	39..46 ± 8.13	17.97 ± 3.11	1.268± 0.143
14	153	149.76 ± 5.61	42.99 ± 9.90	19.06 ± 3.70	1.330 ± 0.164
15	104	152.11 ± 5.32	46.50 ± 9.87	20.03 ± 3.74	1.395 ± 0.156
16	104	153.20 ± 6.60	49.03 ± 8.80	20.90 ± 3.40	1.439 ± 0.146
17	82	154.17 ± 5.42	47.97 ±8.26	20.17 ± 3.24	1.428 ± 0.133
18	111	152.22 ± 5.62	47.77 ± 9.98	20.50 ± 3.45	1.415 ± 0.167

*Data represent mean ± SD

Observations for spirometric variables (FVC, FEV1, PEFR and FEF25-75%) have been summarized in table-2. All the above variables were observed to have been consistently increased with age. Age wise increment of pulmonary function indices were more in early adolescent stage followed by late adolescent and mid adolescent stages.

Table-2: Spirometric characteristic in normal East Indian adolescent girls by age

Age (years)	FVC(L)	FEV1(L)	PEFR(L/SEC)	FEF25-75% (L/Sec))
10	1.277 ± 0.276	1.263 ± 0.270	3.247± 0.750	2.605 ± 0.642
11	1.536 ± 0.313	1.511 ± 0.301	3.634 ± 0.906	2.898 ± 0.726
12	1.575 ± 0.347	1.546 ± 0.343	3.916 ± 0.948	3.126 ± 0.796
13	1.728 ± 0.301	1.692 ± 0.294	4.059 ± 0.816	3.242 ± 0.729
14	1.726± 0.365	1.700 ± 0.351	4.251 ± 0.989	3.455 ± 0.893
15	1.823 ± 0.383	1.792 ± 0.362	4.454 ± 0.763	3.509 ± 0.600
16	1.826 ± 0.350	1.793 ± 0.310	4.531 ±0.757	3.530 ± 0.682
17	1.936 ± 0.419	1.887 ± 0.366	4.600 ± 0.724	3.598 ± 0.694
18	2.220 ± 0.385	2.169 ± 0.351	4.758 ± 0.737	3.669 ± 0.623

*Data represent mean ± SD

Mean values of pulmonary function indices of various group of adolescent girls were represented in table-3. All the values increase gradually with increasing age.

Table-3: Pulmonary function indices of various groups of adolescent girls

Adolescent group (Age in years)	FVC(L)	FEV1(L)	PEFR(L/SEC)	FEF25-75% (L/Sec))
Early (10-13)	1.547 ± 0.336	1.501 ± 0.326	3.732 ± 0.903	2.974 ± 0.756
Mid (14-15)	1.763 ± 0.374	1.738 ± 0.358	4.337 ± 0.942	3.748 ± 0.758
Late (16-18)	2.003 ± 0.418	1.960 ± 0.378	4.635 ± 0.734	3.601 ± 0.663
Over all(10-18)	1.732 ± 0.594	1.683 ± 0.396	4.128 ± 0.952	3.274 ± 0.791

*Data represent mean ± SD

The correlation with age, height, weight, BMI and BSA are given in table-4. In overall adolescent group of girls all the pulmonary function indices have significant correlation with all anthropometric parameters. The maximum correlation was noted between height and pulmonary function indices.

Table-4: Correlation between various anthropometric and lung function variables in adolescent girls

Variable	**FVC**		**FEV1**		**PEFR**		**FEF 25-75%**	
	r	**p**	**r**	**p**	**r**	**p**	**r**	**p**
Age	+0.375	**<0.01**	+0.545	**<0.01**	+0.442	**<0.01**	+0.374	**<0.01**
Height	+0.402	**<0.01**	+0.543	**<0.01**	+0.480	**<0.01**	+0.419	**<0.01**
Weight	+0.380	**<0.01**	+0.511	**<0.01**	+0.398	**<0.01**	+0.328	**<0.01**
BMI	+0.401	**<0.01**	+0.542	**<0.01**	+0.441	**<0.01**	+0.370	**<0.01**
BSA	+0.287	**<0.05**	+0.386	**<0.01**	+0.280	**<0.05**	+0.224	**<0.05**

The prediction equations were derived based upon the correlation coefficients of anthropometric variables with lung functions. Simple regression equations were predicted using age, standing height, weight, BMI and BSA as independent variables (table-4). Multiple regression equations were also predicted using age, standing height and body weight.

Table-4: Simple regression equations for pulmonary function of adolescent girls aged 10 to 18 years

Parameters	Simple regression equations
FVC (liter)	**0.0293 x height(cm) – 2.6184**
	0.0928 x age (year) + 0.4486
	0.0213 x weight (kg) + 0.8385
	0.0615 x BMI (Kg/m^2) + 0.5676
	1.2561 x BSA (m^2) + 0.0904
FEV1 (liter)	**0.0266 x height (cm) – 2.2451**
	0.0899 x age (year) + 0.4492
	0.0190 x weight (kg) + 0.8909
	0.0417 x BMI (kg/m^2) + 0.9012
	1.1282 x BSA (m^2) + 0.2175
PEFR (liter/sec)	**0.0564 x height (cm) – 4.2207**
	0.1753 x age (year) + 1.7215
	0.0357 x weight (kg) +2.6439
	0.0726 x BMI (kg/m^2) + 2.7637
	2.1866 x BSA (m^2) + 1.2866
FEF25-75% (liter)	**0.0409 x height (cm) – 2.7805**
	0.1233 x age (year) + 1.5828
	0.0244 x weight (kg) +2.2584
	0.0483 x BMI (kg/m^2) + 2.3678
	1.5223 x BSA (m^2) + 1.2964

Table-5: Multiple regression equations for pulmonary function of adolescent girls aged 10 to 18 years

Parameters	Multiple regression equations
FVC (liter)	**0.0686 x age (year) + 0.0203 x height (cm) – 2.2257**
	0.0638 x age (year) + 0.0144 x weight (kg) + 0.2482
	0.0144 x height (cm) + 0.0110 x weight (kg) – 0.8712
	0.0712 x age(year) + 0.8896 x BSA (m^2) – 0.4100
FEV1 (liter)	**0.0573 x age (year) + 0.0170 x height (cm) – 1.6140**
	0.0528 x age (year) + 0.0119 x weight (kg) + 0.4633

	0.0126 x height (cm) + 0.0096 x weight (kg) – 0.5810
	0.0652 x age(year) + 0.8154 x BSA (m^2) – 0.2711
PEFR (liter/sec)	**0.1344 x age (year) + 0.0398 x height (cm) – 3.6128**
	0.0943 x age (year) + 0.0213 x weight (kg) + 1.9481
	0.0145 x height (cm) + 0.0111 x weight (kg) + 1.5215
	0.1135 x age(year) + 1.4189 x BSA (m^2) + 0.7264
FEF25-75% (liter)	**0.1005 x age (year) + 0.0298 x height (cm) – 2.5135**
	0.0624 x age (year) + 0.0141 x weight (kg) + 1.8323
	0.0068 x height (cm) + 0.0052 x weight (kg) + 2.0486
	0.0782 x age(year) + 0.9299 x BSA (m^2) + 0.9299

IV. Discussion

Pulmonary function test (PFT) is an invaluable tool for the assessment of lung function. For the diagnosis and follow-up of respiratory diseases, PFT is essential. Predictive reference values are essential for meaningful clinical interpretation of PFT. Reference value describes the level of an index for a group of healthy persons (reference population) in term of definite variable called reference variable. Commonly used reference variables include ethnic group, age, gender and one or more indices of body size. Thus reference values are generated from an equation and the result of an individual subject is obtained by inserting values of subject's features into equation.

The present study has shown correlation for pulmonary function indices with age, height, weight, BMI and BSA as reported by other studies (13, 14).In overall adolescent group of girls all the pulmonary function indices have highly significant correlation ($p<0.01$)with all anthropometric parameters. Correlations were in general highest with height. Vijayan et al., (14) showed highest correlation of FVC and FEV1 with body height.
In India several studies were carried out on school children using anthropometric variables to predict different type of regression equation for lung functions in Indian children (15-19). Some of the studies had used age, height and weight (17), age and height (18), age and BSA (15) or height alone (19) as independent variable for prediction of lung function. These studies have shown that there were differences in the lung function values due to difference in ethnicity among these subjects (14). Present study done on Bengali students has used age, height, weight and BSA as independent variables.

Simple regression equations were drawn using all five anthropometric variables. For prediction of multiple regression equations two independent variables were selected: age and height, height and weight, age and weight and age and BSA.

V. Conclusion

In our study pulmonary function indices correlated with various anthropometric parameters significantly as reported by other studies. PFT of the present study vary with other Indian studies and few Western countries due to difference in geographic location, dietary habits, environmental factors, socioeconomic status and ethnicity. The predicted equations can be used for predicting lung function in large epidemiological studies. The result of PFT cannot be interpreted appropriately without reference to predicted value. Region specific predicted equations for PFT are generated from this study. In view of the large sample size in the age group 10-18 years the equations of the present study can be used largely to calculate lung function of adolescent girls in India particularly in Eastern region

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