

Predictors of pulmonary function test values for Pakistani children, aged 5-14 years

Muhammad Asif,¹ Ghulam Mustafa,² Muhammad Aslam,³ Saima Altaf⁴

Abstract

Objective: To predict pulmonary function test values in children.

Methods: This cross-sectional study was carried out at Nishtar Medical College, Multan, Pakistan, from August 2014 to March 2015, and comprised school-going children aged 5-14 years. After noting their gender, age, height and weight, the pulmonary function test measures, force vital capacity, forced expiratory volume in 1 second and peak expiratory flow rate were taken. Simple and multiple regression models were used for the prediction of pulmonary function test values. SPSS 19 was used for statistical analysis.

Results: Of the 3,275 participants, 1,809(55.2%) were boys and 1,466 (44.8%) were girls. The overall mean age was 10.27±2.41 years. The means height, weight, forced expiratory volume in 1 second, force vital capacity and peak expiratory flow rate were 137.37±13.41cm, 30.44±8.56kg, 1.56±0.58, 1.72±0.50 and 3.66±1.10, respectively. Generally, no significant difference between the mean pulmonary function test values was noted for boys and girls ($p>0.05$), except that the boys of age 13 and 14 had higher mean values ($p<0.05$). All the three variables - age, height and weight - had significant linear relationship with the pulmonary function test values ($p<0.05$).

Conclusion: The pulmonary function test values tended to increase with increase in age, height and weight.

Keywords: Forced expiratory volume in 1 second, Force vital capacity, Peak expiratory flow rate, Pulmonary function test, Spirometry. (JPMA 67: 1323; 2017)

Introduction

Pulmonary function test (PFT) performs a pivotal role in respiratory medicines. Now a days, these tests are more frequently used in the investigation of respiratory diseases as they give reliable information about status of an individual's respiratory system. Abnormality of individual's lung function is diagnosed by defining whether PFT values are within or outside the normal range. Several reference values for lung function indices of the children have been published from different parts of the globe. These values are influenced by age, sex, ethnicity and anthropometric profile of an individual.¹⁻⁶

In Pakistan, few studies are available in the literature that have tried to examine the development of lung function and to formulate the lung function prediction equations for the people of different age groups, regions and ethnicity.⁷⁻⁹ However, only one study⁷ since 1987 has been carried out specifically for the Pakistani children about the PFT values in which regression relationship of PFT values with age, height and weight were measured for both genders to establish specific normal values. With the passage of time, the pattern of lung function growth of a

population at any age changes, hence it becomes necessary that lung function norms should be updated regularly. The present study was conducted to predict PFT values in children.

Subjects and Methods

This cross-sectional study was carried out at Nishtar Medical College, Multan, Pakistan, from August 2014 to March 2015, and comprised school-going children aged 5-14 years with different socio-economic backgrounds. The children having some respiratory symptoms or with any history of pulmonary diseases and taking treatment were excluded. Prior to all physical and PFT measurements, a written consent was taken from their parents.

A questionnaire was administered in which socio-demographic information (like age and gender status), and anthropometric and spirometric measurements of each child were recorded. Age (rounded to next year) was calculated from the date of birth provided by the parents. Body measurements of each child, including standing height (cm) and weight (kg), were measured following standard protocols while body surface area (BSA) was calculated.¹⁰

For this study, the PFT measures — forced vital capacity (FVC), forced expiratory volume 1 (FEV1) and peak expiratory flow rate (PEFR) — were taken using

.....
¹Govt. College, Muzaffar Ghar, ²Department of Pediatrics, Nishtar Medical College, Multan, ^{3,4}Department of Statistics, Bahauddin Zakariya University, Multan, Pakistan.

Correspondence: Muhammad Aslam. Email: aslamasadi@bzu.edu.pk

computerised spirometry device (Spiro USB 5050), and the American Thoracic Society (ATS) guidelines^{2,11} for spirometry were strictly followed.

To study the effect of age, height and weight on the PFT values, simple and multiple regression models were applied. Following Barcala et al.,¹² the PFT values were transformed using natural logarithm due to the fact that these values were non-normally distributed.

The descriptive results were expressed as percentages and mean \pm standard deviation (SD). Two-sample Student's t-test was used to compare the significant difference between mean PFT values of boys and girls. Pearson's correlation coefficient was used to measure linear relationship of the PFT measures with age, height and weight. In order to predict the stated spirometric measures using age, height and weight, simple and multiple linear regression models were used. SPSS 19 was used for statistical analysis.

Results

Of the 3,275 participants, 1,809(55.2%) were boys and 1,466 (44.8%) were girls. The overall mean age was 10.27 \pm 2.41 years and mean weight was 30.44 \pm 8.56kg. Besides, 1,323(40.4%) participants belonged to the age group of 5-9 years and 1,952(59.6%) to 10-14 years (Table-1).

The mean PFT values increased with age for both boys and girls. This increase was fairly slow in the age group of 7 to 9 years, but a sharper and more variable increase was reported at the age of 10 years or after. FEV1, FVC and PEFR for boys (of age 13 and 14 years) were found to be significantly higher than those of girls (Table-2).

Table-1: Descriptive statistics of anthropometric and PFT values.

Variables	N (%)
Total children	3275 (100)
Boys	1809 (55.2)
Girls	1466 (44.4)
Age group (5-9 years)	1323 (40.4)
Age group (10-14 years)	1952 (59.6)

Descriptive statistics	Mean \pm SD
Age	10.27 \pm 2.41
Weight	30.44 \pm 8.56
BSA	0.95 \pm 0.21
FEV1	1.56 \pm 0.58
FVC	1.72 \pm 0.50
PEFR	3.66 \pm 1.10

PFT: Pulmonary function test

BSA: Body surface area

FEV1: Forced expiratory volume 1

FVC: Forced vital capacity

PEFR: Peak expiratory flow rate

SD: Standard deviation.

All the coefficients between different PFT values and physical measures (age, height and weight) were found to be positive, moderate to high and statistically significant (Table-3).

To study the effect of age, height and weight on the PFT values, simple and multiple regression models were applied. Following Barcala et al.,¹² the PFT values were transformed using natural logarithm due to the fact that these values were non-normally distributed. All the

Table-2: The age-wise PFT mean values of boys and girls.

Age	Boys (n=1809)		Girls (n=1466)		FEV1		FVC		PEFR(l/min)	
	n (%)	n (%)	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
05	28 (1.5)	26 (1.8)	0.97 \pm 0.27	0.96 \pm 0.57 NS	0.97 \pm 0.37	1.00 \pm 0.64 NS	2.25 \pm 0.74	2.08 \pm 1.38NS		
06	84(4.6)	50 (3.4)	1.23 \pm 0.29	1.09 \pm 0.23 S	1.36 \pm 0.36	1.17 \pm 0.29 S	2.83 \pm 0.80	2.44 \pm 0.67 S		
07	160 (8.8)	120 (8.2)	1.29 \pm 0.31	1.20 \pm 0.28S	1.43 \pm 0.33	1.33 \pm 0.32S	3.05 \pm 0.84	2.88 \pm 0.70 NS		
08	233 (12.9)	178 (12.1)	1.30 \pm 0.31	1.27 \pm 0.28 NS	1.44 \pm 0.33	1.41 \pm 0.33 NS	3.09 \pm 0.80	3.02 \pm 0.73 NS		
09	250 (13.8)	194 (13.2)	1.30 \pm 0.30	1.28 \pm 0.30 NS	1.47 \pm 0.33	1.44 \pm 0.33 NS	3.07 \pm 0.75	3.07 \pm 0.70 NS		
10	257 (14.2)	188 (12.8)	1.44 \pm 0.31	1.38 \pm 0.32 NS	1.61 \pm 0.33	1.54 \pm 0.37 S	3.41 \pm 0.80	3.27 \pm 0.82 NS		
11	208 (11.5)	111 (7.6)	1.63 \pm 0.38	1.61 \pm 0.38 NS	1.81 \pm 0.40	1.80 \pm 0.41 NS	3.86 \pm 0.90	3.73 \pm 0.81 NS		
12	257 (14.2)	190 (13.0)	1.86 \pm 1.32	1.81 \pm 0.35NS	1.98 \pm 0.43	1.99 \pm 0.39NS	4.28 \pm 1.09	4.14 \pm 0.84 NS		
13	211 (11.7)	173 (11.8)	1.97 \pm 0.42	1.82 \pm 0.33 S	2.17 \pm 0.43	2.01 \pm 0.38 S	4.59 \pm 0.92	4.40 \pm 0.84 S		
14	121 (6.7)	236 (16.1)	2.22 \pm 0.52	1.95 \pm 0.29 S	2.45 \pm 0.53	2.14 \pm 0.30 S	5.12 \pm 1.15	4.63 \pm 0.70 S		

Values expressed as mean \pm S.D; S: significant values p < 0.05; NS: Not significant.

PFT: Pulmonary function test

FEV1: Forced expiratory volume 1

FVC: Forced vital capacity

PEFR: Peak expiratory flow rate

SD: Standard deviation.

Table-3: Correlation coefficients between PFT values and anthropometric measures.

PFT measure	Age	Height	Weight
FEV1	0.50	0.57	0.53
FVC	0.64	0.73	0.67
PEFR(l/min)	0.61	0.67	0.64

PFT measure	Boys	Girls	Boys	Girls	Boys	Girls
FEV1	0.44	0.67	0.54	0.68	0.49	0.66
FVC	0.62	0.67	0.75	0.69	0.67	0.67
PEFR(l/min)	0.59	0.67	0.68	0.66	0.64	0.63

PFT: Pulmonary function test
 FEV1: Forced expiratory volume 1
 FVC: Forced vital capacity
 PEFR: Peak expiratory flow rate.

Table-4: PFT prediction equations using simple and multiple regression.

Equation	R ²	SEE
Boys: Simple regression		
loge (FEV1) = -0.411 +0.0804 Age	0.360	0.248
loge (FVC) = -0.319 +0.0816 Age	0.373	0.245
loge (PEFR)= 0.431+0.0813 Age	0.331	0.268
loge (FEV1) = -0.189 +0.0167 Height	0.501	0.219
loge (FVC) = -1.800 +0.0168 Height	0.513	0.216
loge (PEFR)= -0.968 +0.0162 Height	0.424	0.248
loge (FEV1) = -0.305 +0.0234 Weight	0.404	0.240
loge (FVC) = -0.200 +0.0234 Weight	0.406	0.238
loge (PEFR)= 0.541 +0.0235 Weight	0.369	0.260
Girls:		
loge (FEV1) = -0.451 +0.0798 Age	0.417	0.237
loge (FVC) = -0.355 +0.0804 Age	0.413	0.241
loge (PEFR)= 0.378 +0.0824 Age	0.391	0.259
loge (FEV1) = -1.740 +0.0154 Height	0.460	0.228
loge (FVC) = -1.670 +0.0157 Height	0.463	0.231
loge (PEFR)= -0.875 +0.0154 Height	0.402	0.256
loge (FEV1) = -0.329 +0.0232 Weight	0.420	0.237
loge (FVC) = -0.240 +0.0236 Weight	0.424	0.239
loge (PEFR)= 0.530 +0.0231 Weight	0.366	0.264
Boys: Multiple regression		
loge (FEV1) = -1.61 +0.0151 Age +0.0129 Height +0.00324 Weight	0.509	0.218
loge (FVC) = -1.55 +0.0170 Age +0.0132 Height +0.00240 Weight	0.522	0.214
loge (PEFR)= -0.50 +0.0219 Age +0.0098 Height +0.00610 Weight	0.442	0.244
Girls:		
loge (FEV1) = -1.16 +0.0301 Age +0.0075 Height +0.00620 Weight	0.496	0.221
loge (FVC) = -1.10 +0.0282 Age +0.0078 Height +0.00660 Weight	0.497	0.223
loge (PEFR)= -0.26 +0.0387 Age +0.0068 Height +0.00510 Weight	0.444	0.240

SEE: Standard error of estimate.
 PFT: Pulmonary function test
 FEV1: Forced expiratory volume 1
 FVC: Forced vital capacity
 PEFR: Peak expiratory flow rate.

estimated coefficients of the predictors (age, height and weight) were found to be positive which meant the PFT values tended to increase with increase in age, height and weight (Table-4).

Discussion

In the present study, we found that the mean values of FEV1, FVC and PEFR increased when children got older. Although all the regression coefficients were statistically significant, but similar to previous studies,¹²⁻¹⁴ the values of coefficient of determination R² were not much high. Similar findings have also been reported in a few previous studies.^{7,15,16} The PFT values were observed to be positively correlated with age, height and weight. However, the most significant and strong positive correlation (i.e., 0.73) was observed between FVC and height. The results are in agreement with other studies.^{15,16}

Simple regression models can be considered to predict the PFT values against age, height and weight. For instance, if we consider average height of 137cm, the predicted values of FVC, FEV1 and PEFR will be 1.49, 1.65 and 3.50, respectively, for boys. In the similar order, these values for girls will be 1.45, 1.62 and 3.44. The results reveal that PFT values for boys are greater than those for girls.

For discussion, we focus only on the multiple regression model to predict FVC against given age, height and weight. When rounded mean values of age (10 years), weight (30kg) and height (137cm) were considered, the predicted FVC values were found to be 1.65 and 1.57, respectively, for boys and girls. The PFT values were found to be fairly closer to those of an Indian study¹⁶ having school-going children (aged 6-15 years) as participants. For example, when the above-mentioned mean values of age, height and weight were used, the Indian study¹⁶ predicted FVC values of 1.72 and 1.59 for boys and girls, respectively. However, when the same mean values of age, height and weight were used in the equations given in a study conducted by Barcala et al.,¹² the predicted FVC values were reported to be 2.12 and 2.74 for boys and girls, respectively.

Conclusion

Age, height and weight had statistically considerable and positive correlation with the PFT values, both for boys and girls. Height was found to be most strongly and positively correlated with the PFT values. Older boys (aged 13 and 14 years) had significantly higher PFT values than the girls of the same age group. The fitted regression equations will help to predict the PFT values for the Pakistani children at given age, height and weight.

Disclaimer: None.

Conflict of Interests: None.

Source of Funding: None

References

1. Quanjer PH, Stanojevic S, Cole TJ, Baur X, Hall GL, Culver BH, et al. Multi-ethnic reference values for spirometry for the 3-95-yr age range: the global lung function 2012 equations. *Euro Respir J*. 2012;40:324-43.
2. Townsend MC. Spirometry in occupational health settings-updates 2011. *J Occup Environ Med*. 2011;53:569-84.
3. Karlberg EM, Chan KN, Karlberg JP, Luk KD, Leong JC. Lung function reference values in Chinese children and adolescents in Hong Kong: II. Prediction equations for plethysmographic lung volumes. *Am J Respir Crit Care Med*. 2000;162:430-5.
4. Raju PS, Prasad KV, Ramana YV, Ahmed SK, Murthy KJ. Study on lung function tests and prediction equations in Indian male children. *Indian Pediatrics*. 2003;40:705-12.
5. Trabelsi Y, Ben Saad H, Tabka Z, Gharbi N, BouchezBuvry A, Richalet JP, et al. Spirometric reference values in Tunisian children. *Respiration*. 2004;71:511-8.
6. Vandevorode J, Verbanck S, Schuermans D, Kartounian J, Vincken W. FEV1/FEV6 and FEV6 as an alternative for FEV1/FVC and FVC in the spirometric detection of airway obstruction and restriction. *Chest*. 2005;127:1560-4.
7. Hameed MA, Khan SA, Ahmed A. Pulmonary function studies in healthy Pakistani children. *J Pak Med Assoc*. 1987;37:318-24.
8. Memon MA, Memon SA. Pulmonary Function Tests Vary In Different Ethnic Populations of Pakistan. *Pak J Med Dentist*. 2013;2:12-6.
9. Zafar M, Asmatullah, Ahmed Khan MK. Exposure of vehicular pollution in altering the pulmonary functions in traffic policemen in Multan city. *Punjab Univ J Zool*. 2015; 30:1-5.
10. Schlich E, Schumm M, Schlich M. 3-D-Body-Scan alsanthropometrischesVerfahrenzurBestimmung der spezifischenKörperoberfläche. *ErnährungsUmschau*. 2010; 57:178-83.
11. Miller MR, Hankinson JA, Brusasco V, Burgos F, Casaburi R, Coates A, et al. Standardisation of spirometry. *EurRespir J*. 2005; 26:319-38.
12. Barcala FJG, Suarez CC, Cuadrado LV, Leis R, Cabanas R, Tojo R. Lung function reference values in children and adolescents aged 6 to 18 years in Galicia. *Arch Bronconeumol*. 2008;44:295-302.
13. Bandyopadhyay A. Pulmonary function studies in young healthy Malaysians of Kelantan, Malaysia. *Indian J Med Res*. 2011;134:653-7.
14. Memon MA, Sandila MA, Ahmed ST. Spirometric reference values in healthy, non-smoking, urban Pakistani population. *J Pak Med Assoc*. 2007;57:193-5.
15. Aggarwal AN, Gupta D, Behera D, Jindal SK. Applicability of commonly used Caucasian prediction equations for spirometry interpretation in India. *Indian J Med Res*. 2005 Aug;122(2):153-64.
16. Budhiraja S, Singh D, Pooni PA, Dhooria GS. Pulmonary functions in normal school children in the age group of 6-15 years in north India. *Iran J Pediatr*. 2010; 20:82-90.