

PULMONARY FUNCTION TESTS IN NORMAL INDIAN CHILDREN AND CHANGES IN RESPIRATORY DISORDERS

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ABSTRACT

To document the normal values of pulmonary function tests in children and changes occurring in their values with various respiratory disorders, a study was carried over a period of one year in 95 healthy controls (39 females and 56 males) of 8-13 years of age and 51 cases with respiratory disorders (bronchial asthma-31, pneumonia-10, empyema-10) of matched age, sex and height distribution. The lung functions studied were FVC, FEV₁, FEV₁/FVC, PEF_R and FEF_{25-75%}.

In children with bronchial asthma, the FEV₁/FVC%, PEF_R and FEF_{25-75%} were reduced in accordance with the severity of the disease. A typical restrictive pattern of equivalent decrease in FVC and FEV₁ along with insignificant lowering of flow rates, i.e., PEF_R and FEF_{25-75%} was observed in pneumonia whereas in patients of empyema a combined pattern of significantly decreased FVC and FEV₁ along with mildly reduced FEV₁/FVC%, PEF_R and FEF_{25-75%} was observed.

Keywords: Pulmonary function tests, Respiratory disorders.

Respiratory disorders are a major group of illness affecting children especially in India and are an important cause of childhood morbidity and mortality. Pulmonary function tests, especially spirometry have been studied extensively in adults but till date its use in children has been limited primarily due to the erroneous belief that children can not perform these tests. These tests are important in the initial evaluation of respiratory disorders and help in planning therapy as well as predicting prognosis with a reasonable accuracy. Normal values of these tests differ from population to population and with difference in methods and apparatus used(1-3). The present study was undertaken to define the normal values of pulmonary function tests by spirometry in Indian children and also to study the changes in values of these tests in common respiratory disorders of childhood.

Material and Methods

The present study was done in the Department of Pediatrics, K.G.'s Medical College, Lucknow between May 1991 and April 1992. Ninety five healthy controls (39 females and 56 males) of 8-13 years age group and 51 cases with various respiratory disorders (bronchial asthma—31, pneumonia-10, empyema

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Thoracic-10) of similar age and height distribution in both sexes were included in the study.

Following a detailed history and clinical examination including anthropometry, all the children were subjected to spirometry after explaining the test procedure in detail. Spirometry was performed in standing posture, using a precalibrated computerized spirometer-MEDSPIROR (Recorders and Medicare Systems, Chandigarh, India) following a standard procedure(4). The instrument is computerized and self calibrating and fulfills the criteria for standardized lung functions. The following parameters (values) were studied: forced vital capacity (FVC); forced expiratory volume in first second (FEV₁); forced expiratory volume in first second to forced vital capacity ratio (FEV₁/FVC); peak expiratory flow rate (PEFR) and forced expiratory flow between 25-75% of vital capacity (FEF_{25-75%}); and maximal voluntary ventilation (MVV).

All the children were divided in three groups on the basis of their height for the purpose of comparison between normal and diseased. Group A comprised of children between 100-120 cm, Group B of 121-140 cm and Group C of 141-160 cm height. Normal children (controls) were those who did not have any evidence of respiratory disease or history of allergy or upper respiratory tract infections in previous three weeks, history of asthma in first degree relative or any obvious evidence of other chronic systemic disease.

The children with bronchial asthma were divided into mild, moderate and

severe on the basis of duration of disease and frequency and severity of attacks. Mild asthma was considered when the patient had less than five short attacks per year and each attack responded to bronchodilators within 24-48 hours. Moderate asthma was considered in children who had 5-10 attacks per year with cough and mild wheeze between attacks. Severe asthma was considered when the children had more than 10 attacks per year with almost daily wheeze. Pneumonia and empyema were diagnosed on the basis of radiological findings.

Results

The mean values of different pulmonary function tests in 95 healthy controls as observed in the present study are shown in *Tables I & II*. All the parameters had a linear relation with age, height, weight and body surface area with best correlation with height followed by age. Except for values of FEV₁/FVC% (which was higher in females) all the other values were higher in males.

The values of these parameters in 31 children with bronchial asthma in height Groups A and B are shown in *Tables III & IV*. There was decrease in the values with increasing severity of illness. In bronchial asthma there was reduction in all the measured parameters of lung function, but on comparing them with controls, the difference was not statistically significant.

The values of pulmonary function tests obtained in pneumonia and empyema are shown *Tables V & VI*. In pneumonia (*Table V*) there was reduction in FVC and FEV₁ when compared

TABLE I-Pulmonary Function Tests in Controls in Relation to Sex

	Male (n=56)		Female (n=39)		p value*
	Mean	SD	Mean	SD	
FVC (l/min)	1.478	0.267	1.203	0.209	>0.05
FEV ₁ (l)	1.269	0.241	1.069	0.193	>0.05
FEV ₁ /FVC%	85.79	2.65	38.65	2.57	>0.05
PEFR (l/min)	134.0	22.09	108.33	15.93	>0.05
MVV (l/min)	74.67	14.39	67.67	11.00	>0.05
FEF _{25-75%} (l/sec)	1.806	0.239	1.69	0.215	>0.05

* Calculated by analysis of variance.

FVC : Forced vital capacity; FEV₁: Forced expiratory volume in 1 second; PEFR : Peak expiratory flow rate; MVV: Maximum voluntary ventilation; FEF_{25-75%}: Forced expiratory flow.

TABLE II-Pulmonary Function Tests in Controls in Relation to Height

	Height Group A (100-120 cm) (n= 12)		Height Group B (121-140cm) (n=62)		Height Group C (141-160 cm) (n=21)		p value"
	Mean	SD	Mean	SD	Mean	SD	
	FVC	0.987	0.116	1.26	0.157	1.6907	
FEV ₁	0.813	0.095	1.107	0.136	1.4673	0.0903	0.05
FEV ₁ /FVC%	82.45	2.32	88.3	2.4 0	87.72	1.33	0.03
PEFR	89.17	6.61	119.42	15.11	150.83	8.04	0.02
MVV	43.83	3.18	70.75	5.5	83.41	4.687	0.05
FEF _{25-75%}	1.36	0.096	1.72	0.093	2.089	0.059	>0.05

* Calculated by analysis of variance.

to the controls but the ratio of FVC/FEV₁% remained unchanged. In cases of emphysema (Table VI), there was a statistically significant reduction in PEFR as compared to controls.

Discussion

The normal values in this study

correlate well with the other reports by Indian workers(6-9); but these are lower than that reported in western children(1,10,11). This can be explained on the basis of difference in height and weight of Indian children as compared to their counterparts in western countries.

TABLE III -Pulmonary Function Tests in Children with Bronchial Asthma*Height Group A (100-120 cm)*

Parameter	Severity of asthma						p value*
	Mild (n=7)		Moderate (n=4)		Severe (n=6)		
	Mean	SD	Mean	SD	Mean	SD	
FVC	0.777	0.377	0.667	0.033	0.573	0.115	>0.05
FEV ₁	0.554	0.026	0.447	0.054	0.308	0.075	>0.05
FEV ₁ /FVC%	70.700	2.930	65.850	4.760	53.380	4.530	0.03
PEFR	62.750	3.119	53.650	3.820	51.600	6.930	0.05
FEF _{1575%}	0.887	0.082	0.647	0.207	0.640	0.086	>0.05

* Calculated by analysis of variance. The p value was <0.05 for all parameters when compared to controls (Table II).

TABLE IV--Pulmonary Function Tests in Children with Bronchial Asthma*Height Group B (121-140 cm)*

Parameter	Severity of asthma						p value*
	Mild (n=7)		Moderate (n=5)		Severe (n=2)		
	Mean	SD	Mean	SD	Mean	SD	
FVC	1.092	0.295	0.798	0.115	0.730	0.030	>0.05
FEV ₁	0.832	0.224	0.508	0.066	0.350	0.040	>0.05
FEV ₁ /FVC%	75.500	2.150	64.120	3.350	48.455	7.850	0.01
PEFR	39.780	25.256	63.100	7.780	44.650	8.650	0.04
FEF _{25-75%}	1.311	0.299	0.886	0.092	0.590	0.220	>0.05

*Calculated by analysis of variance. The p value was <0.05 for all parameters when compared to controls (Table II).

Different respiratory disorders show specific patterns of changes in pulmonary function tests when compared to control values. In bronchial asthma, all the pulmonary functions studied showed a decrease in their values with a predominantly obstructive pattern characterized by a marked decrease in val-

ues of FEV₁, FEV₁/FVC, PEFR and FEF as compared to controls. The values showed a significant decrease with increasing severity of the disease. A similar decrease in flow rate has been reported by other workers also(5,12). In moderate and severe asthma, the values of FVC also showed a significant decline

TABLE V-Pulmonary Function Tests in Children with Pneumonia

Parameters	Height Group A		Height Group B		p value*
	(100-120cm) (n=5)		(121-140cm) (n=5)		
	Mean	SD	Mean	SD	
FVC	0.606*	0.056	0.690*	0.129	>0.05
FEV ₁	0.506*	0.049	0.580*	0.122	>0.05
FEV ₁ /FVC%	83.480	4.020	83.400	6.830	>0.05
PEFR	84.800	4.500	105.480	16.540	>0.05
FEF _{25-75%}	1.192	0.109	1.402	0.428	>0.05
MVV	39.400	3.781	66.000	4.560	>0.05

*P value <0.05 when compared to controls (Table II).

TABLE VI-Pulmonary Function Tests in Emphysema

Parameters	Height Group A		Height Group B		p value*
	(100-120 cm) (n=5)		(121-140cm) (n=5)		
	Mean	SD	Mean	SD	
FVC	0.482**	0.085	0.638**	0.161	0.01
FEV ₁	0.392**	0.058	0.496**	0.077	>0.05
FEV ₁ /FVC%	81.700	5.960	79.420	8.890	>0.05
PEFR	52.700*	11.420	61.580*	10.410	>0.05
FEF _{25-75%}	0.686**	0.248	0.958**	0.126	0.04
MVV	36.400	13.296	46.800	5.630	>0.05

* P value <0.01 when compared to controls (Table II).

** p value <0.05 when compared to controls (Table II).

suggesting the presence of restrictive changes as well. This has also been documented earlier(13).

The present study shows that the ratio of FEV₁ to FVC *can* be used to predict the severity of bronchial asthma and can also be used to follow up the patients to see the response to therapy

and prognosis. The value of FEV₁/FVC were 68-76% of control values in mild cases as compared to 45-55% of control in moderate asthma and 30-38% of control values in severe asthma.

In pneumonia, the values showed a pattern of restrictive changes. The values of FVC were decreased to about

55-62% of normal values. The flow rates also showed a decrease, but this was not significant. Similar changes have been reported by Calp *et al.* (14) who reported the values of FVC to 79% of controls.

In empyema, a significant decline in the values of FVC and FEV₁ was observed with a mild decrease in the ratio of FEV₁/FVC. The flow rates were also decreased suggesting a combined pattern of restrictive disorder with early obstructive changes which can be explained by presence of pleural thickening, lung collapse and chest wall deformity in these patients.

The present study shows that children can perform these tests easily with reasonable accuracy and reproducibility, and various disease processes are characterized by specific changes in values of these tests. So, the use of these tests in routine pediatric practice should be encouraged.

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