LUNG FUNCTION TESTS IN NORMAL INDIAN CHILDREN

R.V. Chowgule
V.M. Shetye
J.R. Parmar

ABSTRACT

The forced vital capacity, forced expiratory volume in one second, peak expiratory flow, mid-expiratory flow and maximum voluntary ventilation was measured in 632 healthy, normal children from Metropolitan city of Bombay using computerized spirometer. The children were between age range 6 years to 15 years and belong to high or middle and lower socio economic status. The pulmonary function data was separated by sex, and classified on the basis of height and age. The mean and standard deviation for was calculated for every such variable. The lung function variables show a linear positive correlation with height and age. Forced vital capacity and one second forced expiratory volume show a spurt after height 150 cm. Boys show higher values for lung function variables than girls except for mid expiratory flow rates where girls have higher values than boys over height 140 cm and age 9 yrs. Stepwise regression equation was calculated using height, age and weight as independent variables. Height explained the maximum variance in lung function parameters. Use of logarithmic equations for age, weight do not improve the degree of correlation. Hence, for clinical evaluation of child's lung function, height is the most significant independent parameter in comparison to age and weight.

Keywords: *Flow-volume curve, Vital capacity, Expiratory flow rates.*

During childhood and adolesence there is a correlation between anatomical and physiological growth of lung, chest cage and airway. Normal Indian values are necessary to document abnormal values and assess the severity of the pulmonary dysfunction. The purpose of this paper is to report the results of lung function tests performed on a group of healthy Indian children and to define the range of normal values. Since nutrition plays an important factor in the growth of the children, we tested children from the higher, middle and lower socio-economic group.

Material and Methods

Our study presents results of lung function measurement based on maximum expiratory flow volume (MEFV) curves in 354 boys and 278 girls, age 6 to 15 yrs in higher, middle and lower-socioeconomic group in Bombay. The socio-economic criteria were taken as per Manual of Socioeconomic Status Scale by B. Kuppuswamy. Since each grade has a large number of children, 50% random sample (868 children) from 2nd to the 10th grade was selected. Each student was given a consent letter and questionnaire to be filled by parent or guardians. Children were medically examined by a doctor in the school. Those with past and present history of upper respiratory tract infection, cardio-

From the Pulmonary Function Laboratory, Department of Chest Medicine, Bombay Hospital Institute of Medical Science, Bombay.

Reprint requests: Dr. Rohini V. Chowgule, Bombay Hospital Institute of Medical Sciences, M.R.C. Building 1st Floor, New Marine Line, Bombay 400 020.

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respiratory illness, chest deformity were excluded (171 children). There were 45 children whose parents refused to give consent. Also, 20 students over age 15 were excluded.

Standing height without shoes, weight and arm span were measured. A microprocesser based "JAEGER FLOW-MATE" spirometer with pneumotachograph was used for pulmonary function tests. The system was calibrated every day with a 2 L syringe. The tests performed were maximal expiratory flow-volume (MEFV) curve and maximum voluntary ventilation (MW).

Each test was explained thoroughly to a group, consisting of five students. The test was performed in sitting position using a noseclip. Three acceptable forced expiratory maneuvers were obtained. The best test with the largest sum of forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1) was- selected for the analysis(l).

Data were recorded for sex, age, height, weight, forced vital capacity (FVC), forced expiratory volume at one second (FEV_1), maximal midexpiratory flow (FEF 50% and FEF 25-75%), peak expiratory flow rate (PEFR) and maximal voluntary ventilation (MW). To obtain the data optimally we performed the test in standarized and qualitative control methods suggested by ATS(l-3). A regression equation was derived by statistical analysis.

Results

Tables I &II show mean values of the lung function, variables in relation to height for boys and girls, respectively.

Figs. 1-5 show the mean data of lung function variables (FVC, FEV_1, PEF, FEF 50% and FEF 25-75%) plotted against

TABLE I—*Lung Function Tests (Mean ± SD) in Boys in Relation to Height*

Height (cm)	No.	Age	FVC (L)	FEV_1 (L)	PEF (L/s)	PEF50% (L/s)	FEF25-75% (L/s)	MVV (L/min)
<110	10	6.7 ± 0.5	1.2 ± 0.1	1.1 ± 0.2	2.6 ± 0.5	1.9 ± 0.5	1.7 ± 0.5	39.0 ± 8.0
111-120	29	7.8 ± 0.9	1.4 ± 0.2	1.2 ± 0.2	3.0 ± 0.5	2.1 ± 0.5	1.8 ± 0.4	44.6 ± 9.2
121-130	84	9.0 ± 1.7	1.6 ± 0.2	1.4 ± 0.2	3.6 ± 0.5	2.2 ± 0.5	1.9 ± 0.4	52.0 ± 9.0
131-140	66	10.5 ± 1.8	1.8 ± 0.2	1.6 ± 0.2	4.0 ± 0.7	2.4 ± 0.6	2.1 ± 0.6	58.8 ± 11.2
141-150	57	12.4 ± 1.6	2.1 ± 0.3	1.9 ± 0.2	4.6 ± 0.8	2.8 ± 0.7	2.4 ± 0.6	68.3 ± 14.8
151-160	49	13.4 ± 1.3	2.6 ± 0.3	2.3 ± 0.3	5.6 ± 1.1	3.2 ± 0.9	2.8 ± 0.7	83.3 ± 15.0
161-170	38	13.9 ± 0.9	3.3 ± 0.4	3.0 ± 0.3	6.9 ± 1.0	4.0 ± 0.9	3.6 ± 0.7	103.5 ± 16.5
171-180	20	14.8 ± 0.6	3.9 ± 0.4	3.6 ± 0.4	8.3 ± 1.1	4.7 ± 1.3	4.3 ± 1.1	126.1 ± 22.6

FVC = Forced vital capacity, FEV_1 = Forced expiratory volume in one second, PEF = Peak expiratory flow, FEF 50% and FEF 25-75% = mid expiratory flow, SD = Standard deviation.

TABLE II—*Lung Function Tests (Mean ± SD) in Girls in Relation to Height*

Height (cm)	No.	Age	FVC (L)	FEV_1 (L)	PEF (L/s)	PEF50% (L/s)	FEF25-75% (L/s)	MVV (L/min)
111-120	35	7.4 ± 1.3	1.2 ± 0.2	1.1 ± 0.2	2.8 ± 0.4	1.9 ± 0.5	39.7 ± 8.3	39.7 ± 8.3
121-130	74	8.9 ± 1.5	1.4 ± 0.2	1.3 ± 0.2	3.3 ± 0.6	2.2 ± 0.5	2.0 ± 0.4	47.0 ± 9.8
131-140	60	11.0 ± 1.9	1.7 ± 0.3	1.5 ± 0.2	3.9 ± 0.9	2.4 ± 0.7	2.1 ± 0.7	57.6 ± 13.0
141-150	51	12.2 ± 1.7	2.0 ± 0.3	1.9 ± 0.3	4.6 ± 0.9	3.1 ± 0.9	2.8 ± 0.8	66.5 ± 14.1
151-160	46	13.3 ± 1.3	2.6 ± 0.4	2.3 ± 0.3	5.6 ± 0.9	3.6 ± 0.7	3.2 ± 0.7	84.2 ± 16.6
161-170	10	14.2 ± 1.0	2.9 ± 0.5	2.7 ± 0.5	6.0 ± 1.1	4.0 ± 0.8	3.7 ± 0.8	86.3 ± 12.8

FVC = Forced vital capacity, FEV_1 = Forced expiratory volume in one second,
PEF = Peak expiratory flow, FEF 50% and FEF 25-75% = mid expiratory flow,
SD = Standard deviation.

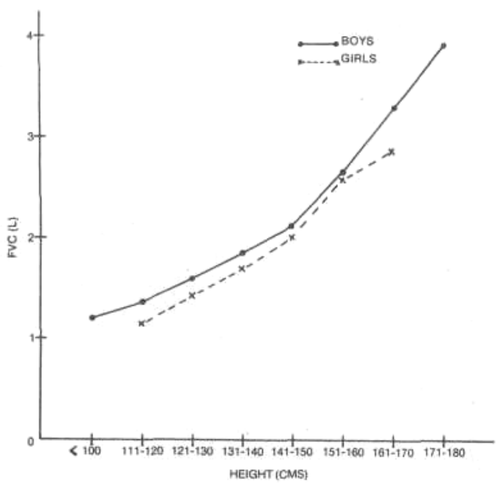

Fig. 1. Relationship between FVC value and height.

height (10 cm interval) for boys and girls. These variables show positive correlation with height. These lung function variables also show positive correlation when compared with age. Boys show higher values for lung function than girls. The difference is more significant when these lung function variables are compared with age.

The mid flows (FEF 50% and FEF 25-75%) when compared with height showed no difference between boys and girls between height 110 cm to 130 cm. Both show spurt at 130 cm but girls show higher values than boys which are statistically significant *(Figs. 4 & 5)*.

Stepwise regression was performed by putting lung function parameters (FVC, FEV_1, FEF 50%, FEF 25-75%, PEFR and MW) as dependent variables and height, weight and age as independent variables separately for boys and girls. *Tables III & IV* give regression equation for lung function variable for normal boys and girls.

In the step wise regression *(Tables III & IV)* height was the most important independent variable. In particular, height alone explained 86% of the FVC variance and 84% of the FEV_1 variance among boys, and 81% and 71% among girls, respectively. Weight added only 2% to 1% among boys and 4% among girls but regression coefficient for

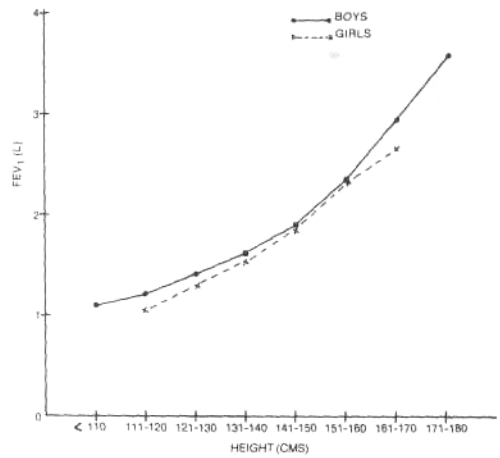

Fig. 2. Relationship between FEV_1 value and height.

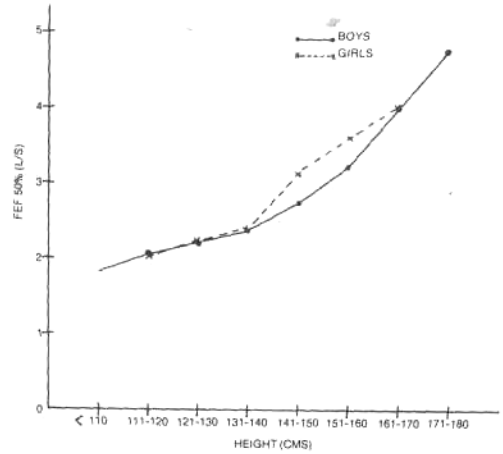

Fig. 4. Relationship between FEF 50% value and height.

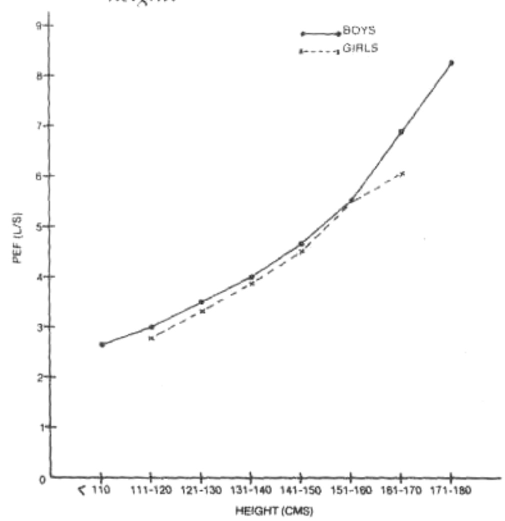

Fig. 3. Relationship between PEF value and height.

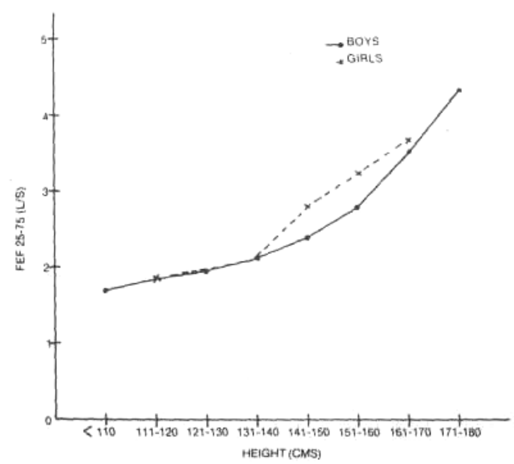

Fig. 5. Relationship between FEF 25-75% value and height.

weight was significant. In boys, age did not make any significant additional contribution but among girls age made a small but significant contribution for FVC and PEFR. For midflows, weight did not contribute anything significant but the age did.

Discussion

This study determines the normal values of ventilatory functions and prediction formula in the children. For the first time normal values and regression equations for normal Indian population have been calculated using MEFV

TABLE III—*Regression Equations of Lung Function Variables for Normal Boys*

	Coefficient		Constant	R^2
	Height (cm)	Weight (kg)		
FVC	0.0413		–3.6542	0.86
	0.0273	0.0206	–2.3619	0.88
FEV_1	0.0366		–3.2291	0.84
	0.0262	0.0153	–2.2690	0.85
PEF	0.0823		–6.9387	0.76
	0.0706	0.0172	–5.8592	0.76
FEF 50%	0.0411		–3.0092	0.48
	0.0298	0.0167	–1.9647	0.49
FEF 25-75%	0.0371		–2.7769	0.50
	0.0291	0.0118	–2.0360	0.50
MVV	1.2688		–109.3992	0.72

R^2 = Correlation coefficient.

TABLE IV—*Regression Equations of Lung Function Variables for Normal Girls*

	Coefficient			Constant	R^2
	Height (cm)	Weight (kg)	Age (yrs)		
FVC	0.0364			–3.1581	0.81
	0.0199	0.0235		–1.6335	0.85
	0.0152	0.0246	0.0260	–1.3051	0.85
FEV_1	0.0326			–2.7962	0.79
	0.0188	0.0196		–1.5273	0.83
PEF	0.0704			–5.5233	0.64
	0.0539		0.1084	–4.4358	0.66
	0.0303	0.0308	0.1219	–2.3075	0.67
FEF 50%	0.0446			–3.3766	0.47
	0.0307		0.0914	–2.4596	0.49
FEF 25-75%	0.0402			–3.0799	0.46
	0.0299		0.0677	–2.3997	0.47
MVV	1.0951			–89.8740	0.62
	0.8025		1.9286	–70.5191	0.64

R^2 = Correlation coefficient.

curve(4-8). The maximum expiratory flow volume (MEFV) curve provides quantitative data which reflects the state of the airway as well as that of the lung. The correlations between the spirometric measurements, height and age are striking. Both volume and indices of flow increased uniformly with height, which affords a better index of body size than does age.

There is a rapid increase in pulmonary indices at approximately 150 cm for both sexes *(Figs. 1 & 2)* and marked difference is seen between boys and girls. These results are comparable to earlier work(9).

Schoenberg(10) studied white and black population from USA over age 7 years. We compared our data for age group 7-9 and 10-14 years. FVC and FEV_1 in our study was significantly lower ($p < 0.005$) than white population for both sexes and age groups. However, they do not reveal any significant difference when compared with black population. Peak flow rate (PEFR) is comparable with our values for both sexes and races except for boys in age group 10-14 years where our study show significantly higher values for PEFR than an earlier report(10). Mid expiratory flow rate (FEF 50%) in our study is significantly lower than white and black population.

Knudson(11) studied American population over age 6 years for flow volume curve. We compared our data for boys between age 6-12 years and girls between age 6-11 years. Our values for FVC and FEV_1 in this age range are significantly lower ($p < 0.005$) than Knudson study for both boys and girls. However, mid expiratory flow rates FEF 50% and FEF 25-75 did not reveal any significant difference.

We compared our data with Indian studies(6,7); there were no significant differences in pulmonary indices with Malik's(6) studies. However the other study(7) had lower pulmonary indices than ours.

Regression analysis demonstrated the importance of height and sex in determining level of lung function. There was also a small but significant association between lung function and the child's weight and age. However, for clinical evaluation of a child's lung function, height is the most significant parameter, the effect of weight and age do not substantially influence the predicted pulmonary function.

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REFERENCES

1. Taussig LD. Chernick V, Wood R, Farrell P, Mellins RB. Standardization of lung function testing in children. J Pediatr 1980, 97: 668-676.

2. Brough FK, Duwayne Schmidt C, Dickman M. Effect of two instructional procedures on the performance of the spiromeuy test in children five to seven years of age. Am Rev Resp Dis 1972,106: 604-606.

3. Polgar G, Promadhat V. Pulmonary function testing in children: Techniques and Standards. Philadelphia, WB, Saunders, 1971.

4. Malik SK, Jindal SK, Sharda SK, Banga N. Peak expiratory flow rates of school age girls from Punjab. Indian Pediatr 1982,19:161-164.

5. Malik SK, Jindal SK, Sharda PK, Banga N. Peak expiratory flow rate of healthy school boys from Punjab. Indian Pediatr 1981, 18: 517-519.

6. Malik SK, Jindal SK. Pulmonary function tests in healthy children. Indian Pediatr 1985, 22: 677-681.

7. Vohra RS, Shah SC, Shah GS. Pulmonary function in normal children. Indian Pediatr 1984, 21: 785-790.

8. Bhattacharya AK, Banerjee S. Vital Capacity in Children and Young adults of India. Indian J Med Res 1966, 54: 62-71.

9. Dickman ML, Duwayne SC, Gardner RM. Spirometric standards for normal children and adolescents (age 5 through 18 years). Am Rev Resp Dis 1971,104: 680-687.

10. Schoenberg JB, Beck GJ, Bouhuys A. Growth and decay of pulmonary function in healthy blacks and whites. Resp Physiol 1978, 33: 367-393.

11. Knudson RJ, Lebowitz MD, Holberg CJ, Burrows B. Changes in the normal maximal expiratory flow volume curve with growth and aging. Am Rev Resp Dis 1983,127: 725-734.