Pulmonary Function Test in Normal Healthy School Children

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Abstract

Pulmonary function tests were studied in 1000 (500 boys and 500 girls) healthy school going children of Rohtak (Haryana) of 10-14 age years. Recording was done by portable Spirolab 1spirometer. Forced Vital Capacity (FVC), Forced Expiratory Volume (FEV_1), Forced Expiratory Flow ($FEF_{25-75\%}$) showed a significant correlation with age, weight, height, body surface area and body mass index in both sex except for correlation of $FEF_{25-75\%}$ with BMI in females. In males, FVC and FEV_1 had the best correlation with body surface area followed by weight and age in both males and females. The correlation of FEV_1/FVC% with age, weight, height, body surface area and body mass index was not significant. The mean values of all pulmonary function measurements were higher in boys as compared to girls but statistically significant difference ($p<0.001$) was found for FVC and FEV_1.

Key-words: FEV_1, FVC, FEV_1/FVC, $FEF_{25-75\%}$.

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Introduction

Respiratory illnesses are leading cause of morbidity and mortality in children. In some pulmonary disorders pulmonary function testing plays an important role in diagnosis, assessment of severity and response to medications[1]. With great advances in pulmonary physiology and medical instrumentation, pulmonary function testing has come to assume a central place in the practice of pulmonary medicine. During the last few decades, pulmonary function tests have evolved from tools for physiologic study to clinical investigations and are widely used in assessing the respiratory status in children. These have become a part of routine health examination in respiratory, occupational, sports medicine and as public health screening tool[2]. Enough data regarding pulmonary function tests in children is available for Caucasian, Negroid, Aboriginal and Chinese children[3]. Though data on pulmonary function tests of Indian children is available but very few studies in North Indian healthy children are available, especially in healthy children of Haryana[4-9]. Various factors including age, sex, body build, Body Mass Index are known to affect the pulmonary function tests. Keeping in view all these factors which may affect the normal values, present study was done to have normogram of pulmonary function tests and its correlation with age, sex, weight and body surface area of children aged 10-14 years studying in schools.

Material and methods

Present study was conducted in 1000 healthy school going children aged 10-14 years (500 boys & 500 girls). Simple randomization was carried out for selecting schools and children in various age groups. Children having history of smoking, respiratory infections in preceding three weeks, chronic pulmonary diseases including bronchial asthma, thoracic surgery, systemic diseases which can affect respiratory system and smokers were excluded.

Children and school authorities were explained the aim and objectives of the study and consent was taken from children. Detailed history and clinical examination was performed in all the subjects before doing their pulmonary function tests and the informations were recorded on a predetermined performa. Anthropometric measurements of every child were recorded (Weight in Kg, height in cm, body surface area and body mass index).

Pulmonary function tests were done by using portable spirometer (Spirolab I) from Medical International Research Instrument. Standard methodology for assessment of lung functions as recommended by American Thoracic Society were applied. Student was asked to sit comfortably and nose clipped. Then child was asked to inhale and exhale maximally in one go via mouthpiece with lips tightly sealed around mouth piece. Three acceptable readings were taken and largest of them was recorded for study purpose. Following parameters were recorded in each case; forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), FEV_1 /FVC % and $FEV_{25-75\%}$.

Results

One thousand healthy school children divided into four groups had the following observations regarding different pulmonary function tests.

1. FVC, FEV_1, $FEF_{25-75\%}$ increased with increase in age and most of the values were found higher in boys than girls of the same age group (table 1).

Table 1. Pulmonary Function Tests in relation to Age and Sex

Age (Years)	Sex	Number	FVC (Liter)	FEV_1 (Liter)	FEV_1/FVC (%)	$FEF_{25-75\%}$ (Liter/second)
10	Male	100	1.89 ± 0.17	1.60 ± 0.15	85.15 ± 1.39	2.30 ± 0.39
	Female	100	1.70 ± 0.14	1.45 ± 0.13	85.32 ± 1.64	2.15 ± 0.19
11	Male	100	2.00 ± 0.15	1.72 ± 0.13	85.46 ± 1.35	2.62 ± 0.33
	Female	100	1.79 ± 0.15	1.53 ± 0.13	85.30 ± 1.49	2.49 ± 0.63
12	Male	100	2.04 ± 0.19	1.74 ± 0.16	85.22 ± 1.38	2.50 ± 0.33
	Female	100	2.24 ± 0.17	1.90 ± 0.14	84.78 ± 1.25	2.61 ± 0.27
13	Male	100	2.57 ± 0.22	2.19 ± 0.19	85.05 ± 1.59	2.91 ± 0.22
	Female	100	2.28 ± 0.23	2.15 ± 0.20	85.07 ± 1.27	3.17 ± 0.20
14	Male	100	2.63 ± 0.20	2.26 ± 0.21	85.43 ± 1.91	3.36 ± 0.23
	Female	100	2.54 ± 0.27	2.18 ± 0.24	85.29 ± 1.45	3.17 ± 0.60

2. FVC, FEV_1, $FEF_{25-75\%}$ increased with increase in weight and were higher in males than females (table 2).

Table 2. Pulmonary Function Tests in relation to Weight and Sex.

Weight (kg)	Sex	Number	FVC(Liter)	FEV_1(Liter)	FEV_1/FVC%	$FEF_{25-75\%}$ (Liter/sec)
21-25	Male	11	1.75 ± 0.08	1.50 ± 0.08	85.36 ± 1.12	2.35 ± 0.36
	Female	11	1.66 ± 0.12	1.44 ±0.09	86.18 ± 1.57	2.15 ± 0.23
26-30	Male	64	1.84 ± 0.15	1.56 ± 0.14	85.42 ± 1.31	2.29 ± 0.39
	Female	77	1.68 ± 0.15	1.43 ± 0.13	85.30 ± 1.58	2.24 ± 0.75
31-35	Male	81	1.99 ± 0.21	1.70 ± 0.19	85.15 ± 1.48	2.48 ± 0.41
	Female	85	1.88 ± 0.29	1.60 ± 0.25	85.14 ± 1.51	2.50 ± 0.34
36-40	Male	92	2.06 ± 0.20	1.76 ± 0.17	85.29 ± 1.42	2.52 ± 0.30
	Female	132	2.18 ± 0.25	1.85 ± 0.21	84.99 ± 1.41	2.87 ± 0.41
41-45	Male	69	2.25 ± 0.29	1.93 ± 0.29	85.06 ± 1.51	2.78 ± 0.38
	Female	138	2.28 ± 0.32	1.95 ± 0.27	85.17 ±1.33	2.95 ± 0.61
46-50	Male	119	2.51 ± 0.23	2.14 ± 0.20	85.25 ± 1.58	3.05 ± 0.32
	Female	43	2.35 ± 0.28	2.00 ± 0.26	85.01 ± 1.53	2.85 ± 0.29
51-55	Male	57	2.63 ± 0.19	2.26± 0.18	85.41 ± 1.99	3.25 ± 0.32
	Female	11	2.49 ± 0.33	2.12 ± 0.29	85.17 ± 1.13	2.90 ± 0.41
56-60	Male	4	3.02 ± 0.22	2.57 ± 0.21	84.97 ± 2.14	3.40 ± 0.30
	Female	3	2.86 ± 0.15	2.47 ± 0.18	85.00 ± 0.86	3.32 ± 0.49
61-65	Male	1	2.59 ± 0.00	2.19 ± 0.00	84.50 ± 0.00	3.29 ± 0.00
	Female	0	-	-	-	-
66-70	Male	2	3.04 ± 0.15	2.65 ± 0.21	87.10 ± 2.54	3.36 ± 0.78
	Female	0	-	-	-	-

3. FVC, FEV_1 and $FEF_{25-75\%}$ increased with increase in height and were often higher in boys than girls (table 3).

Table 3. Pulmonary Function Tests in relation to Height and Sex.

Height(cm)	Sex	Number	FVC (Liter)	FEV_1(Liter)	FEV_1/FVC%	$FEF_{25-75\%}$
121-125	Male	3	1.63 ± 0.03	1.41 ± 0.06	84.83 ± 1.58	2.15 ± 0.51
	Female	5	1.51 ± 0.22	1.29 ± 0.18	85.34 ± 1.30	2.30 ± 0.63
126-130	Male	33	1.75 ± 0.12	1.49 ± 0.10	85.04 ± 1.60	2.32 ± 0.36
	Female	50	1.61 ± 0.09	1.39 ± 0.09	85.49 ± 1.71	2.19 ± 0.26
131-135	Male	55	1.86 ± 0.14	1.58 ± 0.13	85.36 ± 1.44	2.30 ± 0.37
	Female	77	1.69 ± 0.10	1.44 ± 0.08	85.11 ± 1.41	2.22 ± 0.24
136-140	Male	109	1.97 ± 0.12	1.69 ± 0.11	85.39 ± 1.34	2.46 ± 0.33
	Female	51	1.88 ± 0.17	1.60 ± 0.15	85.29 ± 1.61	2.61 ± 0.87
141-145	Male	71	2.12 ± 0.14	1.81 ± 0.11	85.26 ± 1.41	2.63 ± 0.36
	Female	93	2.09 ± 0.16	1.78 ± 0.13	85.20 ± 1.44	2.69 ± 0.35
146-150	Male	129	2.44 ± 0.23	2.10 ± 0.23	85.33 ± 1.60	3.02 ± 0.40
	Female	150	2.30 ± 0.16	1.96 ± 0.15	84.99 ± 1.30	3.08 ± 0.37
151-155	Male	78	2.63 ± 0.16	2.25 ± 0.15	84.95 ± 1.53	3.11 ± 0.28
	Female	55	2.55 ± 0.21	2.17 ± 0.20	84.99 ± 1.50	3.18 ± 0.80
156-160	Male	15	2.72 ± 0.22	2.32 ± 0.21	85.67 ± 2. 85	3.24 ± 0.34
	Female	17	2.68 ± 0.27	2.29 ± 0.24	85.60 ± 0.99	3.18 ± 0.11
161-165	Male	6	3.04 ± 0.10	2.58 ± 0.13	84.91 ± 1.72	3.34 ± 0.24
	Female	2	3.35 ± 0.29	2.72 ± 0.09	83.00 ± 2.40	3.47 ± 0.58
166-170	Male	1	3.16 ± 0	2.72 ± 0	86.00 ± 0	2.99 ± 0
	Female	0	-	-	-	-

4. FVC, FEV_1 and $FEF_{25-75\%}$ increased with increase in body surface area and were most of the times higher in boys than girls (table 4).

Table 4. Values of various function tests in relation to BSA and Sex.

BSA(m^2)	Sex	Number	FVC (Liter)	FEV_1 (Liter)	FEV_1/FVC %	$FEF_{25-75\%}$ (Liter/sec)
0.90-0.98	Male	32	1.77 ± 0.10	1.52 ± 0.08	85.42 ± 1.34	2.25 ± 0.34
	Female	28	1.63 ± 0.11	1.40 ± 0.09	85.44 ± 1.84	2.10 ± 0.16
0.99-1.07	Male	54	1.85 ± 0.18	1.57 ± 0.17	85.08 ± 1.55	2.33 ± 0.39
	Female	80	1.69 ± 0.15	1.44 ± 0.13	85.29 ± 1.45	2.30 ± 0.74
1.08-1.16	Male	53	1.94 ± 0.13	1.66 ± 0.11	85.43 ± 1.35	2.40 ± 0.35
	Female	47	1.76 ± 0.20	1.50 ± 0.17	85.27 ± 1.62	2.34 ± 0.22
1.17-1.25	Male	102	2.06 ± 0.19	1.76 ± 0.17	85.27 ± 1.36	2.53 ± 0.35
	Female	111	2.14 ± 0.22	1.82 ± 0.18	85.05 ± 1.37	2.84 ± 0.39
1.26-1.34	Male	63	2.22 ± 0.24	1.89 ± 0.20	85.07 ± 1.46	2.74 ± 0.30
	Female	143	2.24 ± 0.25	1.91 ± 0.21	85.11 ± 1.40	2.90 ± 0.34
1.35-1.42	Male	78	2.46 ± 0.25	2.13 ± 0.27	85.37 ± 1.63	3.01 ± 0.37
	Female	73	2.42 ± 0.30	2.07 ± 0.27	84.96 ± 1.45	3.03 ± 0.75
1.43-1.50	Male	106	2.62 ± 0.16	2.23 ± 0.14	85.22 ± 1.57	3.18 ± 0.30
	Female	11	2.56 ± 0.36	2.19 ± 0.33	85.29 ± 1.13	2.88 ± 0.32
1.51-1.58	Male	6	2.86 ± 0.27	2.40 ± 0.27	85.63 ± 4.33	3.46 ± 0.24
	Female	5	2.69 ± 0.16	2.31± 0.18	85.18 ± 0.52	3.32 ± 0.33
1.59-1.66	Male	3	2.93 ± 0.24	2.46 ± 0.25	83.63 ± 1.86	3.32 ± 0.40
	Female	2	2.83 ± 0.20	2.40 ± 0.20	84.75 ± 1.06	3.03 ± 0.07
1.67-1.74	Male	2	2.65 ± 0.09	2.29 ± 0.14	86.35 ± 2.61	3.15 ± 0.19
	Female	0	-	-	-	-
1.75-1.82	Male	1	3.21 ± 0.00	2.77 ± 0.00	86.2 ± 0.00	3.13 ± 0.00
	Female	0	-	-	-	-

5. FVC, FEV_1 and $FEF_{25-75\%}$ increased with increase in body mass index (BMI) and males mostly had higher values than females (table 5).

Table 5. Pulmonary function tests values in relation to BMI and Sex.

BMI (kg/m^2)	Sex	Number	FVC (Liter)	FEV_1 (Liter)	FEV_1/FVC %	$FEF_{25-75\%}$ (Liter/sec)
12.5-14.19	Male	13	1.92 ± 0.20	1.56 ± 0.19	85.58 ± 1.29	2.28 ± 0.40
	Female	4	1.78 ± 0.05	1.55 ± 0.04	86.92 ± 1.45	2.36 ± 0.29
14.2-15.89	Male	47	1.92 ± 0.23	1.63 ± 0.20	85.24 ± 1.42	2.38 ± 0.43
	Female	66	1.96 ± 0.36	1.67± 0.30	85.51 ± 1.55	2.45 ± 0.47
15.90-17.59	Male	69	2.06 ± 0.32	1.78 ± 0.32	85.29 ± 1.22	2.53 ± 0.46
	Female	96	2.03 ± 0.38	1.72 ± 0.32	85.02 ± 1.43	2.64 ± 0.53
17.6-19.29	Male	85	2.09 ± 0.34	1.78 ± 0.29	85.17 ± 1.56	2.56 ± 0.40
	Female	166	2.17 ± 0.38	1.85 ± 0.23	85.05 ± 1.46	2.83 ± 0.62
19.3-20.99	Male	90	2.14 ± 0.24	1.83 ± 0.23	85.09 ± 1.45	2.67 ± 0.41
	Female	92	2.17 ± 0.38	1.86 ± 0.27	85.38 ± 1.39	2.86 ± 0.37
21.0-22.69	Male	159	2.47 ± 0.27	2.11± 0.23	85.34 ± 1.76	3.00 ± 0.36
	Female	53	2.18± 0.32	1.86 ± 0.28	84.88 ± 1.29	2.89 ± 0.40
22.7-24.39	Male	28	2.49 ± 0.35	2.14 ± 0.32	85.44 ± 1.57	3.19 ± 0.47
	Female	17	2.20 ± 0.20	1.87 ± 0.17	84.67 ± 1.14	2.68 ± 0.30
24.4-26.09	Male	5	2.31 ± 0.50	1.96 ± 0.39	84.92 ± 1.43	2.96 ± 0.51
	Female	5	2.52 ± 0.57	2.14 ± 0.49	84.88 ± 1.10	2.72 ± 0.53
26.1-27.79	Male	1	1.8 ± 0	1.6 ± 0	85.1 ± 0	2.83 ± 0
	Female	0	-	-	-	-
27.8-29.49	Male	4	2.23± 0.74	2.02 ± 0.66	85.77 ± 1.87	2.49 ± 0.66
	Female	1	1.98 ± 0	1.65± 0	83.3 ± 0	2.13± 0

6. FVC, FEV_1 and $FEF_{25-75\%}$ showed a significant correlation with age, weight, height, body surface area (BSA) and body mass index (BMI) in both males and females, except for the correlation of $FEF_{25-75\%}$ with BMI in females (table 6). In males, FVC and FEV_1 had the best correlation with BSA followed by weight and age. $FEF_{25-75\%}$ had highest correlation with age in both males and females. The correlation of FEV_1/FVC% with age, weight, height, BSA and BMI was not significant (table 6).

Table 6. Correlation coefficients PFTs and Anthropometry

Age/Anthropometric measurements	Sex	FVC (Liter)	FEV_1 (Liter)	FEV_1/FVC %	$FEF_{25-75\%}$ (Liter/second)
Age (Years)	Male Female	0.798* 0.796*	0.789* 0.797*	0.012 - 0.038	0.706* 0.657*
Weight (Kg)	Male Female	0.798* 0.673*	0.778* 0.669*	0.020 - 0.084	0.662* 0.416*
Height (Cm)	Male Female	0.709* 0.899*	0.686* 0.889*	- 0.053 - 0.076	0.551* 0.597*
BSA (m^2)	Male Female	0.836* 0.773*	0.815* 0.768*	0.005 - 0.094	0.682* 0.492*
BMI (Kg/m^2)	Male Female	0.458* 0.165*	0.435* 0.159*	0.003 - 0.102	0.419* 0.076

*p<0.001

7. The mean values of all pulmonary function measurements were higher in boys as compared to girls but statistically significant difference (p<0.001) was found for FVC and FEV_1 (table 7).

Table 7. PFTs and its relation with Sex

PFT	Male (Mean ± SD)	Female (Mean ± SD)	p value
FVC (Liter)	2.22 ± 0.36	2.09 ± 0.36	0.000*
FEV_1 (Liter)	1.90 ± 0.32	1.78 ± 0.31	0.000*
$FEF_{25-75\%}$ (Liter/sec)	2.74 ± 0.48	2.72 ± 0.58	0.551

*p< 0.001

Discussion

Pulmonary function tests play an important role in diagnosis, assessment of severity and response to medications. They are important in children not only for clinical reasons but also due to considerable growth and development of respiratory system which occurs with age. Besides diseases other factors which affect pulmonary functions are genetic, age, sex, height, weight , surface area, race, environment, birth weight, socioeconomic status, duration of breast feeding & history of childhood respiratory tract infections[10,11].Pulmonary function tests can identify abnormalities of lung volumes, airflow, diffusion, respiratory endurance and respiratory muscle strength. They permit an accurate and reproducible assessment of the respiratory system and allow quantification of the severity of disease, thereby enabling assessment of the natural history and response to therapy[12.]

In the present study, FVC, FEV_1, $FEF_{25-75\%}$ increases with increasing age in both sex while FEV_1/FVC% remained almost constant in all the groups. Values of FVC and FEV_1 were higher in boys in all the age groups. However, $FEF_{25-75\%}$ was also found to be higher in boys as compared to girls in all the age groups except in 12-13 years and 13-14 years age groups where girls had higher $FEF_{25-75\%}$ values than boys. Values of FEV_1 /FVC % were

slightly lower in girls in all the age groups except in 10-11 years and 13-14 years age groups where the values were slightly higher in boys (table 1). Bhattacharya and Banerjee in Jaipur also observed that vital capacity increases with increase in age in both the sexes and they also found that females have lower vital capacities than males[13]. Chowgule et al in Bombay also found that boys have higher values of FVC than girls[8]. Sharma et al in Delhi also observed that FVC values were significantly ($p<0.05$) greater for boys than girls[4]. Vijayan et al found that in south Indian children, the mean FVC values were 2.43±0.07 liter in boys and 1.86 ± 0.05 liter in girls, which was significantly high in boys[7]. The mean values of FVC in our study were 2.22±0.36 liter for boys and 2.09±0.36 liter for girls and values were significantly higher in boys (table 7). Though the mean values of FVC of boys aged 10-14 years in our study were slightly higher than those obtained by Sharma et al and Raju et al[4,5]. This could be explained as a multitude of factors affect FVC apart from anthropometry to environment, socioeconomic factors and race which need further evaluation. FVC, FEV_1, and $FEF_{25-75\%}$ were found higher for boys as compared to girls. But the difference was statistically highly significant ($p<0.001$) for FVC and FEV_1, while $FEF_{25-75\%}$ did not vary significantly (table 7). We also correlated the mean values of FEV_1 in different age groups in both males and females of 10-14 years of age and observed that the correlation of FEV_1 increases with increase in age, weight, height, BSA and BMI as shown in (table 1 to 5). The correlation of FEV_1 with these variables was statistically significant ($p<0.001$). This was similar to the observations made earlier by Sharma et al, Raju et al, Vijayan et al. and Chowgule et al., in various parts of India[4,6-8]. The mean values of FEV_1 were similar to the mean values obtained by Sharma et al and Raju et al. in boys of same age[4,6]. We also observed that FEV_1 increases with increase in BMI as shown in table 5. The increase was more marked till a BMI of 21.0-22.69 kg/m^2 in males and 19.3-20.99 kg/m^2 in females. The correlation coefficients for FEV_1 with BMI were 0.435 for males and 0.159 for females (table 6). Correlation coefficients for FVC, FEV_1, FEV_1 /FVC % and $FEF_{25-75\%}$ with age, weight, height, BSA and BMI for both males and females are shown which is reflecting a good correlation. The correlation was found to be statistically highly significant ($p<0.001$) for all the variables except for BMI with $FEF_{25-75\%}$ in females (table 6).

From table 1-5, it was also analyzed that there is no relationship of FEV_1/FVC% with age, weight, height, BSA and BMI in children of 10-14 years of age in both the sexes. We also computed correlation coefficients of FEV_1/FVC% with age and anthropometric measurements ($p>0.05$). Correlation coefficient values of FEV_1/FVC% with age (0.012-males, 0.038-females), weight (0.020-males, -0.084-females), height (-0.053-males, -0.076-females), BSA (0.005-males, -0.094-females) and BMI (0.003-males, -0.102 females) were observed (table 6). Vijayan et al. did not find significant correlation of FEV_1/FVC% with age, height and weight[7]. Sharma et al observed that FEV_1/FVC% was more than 80% in age and sex categories and the difference being insignificant between the two sexes[4]. The mean values of FEV_1/FVC% for boys in our study were lower than the mean values reported by Raju et al for all age groups[6].

In our study, Forced expiratory flow ($FEF_{25-75\%}$) showed increase with increase in age, weight, height, BSA and BMI in both sexes (table 1-5). The correlation of $FEF_{25-75\%}$ was

significant ($p<0.001$) with all anthropometric measures except with BMI in females (table 6). Vijayan et al. found correlation between $FEF_{25-75\%}$ and age, weight and height to be significant ($p<0.01$)[7]. Coefficient of correlation was highest with height and was higher in boys than girls. We found maximum correlation of $FEF_{25-75\%}$ with age in both boys and girls (table 6). We found that $FEF_{25-75\%}$ was significantly correlated with age and height (table 3 and 6). Sharma et al also observed significant ($p<0.001$) increase in $FEF_{25-75\%}$ with age and height in both sexes[4]. We found slightly higher values of $FEF_{25-75\%}$ in girls than boys when the boys and girls of similar heights were compared (table 3). Raj Kapoor et al observed higher FVC, FEV_1, $FEF_{25\%}$, in boys while $FEF_{50\%,}$ $FEF_{75\%}$ and $FEF_{75-85\%}$ were higher in girls but this study was done in only 186 students[14]. After correlation for body size, girls have higher expiratory flow rates than boys whereas adult men have larger volumes and flow rates than women[15,16]. In our study (table 7), mean values of $FEF_{25-75\%}$ of males is higher than females but the difference was not statistically significant ($p=0.551$).

Conclusion

We found positive correlation of FVC, $FEV_{1,}$ and $FEF_{25-75\%}$ with age, height, BSA and BMI. There were some differences in pulmonary function between the values obtained in our study and the studies done earlier on Indian children. This could possibly be due to multiple factors; ethnic background, environmental, body build, socioeconomic status, and pollution.

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