PULMONARY FUNCTION STUDIES IN HEALTHY PAKISTANI CHILDREN

Pages with reference to book, From 318 To 324

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Abstract

Pulmonary function tests were studied in 519 healthy children (263 boys and 256 girls) from various schools of Rawalpindi and Karachi.
FVC, FEV1, MVV and PEFR were measured in all. FVC and FEV1 showed fairly constant increase from 5-12 years age, more variable in 13-15 years and constant in boys after 15 years while it declined in girls. Mean of FEV1/FVC ratio was 78.19% ± 2.4 in boys and 78. 14% ± 3.4 in girls. In younger age group (5-10 years), the mean was 76.04% ± 2.67 for boys and 76.45% ± 3.52 for girls while in older age group (11-16 years), it was 80.44% ± 2.41 and 79.55% ± 4.06 respectively. Both groups showed increased tendency with age, more significant in boys.
Multiple linear regression equation and correlation coefficient for age, weight and height were drawn. The results showed boys and taller subjects higher values for all parameters. Present values approximate to those of Western countries but are significantly higher ($P < 0.01$) than that of Indian children (JPMA 37: 318, 1987).

INTRODUCTION

Respiratory tract in children is probably most often affected by the disease than any other system of the body. The studies of lung function in infants and children are important to describe the normal growth and development of respiratory system and to understand the physiological abnormalities that occur in disease state[1]. With the proliferation of equipment the lung function testing by the physicians in their private offices or in general pediatric clinics has become popular, with little standardization of testing procedures and little consensus as to “normal” or “abnormal” test values. Anthropometric measurements affect the results of lung function tests in children[2-5].
To assess pulmonary function, measurements of forced vital capacity (PVC), forced expiratory volume for first, second (FEV1), maximum ventilatory volume (MW), and Peak expiratory flow rate (PEFR) are done in common practice. Decades have passed since the introduction of these pulmonary function tests; spectacular increase in their use testifies that most physicians are convinced of their value. Data of last six decades on the pulmonary function in children are available to help clinicians assess the related problems. [6-7] Most of the values reported in literature pertain to the Western world and only few studies have been carried óut in Pakistani children.
Lack of normal values for children from a particular population may jeopardise the clinical value of such data as it must be derived specifically from a sampling of that population. The purpose of this study was to analyse data obtained from healthy Pakistani subjects and to establish specific normal values.

PATIENTS AND METHODS

Five hundred and nineteen healthy children (263 boys and 256 girls) between the age of 5 to 16 years were selected from primary and secondary schools in Rawalpindi and Karachi area. Most of the

children belonged to the middle socioeconomic group. Data were recorded for sex, age, height and weight.

The criteria for healthy status were: No present acute or past chronic disease of respiratory system, no major respiratory disease, i.e., congenital anomalies, destructive type of pneumonia or thoracic surgery in the past. No systemic disease which directly or indirectly was known to influence the respiratory system. No more than incidental smoking experience and no history of upper respiratory tract infection during the previous three weeks.

TESTS

Testing consisted of measurements of PVC, FEV1, MVV and PEFR in the standing position with a nose clip on by means of Digital Pulmometer (Kinetics) and mini Wright's Peak Flowmeter. Both instruments were standardized and adequate training was given to the participants about their use. Three test values were obtained for all these tests and the mean of the three was recorded for further analysis. The ambient temperature during testing at all locations ranged between 22°C to 28°C. The values were subse quently computed for standard barometric pressure and temperature.

Indices of lung function were analysed and the results expressed as mean values with standard deviation. Correlation coefficients and various parameters were calculated with the height of the subjects. Multiple regression equation was drawn to find regression relationship of lung function on age, height and weight, separately for boys and girls. Comparison of low age group and high age group was made by using student's "t" test.

RESULTS

The age and sex distribution of 519 children is shown in Table-l.

TABLE – 1
Age and Sex Distribution of Children Studied.

Age (Yrs)	Boys	Girls
5	21	20
6	18	20
7	24	20
8	22	22
9	21	25
10	22	20
11	20	24
12	23	22
13	24	25
14	22	22
15	24	19
16	22	17
Total	263	256

The relationship of age to mean value and range for most of the indices of lung function are listed in

TABLE – II

Relationship of Age to Means (Standard Deviation) of Height, Weight, FVC, FEV_1, FEV_1/FVC, PEFR and MVV in 263 Boys.

Age (Yrs)	No.	Height (Cm)	Weight (Kg)	FVC (1)	FEV_1 (1)	FEV_1/FVC(%)	PEFR (1)	MVV
5	21	102.40(5.03)	20.62(2.25)	1.64(0.11)	1.28(0.18)	75.98(1.64)	157.43(10.18)	25
6	18	105.39(5.50)	23.83(3.11)	2.10(0.13)	1.59(0.09)	75.68(2.86)	173.11(19.30)	32
7	24	108.50(4.93)	24.92(2.80)	2.31(0.22)	1.77(0.18)	76.77(1.55)	191.87(22.30)	34
8	22	121.18(6.79)	26.82(2.24)	2.64(0.15)	1.96(0.17)	74.30(4.00)	204.09(17.18)	36
9	21	130.05(5.71)	27.76(2.90)	2.88(0.16)	2.20(0.11)	76.57(2.59)	224.52(25.98)	42
10	22	135.77(4.38)	29.59(3.53)	2.90(0.15)	2.23(0.13)	76.83(2.09)	243.86(28.86)	49
11	20	140.55(4.38)	34.55(4.76)	3.12(0.19)	2.33(0.17)	74.69(2.53)	258.05(27.20)	55
12	23	148.43(8.90)	37.26(3.87)	3.34(0.32)	2.58(0.28)	77.22(3.95)	266.30(35.94)	62
13	24	159.04(4.66)	48.68(3.85)	3.71(0.25)	2.92(0.22)	78.67(2.36)	303.64(31.52)	69
14	22	162.23(8.86)	46.59(4.57)	4.32(0.36)	3.47(0.30)	80.28(1.99)	337.05(39.24)	80
15	24	167.67(4.17)	55.29(4.64)	4.83(0.25)	4.13(0.19)	85.59(1.74)	376.96(33.45)	90
16	22	173.45(4.67)	60.36(5.57)	4.75(0.25)	4.07(0.18)	85.76(1.67)	428.41(37.65)	103

Table-Il for boys and Table-III for girls.

TABLE – III

Relationship of Age to Means (Standard Deviation) of Height, Weight, FVC, FEV_1, FEV_1/FVC, PEFR and MVV in 256 Girls.

Age (Yrs)	No.	Height (Cm)	Weight(Kg)	FVC (1)	FEV_1(1)	FEV_1/FVC(%)	PEFR (1)	MVV
5	20	100.20(4.24)	18.15(2.56)	1.41(0.09)	1.11(0.06)	78.60(1.98)	148.10(11.88)	21.4
6	20	104.90(4.10)	22.05(2.35)	1.82(0.13)	1.44(0.10)	79.33(3.78)	156.75(11.40)	26.9
7	20	107.00(9.29)	26.15(2.08)	2.11(0.11)	1.59(0.09)	75.10(1.45)	173.25(17.72)	28.7
8	22	121.27(4.87)	27.73(2.86)	2.36(0.18)	1.73(0.19)	73.00(4.16)	203.41(22.50)	36.4
9	25	128.04(4.69)	27.84(3.14)	2.65(0.26)	1.99(0.20)	75.12(2.14)	216.00(21.79)	40.2
10	20	133.40(7.57)	30.35(3.63)	2.66(0.25)	2.08(0.21)	78.26(1.62)	237.75(36.22)	44.1
11	24	142.12(5.19)	32.12(4.03)	3.08(0.16)	2.36(0.16)	76.48(2.42)	244.58(27.66)	49.5
12	22	141.77(6.32)	37.36(3.72)	3.29(0.25)	2.62(0.31)	78.77(3.46)	271.32(28.85)	57.8
13	25	143.36(4.33)	39.64(4.20)	3.42(0.36)	2.77(0.23)	80.25(3.86)	315.20(38.85)	66.0
14	22	148.77(3.84)	47.09(4.34)	4.24(0.29)	3.37(0.33)	79.58(2.86)	340.91(35.81)	77.8
15	19	159.16(7.57)	50.79(6.23)	4.41(0.34)	3.68(0.54)	81.46(6.27)	349.21(45.83)	85.2
16	17	164.11(8.46)	54.70(4.83)	4.20(0.18)	3.43(0.23)	81.81(2.49)	402.29(42.06)	92.8

The mean and standard deviations of the variables were calculated for age, 5 to 16 years.
The mean values of FVC are plotted against age (Figure 1 a).

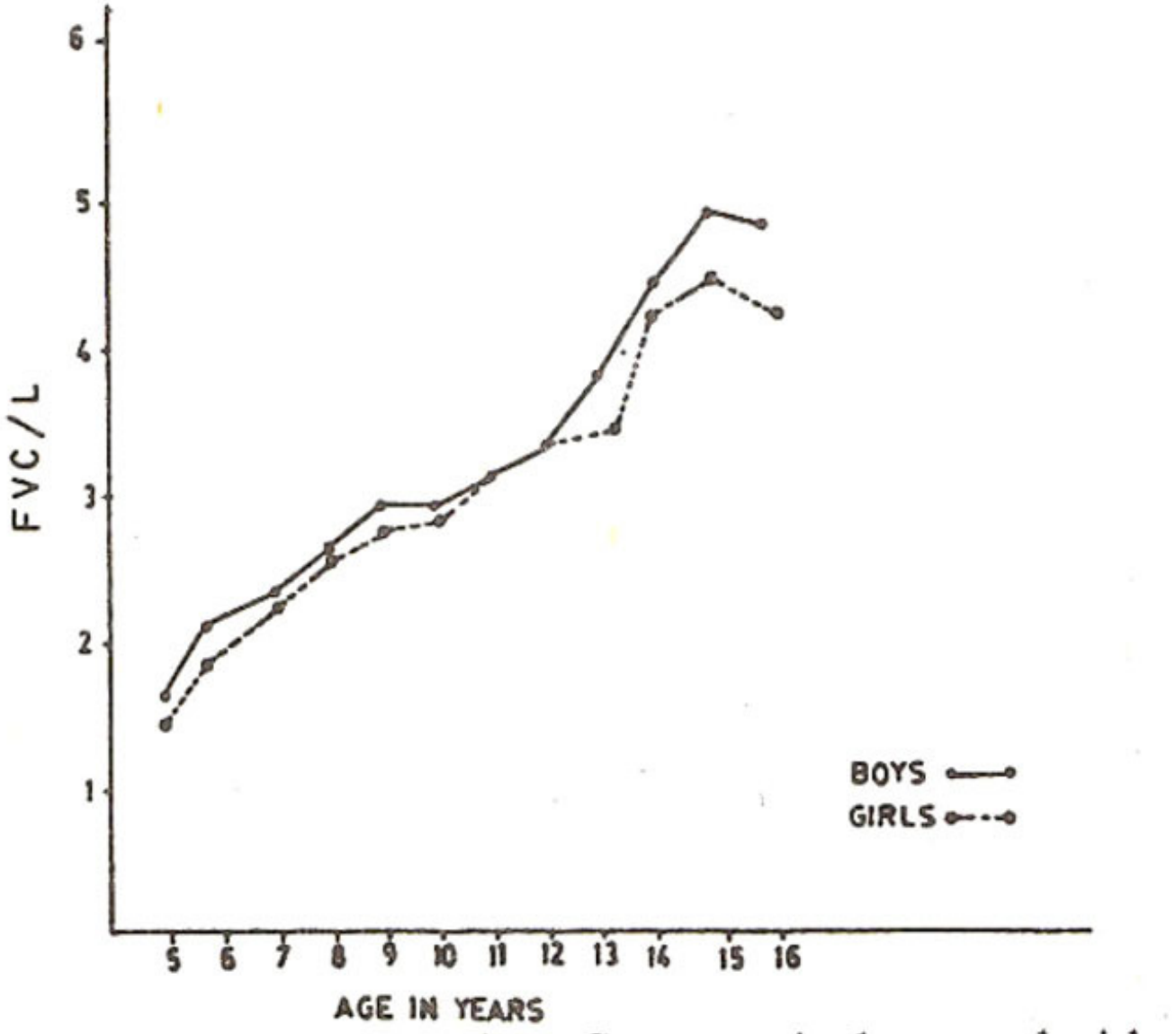

Figure 1a. Relation of FVC to age in boys and girls.

For boys the graph showed a fairly constant increase in FVC from ages 5 to 12 years, a sharper and more variable increase in the years 13 to 15, after which the values are fairly constant. Differences between boys and girls were negligible in the early years but girls attained their maximum FVC at approximately 15 years after which the values showed a decline.

Relation of FEy1 to age in boys and girls (Figure 1)

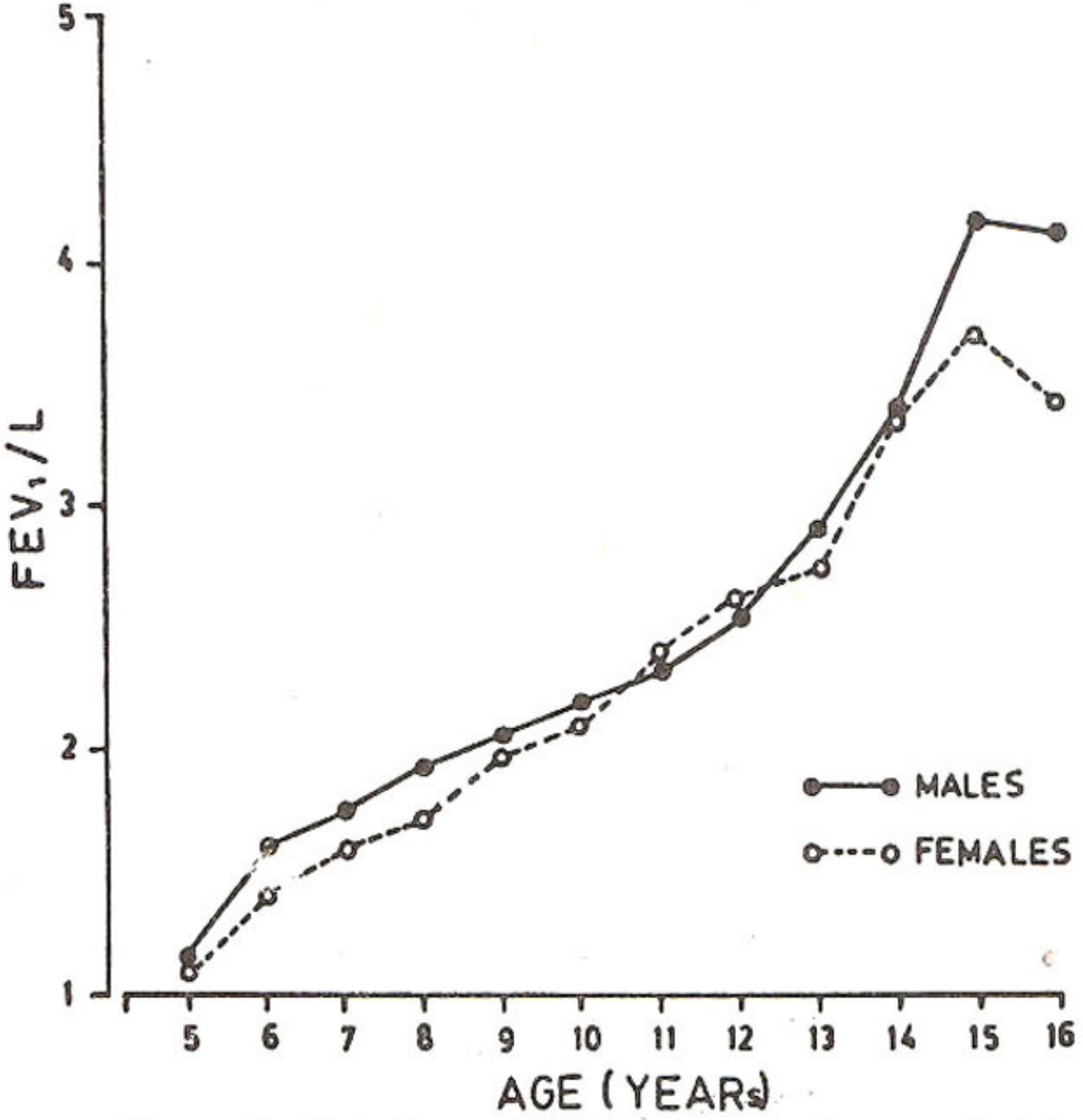

Figure 1. Relation of FEV_1 to age in boys and girls.

follows approximately the same pattern as in Figure-la.

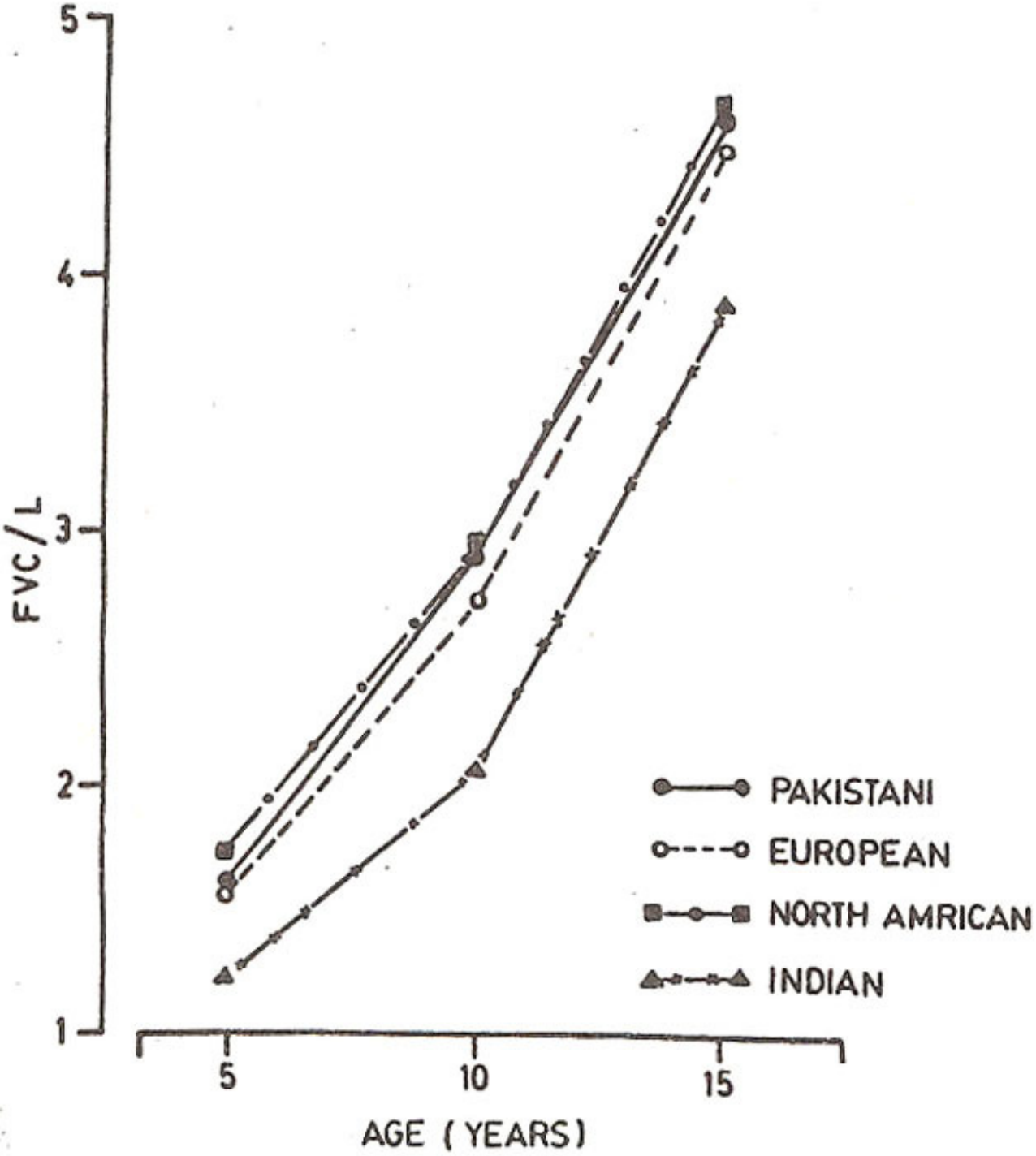

Figure 2. Comparative relation of FVC to age in Pakistan, European, American and Indian children.

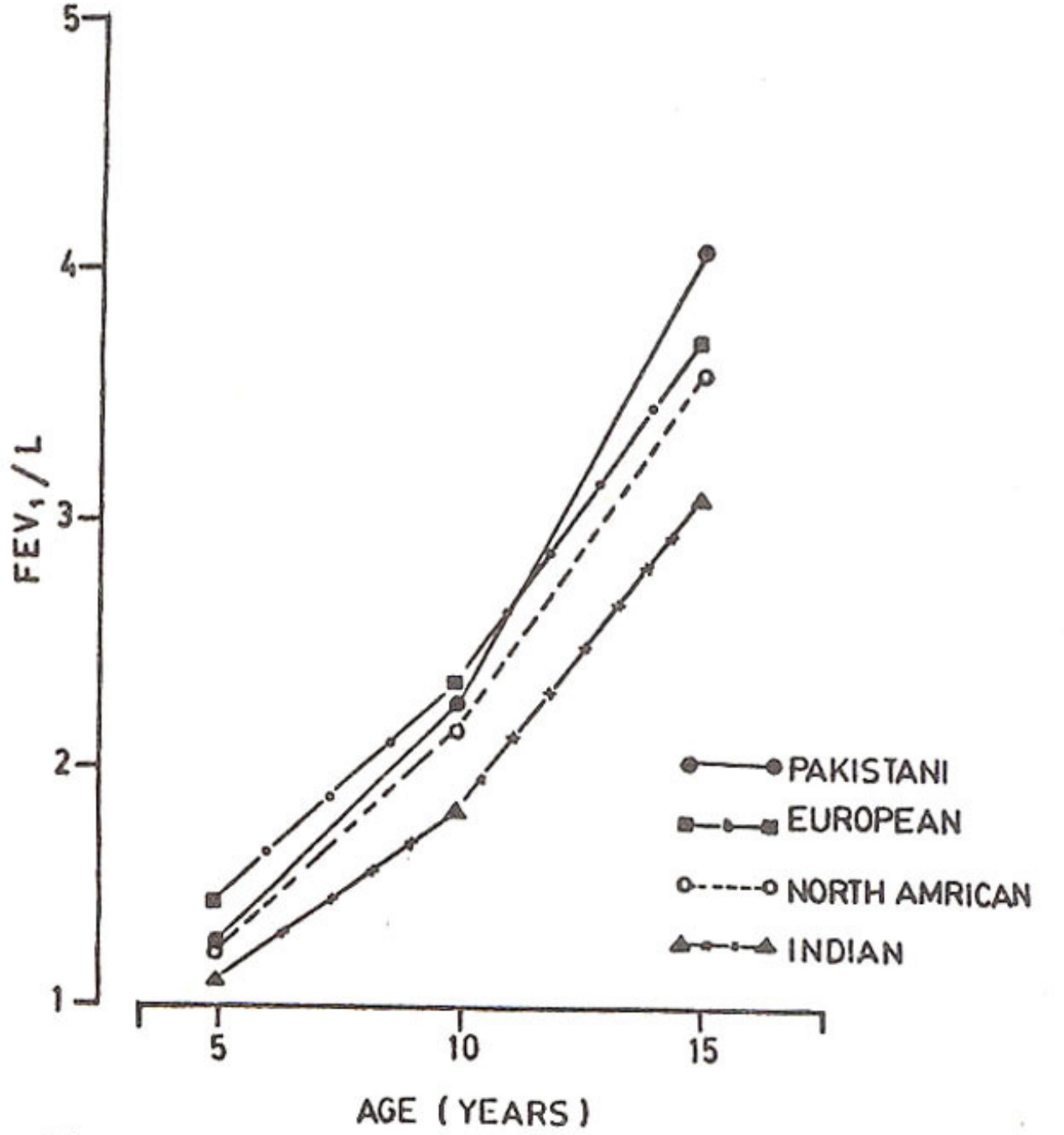

Figure 3. Comparative relation of FEV_1 to age in Pakistan, European, American and Indian children.

Figure 2 and 3 show the relationship of FVC and FEy1 with age for Pakistani, European, white North American and Indian children.

The two correlation matrices are presented in Table IV.

TABLE – IV

Correlation Coefficients Among Pulmonary Function Measurements in Normal Pakistani Children Aged 5 –16 Years.

Measurement	Sex	Age (Yrs)	Weight (Kg)	Height (Cm)	FVC (1)	FEV_1 (1)	FEV_1/FVC (%)	PEFR (1)
Age (Yrs)	M	1.00	0.9070	0.9476	0.9446	0.9280	0.9804	0.9117
	F	1.00	0.9242	0.9289	0.9492	0.9343	0.9056	0.9130
Weight (Kg)	M		1.00	0.8799	0.9226	0.9348	0.6007	0.9069
	F		1.00	0.8560	0.9035	0.8837	0.9128	0.9874
Height (Cm)	M			1.00	0.9261	0.9050	0.9064	0.8827
	F			1.00	0.8988	0.8794	0.8981	0.8573
FVC (1)	M					0.9897	0.8694	0.9210
	F				1.00	0.9671	0.9043	0.9039
FEV_1 (1)	M					1.00	0.8652	0.9286
	F					1.00	0.9118	0.8851
FEV_1/FVC(%)	M						1.00	0.9282
	F						1.00	0.8461
PEFR (1)	M							1.00
	F							1.00
MVV (1)	M							
	F							

The correlation between FVC and FEy1 was nearly perfect (r:=0.99) in healthy boys and girls. The FVC, FEy1 , PEFR and MW showed very close correlation with height, age and weight. There was a trend for the FEV1/FVC to increase with age in both boys and girls; increase in boys was more significant. In general the correlation coefficients calculated for the girls were less than those for the boys.

Comparison between low age group (5 to 10 years) and high age group (11 to 16 years) for lung function indices shows a significant difference ($P < 0.00001$) both in boys (Table V) and in girls (Table VI).

TABLE – V

Comparison between Low Age (5–10 Yrs) and High Age (11–16 Yrs) in Boys.

Variables	Low Age (5–10 Yrs) n=128	High Age (11–16 Yrs) n=135
FVC (1)	2.42 ± 0.48	3.97 ± 0.86*
FEV_1 (1)	1.85 ± 0.37	3.22 ± 0.83*
FEV_1/FVC (%)	76.04 ± 2.67	80.44 ± 2.41*
PEFR (1)	199.98 ± 36.05	324.84 ± 79.39*
MVV (1)	36.91 ± 9.35	76.04 ± 20.98*

n = Numbers

P* $<$ 0.00001

TABLE – VI
Comparison between Low Age (5 –10 Yrs) and High Age (11 –16 Yrs) in Girls.

Variables	Low Age (5 –10 Yrs) n=125	High Age (11 –16 Yrs) n=131
FVC (1)	2.19 ± 0.48	2.36 ± 0.49*
FEV_1 (1)	1.67 ± 0.36	2.99 ± 0.56*
FEV_1/FVC (%)	76.45 ± 3.52	79.55 ± 4.06*
PEFR (1)	190.49 ± 73.22	315.32 ± 61.80*
MVV (1)	33.32 ± 9.17	69.80 ± 17.63*

n = Numbers
P* $<$ 0.00001

This suggests that rapid growth of airway passages is commensurated with height and weight as age advances.

Multiple regression analyses were carried out for each lung function variable using anthropometric measurements as independent variables and dealing with each sex separately (Table VII for boys and Table VIII for girls).

TABLE – VII

Regression Relationship of Lung Function to Age, Weight and Height for Boys in the form of $y = b_0 + b_1$ (Age) $+ b_2$ (Weight) $+ b_3$ (Height) where y is Lung Function.

	b_0	b_1	b_2	b_3
FVC (1)	-0.3518	0.1082	0.0278	0.0102
FEV_1 (1)	-0.3863	0.0853	0.0359	0.0053
FEV_1/ FVC (%)	-2.1166	15.3936	-2.8542	0.0816
PEFR (1)	3.3366	10.4399	2.8920	0.3192
MVV (1)	-16.4281	3.9297	0.8496	-0.0244

TABLE – VIII

Regression Relationship of Lung Function to Age, Weight and Height For Girls in the form of $y = b_0 + b_1$ (Age) $+ b_2$ (Weight) $+ b_3$ (Height) where y is lung Function.

	b_0	b_1	b_2	b_3
FVC (1)	-0.4443	0.2035	0.0115	0.0059
FEV_1 (1)	-0.4647	0.1992	0.0047	0.0034
FEV_1/ FVC (%)	-5103.4371	-433.234	-0.2387	74.8750
PEFR (1)	-14.5758	14.2216	2.1534	0.2895
MVV (1)	-26.5140	3.9748	0.6591	0.0913

For all pulmonary function variables, multiple regression equations constructed provide more accurate prediction. These formulae can be applied to Pakistani children in any age group to evaluate their respective lung function.

DISCUSSION

In the present study, reference standards of pulmonary function in healthy Pak1stani children were determined Proper instructions to first, second and third grade school children (5 to 9 years of age) resulted in meaningful and reproducible FVC maneuvers in over 95% of the subjects. The number of attempts a child should be asked to make to provide 3 acceptable values is important[8]. A balance is needed to allow for learning effect and yet not reach the stage where child tires or becomes bored[9]. In this group of children where pretest training was given most of the children achieved their maximal values in the first recording. However in order to have better stability of measurement mean values were used to safeguard occasional erroneous measurements.[10]

Pulmonary function in normal healthy Pakistani children is closely related to growth and development (Table II, III). The growth of lung function from ages 5 to 16 years can best be described in curvilinear fashion (Figure la 1). This confirms observations of previous workers. [7,11,12]

The correlation between the lung indices and height, weight and age were striking (Table. W). In younger age (5 to 12 years) the differences between bbys and girls were minor and the volume and indices of flow increased uniformly with height, which affords a better index of body size than does age[13]. At adolescence, the rate of pulmonary development increases and marked differences between boys and girls were noted. This conforms to present findings (Figure 1, la). In boys, pulmonary function peaks at approximately age 15 years. While female subjects attain their! maximum pulmonary function at approximately age 15 years then decrease with increasing age. These figures are slightly on lower side compared to Dickman and associates, may be because our study group range was 5 to 15 years while they studied upto 18 years.

The FEV,/FVC in normal subject was impressively stable regardless of age, sex or height. Mean values were 78.20% ± 2.4 for boys and 78.14% ± 3.4 for girls. Means for boys and girls were 76.04% ± 2.67 and 76.45% ± 3.52 respectively in low age group (5 to 10 years) while it was 80.44% ± 2.41 forboysand79.55%±4.06 forgirls in high age group (11 to 16 years). Although these values were quite stable in their own group but were significantly (P<0.0000l) different from those observed by other workers[11,13,14] However in view of the standard deviations observed in all these studies, the practical clinical conclusion is that a ratio of FEV1 to FVC less than 70% is abnormal for any age, sex or height.

To assess pulmonary function of a particular adult the observer usually refers to nomogram of linear regression curve. In children, however, these two methods cannot be used because other factors, i.e., weight and growth spurt, not represented in such computations have an important role. Multiple linear regression formulae are thus better expressions. The regression relationship determined presently, Table VII for boys and Table VIII for girls, could be reliably applied to Pakistani children belonging to any age, height and weight groups.

In figure 2 and 3 we compared the FVC and FEy, values of Pakistani children with those of European, white North American and Indian children as reported by other workers[5,11,13,15,17] The data suggest that these values for Pakistani children are in conformity with those of Euiopean, white North American but are significantly higher (P< 0.01) than those of Indian children. This disparity may be due to selection of the subjects from the two major cities of the country where socio.economic conditions of the people are better than in the remote places.

In conclusion our findings provide baseline data for lung function indices in healthy Pakistani children and we support the need to establish similar normal values in men and women in any previously untested ethnic or geographical group before decisions are made about the prevalence of dysfunction relating to disease.

ACKNOWLEDGEMENT

The writers wish to thank the teachers and local administration of the schools for making the students available to participate in this study. We also acknowledge the efforts of Mr. Aftab Qazi for providing help and guidance in cons¬truction of various statistical figures, Mr. Muhammad Irtiza Khan and Mr. M. Yaqoob for typing the manuscript.
The study was supported by PMRC Research Centre, Army Medical College, Rawal¬pindi.

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