Journal of Diagnostics
2014 Vol.1, No.1, pp.6-12
ISSN(e): 2409-322X
ISSN(p): 2413-8371
DOI: 10.18488/journal.98/2014.1.1/98.1.6.12

ANTHROPOMETRIC PARAMETERS AS PREDICTORS OF PEAK EXPIRATORY FLOW RATE IN CENTRAL INDIAN CHILDREN 5-15 YEARS

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ABSTRACT

The development of pulmonary function and growth of physical parameters are concurrent in children. Hence, measurement of lung function is essential for evaluation of physical development of children and adolescent with respiratory disease. A cross sectional study was conducted on 200 primary, middle and high school children of 5-15 years. Their anthropometric parameters and peak expiratory flow rate (PEFR) were recorded and multiple regression equations for predicting PEFR from anthropometric variables were derived. Highly significant positive correlation ($P<0.01$) was observed between all the anthropometric and pulmonary parameters. Significantly high R^2 values were found when age, height, weight, chest circumference, BSA and arm span were used as independent variables in the regression analysis. Thus, this study establishes reference standards for predicting PEFR in normal healthy children residing in Central India.

Keywords: PEFR, Anthropometric parameters, Regression equations, PFT, School children, Central India.

1. INTRODUCTION

Pulmonary function test provides a better understanding of functional changes in lungs and their significance from diagnostic viewpoint [1] and therefore they are considered as an essential component for evaluation of lung functions. During last few decades, pulmonary function tests have been evolved from the tools for physiologic study to clinical investigation in assessing respiratory status of the patients. The development of pulmonary function and growth of physical parameters are concurrent in children [2]. Therefore, measurements of lung functions are equally important for the evaluation of physical development and complete assessment of children

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and adolescent with respiratory disease. The prevalence of childhood pulmonary diseases especially bronchial asthma is increasing worldwide [3] and this necessitates the need for establishing regression equations for predicting pulmonary function in children. Usually the values are compared with the standards obtained from healthy individuals of similar age and height. Development of pulmonary function is then described by means of regression equations usually employing sex, age and standing height as independent variables [4]. PFTs are influenced by various parameters like anthropometric, geographic, genetic, ethnic, racial, socio-economic, life-style and technical factors [5] .The size and shape of ribcage, respiratory muscle strength and possibly parenchymal lung development varies according to different genetic, racial, ethnic and geographic set-up. Similarly, nutrition in young age affects the body size which may directly affect the size of lungs.

PEFR (Peak Expiratory Flow Rate) depends on expiratory efforts exerted during forceful expiration as well as status of airways and it is mainly influenced by efficiency of expiratory muscle, elastic recoil pressure of lung and airway size and all these factors have geographic, ethnic and genetic variation.

India being a subcontinent, pulmonary norms may vary according to different geographic locations. Therefore it is important to have normal pulmonary function data in native population to interpret accurately the pulmonary function changes in childhood pulmonary diseases. Hence, this study was undertaken to study the correlation of PEFR with some of the anthropometric parameters and to derive its prediction equations.

2. MATERIALS AND METHODS

A cross sectional study was conducted on 200 primary, middle and high school children of 5-15 years (99 males and 101 females). Study was carried out at Navyug Primary School and Pt. Bachharaj Secondary School, Nagpur after getting Institutional Ethics Committee's approval. Children with past or present history of respiratory disease, cardio-respiratory illness, thoracic cage disorder, chest or upper limb deformity, allergic illness were excluded from this study. Study subjects were divided into 11 groups with an age difference of one year viz.5, 6, 7, 8, 9, 10, 11, 12, 13, 14 and 15 years. Anthropometric parameters included in this study were – weight in kg, standing and sitting height in cm, chest circumference (resting and on full inspiration) in cm, body surface area (BSA) in square meter and arm span in cm.

Study was done in a group of five children in morning hours 10 AM to 12 Noon to avoid diurnal variations. Weight was measured without shoes with the help of Soehnle's weighing machine to the nearest 0.5 Kg mark [6]. Standing and sitting height was measured against the wall inscribed measuring scale to the nearest completed centimeter. Age was calculated from date of birth recorded in school register. Chest circumference was measured with measuring tape to nearest centimeter just below the nipple. Body surface area (BSA) was calculated with help of Dubois' nomogram and arm span was measured as the distance between the tips of both middle fingers of horizontally abducted and maximally outstretched hands with subjects standing and facing the wall. PEFR was measured with MIR-SPIROLAB II. The techniques were demonstrated to each child and they were made three efforts while standing and wearing a nose clip with an interval of five minutes between two consecutive maneuvers and the best of three was recorded. Single expiratory maneuver gave the spirometric parameters required for study – PEFR (Peak expiratory flow rate in liters/second).

2.1. Statistical Analysis

Results were expressed as Mean ± SD, range and SEM (Standard error of mean). Statistical analysis of data was performed using one way analysis of variance (ANOVA). Pearson's correlation coefficient(r) is calculated between dependent and independent variables and their significance is tested by using Student's t-test for testing the significance of correlation. Two tailed p-values were used throughout and p-values less than 0.01 were judged statistically significant. Statistical calculations were done by using SPSS (Statistical Package for Social Sciences) version 10.0. Multiple regression equations for predicting indices of lung function from independent variables were derived.

3. RESULTS

Table No. 1 and 2 show mean value of anthropometric parameters in healthy children. All the anthropometric parameters viz. weight, height, chest circumference, BSA and arm span showed gradual increase with increasing age. Table No. 3 indicates mean values of PEFR. The PEFR showed gradual increase with advancing age and showed significant positive correlation with age, height, weight, chest circumference, BSA and arm span ($P < 0.01$). Among various anthropometric parameters standing height and arm span were shown to have strongest correlation with pulmonary parameters (Table No.4). The multiple regression equations for normal healthy Central Indian boys and girls based on various anthropometric variables are shown in Table No. 4 and 5. These regression equations may be useful to derive predicted lung function indices.

Table-1. Statistical profile of anthropometric parameters: Male Subjects

Age (Years)	Statistics	5	6	7	8	9	10	11	12	13	14	15
No. of subjects	n	4	11	8	11	7	10	5	16	9	14	4
Weight (Kg)	Mean±SD	17.12± 0.62	18.33±1.62	19.31±2.63	23.15±6.91	22.07±3.03	30.11±7.44	38.50±12.02	33.33±7.11	37.66±8.40	53.15±9.99	53.25±11.39
	Range	16.50-18.00	15.00-20.00	16.00-23.00	19.00-42.00	19.00-27	22.00-42.00	26.00-53.00	24.00-52.50	23.00-50.00	42.50-78.50	43.50-69.00
	SEM	0.31	0.54	0.93	2.18	1.14	2.48	5.37	2.05	2.80	2.77	5.69
Height(Cm) (Standing)	Mean± SD	107.37±4.64	115.11±5.39	118.00±5.00	126.35±6.39	128.00±7.16	137.11±4.51	147.30±9.57	144.75±5.10	152.77±9.58	167.96±7.06	163.25±4.11
	Range	101.50-112.00	102.00-120.00	113.00-126.50	119.00-139.00	121.00-139.00	129.00-144.00	129.00-162.00	134.00-152.00	135.00-170.00	154.00-183.00	158.00-168.00
	SEM	2.32	1.79	1.76	2.02	2.70	1.50	4.28	1.47	3.19	1.95	2.05
Height(Cm) (Sitting)	Mean± SD	56.12±2.01	60.31±1.76	61.25±2.93	63.95±3.08	63.07±2.55	68.15±2.94	72.40±4.27	70.06±3.18	73.00±5.19	81.42±3.96	81.37±3.30
	Range	54.50-59.00	57.00-64.00	57.50-66.00	60.00-70.00	58.00-66.00	63.00-73.00	68.00-79.00	65.00-75.00	61.00-79.00	74.50-90.00	77.50-85.00
	SEM	1.00	0.53	1.03	0.93	0.96	0.93	1.91	0.79	1.73	1.05	1.65
Chest(Cm) Circumference (Resting)	Mean± SD	51.12±1.75	55.04±1.87	55.00±3.07	56.77±6.29	56.85±3.07	66.75±8.50	70.00±9.38	66.81±7.31	69.05±7.08	77.28±7.07	79.00±9.93
	Range	49.00-53.00	52.00-58.00	52.00-60.00	52.00-75.00	54.00-61.00	57.00-80.00	62.00-82.00	61.00-88.00	58.00-76.50	69.00-92.00	71.00-93.00
	SEM	0.87	0.56	1.08	1.89	1.16	2.68	4.19	1.82	2.36	1.88	4.96
Chest(Cm) Circumference (Full Inspiration)	Mean± SD	53.00±1.58	57.50±2.09	57.87±3.50	60.09±5.99	59.71±2.78	69.40±8.11	72.50±9.15	69.56±6.97	71.83±6.67	80.57±6.35	83.25±8.53
	Range	51.00-54.50	54.50-61.00	53.50-63.50	55.50-77.00	56.50-63.50	59.50-81.50	64.00-84.50	63.00-90.00	61.00-79.00	74.00-94.00	76.00-95.00
	SEM	0.79	0.63	1.23	1.80	1.05	2.56	4.09	1.74	2.22	1.69	4.26
BSA (Sq. m.)	Mean± SD	0.71±0.02	0.76±0.04	0.79±0.07	0.89±0.13	0.89±0.09	1.09±0.13	1.25±0.22	1.15±0.12	1.29±0.17	1.57±0.14	1.54±0.13
	Range	0.68-0.74	0.65-0.84	0.70-0.90	0.79-1.25	0.80-1.04	0.93-1.29	1.03-1.54	0.96-1.46	0.95-1.55	1.41-1.99	1.39-1.72
	SEM	0.01	0.01	0.02	0.03	0.03	0.04	0.09	0.03	0.05	0.03	0.06
Arm Span(Cm)	Mean± SD	108.37±6.03	116.27±6.24	119.18±5.92	127.72±6.80	131.21±9.06	139.85±6.19	153.10±12.03	148.12±5.44	154.83±9.72	172.25±7.98	171.87±5.54
	Range	101.50-115.00	99.00-122.00	112.50-127.00	120.00-143.50	120.50-146.00	131.00-149.00	141.00-169.00	136.00-156.50	140.00-170.00	161.00-192.00	165.50-179.00
	SEM	3.01	1.88	2.09	2.05	3.42	1.95	5.38	1.36	3.24	2.13	2.77

Values are Mean ±SD, n=20 in each age. Range is from lowest value to highest value. SEM is standard error of mean=SD/ √n

Table-2. Statistical profile of anthropometric parameters: Female Subjects

Age (Years)	Statistics	5	6	7	8	9	10	11	12	13	14	15
No. of subjects	n	8	9	10	10	7	9	8	12	11	13	4
Weight (Kg)	Mean±SD	17.00 ±1.68	18.55±2.06	18.12±3.00	21.75±2.21	25.57±6.09	25.66±4.86	25.90±3.48	37.95±8.86	37.66±9.26	45.42±5.00	50.37±4.30
	Range	15.00-19.00	16.00-22.00	14.00-24.00	19.50-26.00	18.50-37.00	19.50-35.50	22.00-30.00	29.00-60.00	25.00-53.00	39.00-56.00	46.00-55.00
	SEM	0.84	0.68	1.06	0.70	2.30	1.62	1.56	2.55	3.08	1.38	2.15
Height(Cm) (Standing)	Mean±SD	112.37±1.49	114.83±4.10	117.81±5.71	127.10±5.63	131.50±6.98	134.44±7.13	137.50±6.96	147.25±6.25	150.00±10.70	156.19±5.36	157.50±5.91
	Range	110.50-114.00	109.00-120.50	107.50-128.00	119.50-136.00	123.50-144.50	122.50-149.50	125.00-143.00	132.00-154.00	136.00-169.00	149.50-169.00	152.00-164.00
	SEM	0.74	1.36	2.02	1.78	2.64	2.37	3.11	1.80	3.56	1.48	2.95
Height(Cm) (Sitting)	Mean±SD	57.75±2.84	60.22±1.73	60.60±1.86	63.25±3.13	65.92±4.16	66.72±3.91	67.31±3.17	73.20±2.48	74.81±4.62	79.03±2.89	79.12±2.09
	Range	52.50-61.00	58.00-63.00	56.50-62.00	60.00-70.00	61.00-73.00	60.00-75.00	62.50-71.00	69.00-77.00	68.00-80.50	74.00-85.00	77.00-82.00
	SEM	1.00	0.57	0.59	0.99	1.57	1.30	1.12	0.71	1.39	0.80	1.04
Chest(Cm) Circumference (Resting)	Mean±SD	51.00±1.87	52.16±2.31	52.40±2.45	54.90±2.13	59.57±4.79	61.11±3.69	62.75±7.70	71.45±8.00	72.36±7.57	76.00±3.64	80.75±3.96
	Range	49.00-54.00	49.00-57.00	49.00-58.00	52.00-58.00	54.00-68.00	57.00-67.00	52.00-78.00	63.50-91.00	59.00-87.00	70.00-82.50	75.50-85.00
	SEM	0.66	0.77	0.77	0.67	1.81	1.23	2.72	2.31	2.28	1.01	1.98
Chest(Cm) Circumference (Full Inspiration)	Mean±SD	52.93±2.17	54.33±2.91	55.25±2.16	58.10±2.40	61.71±4.58	63.61±3.69	65.12±7.54	73.95±7.86	74.81±7.59	78.34±3.98	82.12±3.79
	Range	51.00-57.00	51.00-60.50	52.00-59.50	54.50-62.00	56.50-69.50	59.00-69.00	54.00-80.00	67.00-92.00	62.50-90.00	72.50-86.00	77.00-86.00
	SEM	0.77	0.97	0.68	0.75	1.73	1.23	2.66	2.26	2.28	1.10	1.89
BSA (Sq. m.)	Mean±SD	0.70±0.07	0.76±0.05	0.77±0.06	0.88±0.06	0.97±0.13	0.98±0.11	1.02±0.15	1.24±0.12	1.28±0.17	1.40±0.09	1.47±0.06
	Range	0.61-0.83	0.71-0.86	0.64-0.88	0.81-1.01	0.81-1.22	0.82-1.23	0.85-1.34	1.03-1.54	0.99-1.54	1.28-1.62	1.40-1.55
	SEM	0.02	0.01	0.02	0.02	0.05	0.03	0.05	0.03	0.05	0.02	0.03
Arm Span (Cm)	Mean±SD	107.62±5.86	113.72±4.74	118.85±6.22	129.25±5.38	133.64±6.68	137.77±9.46	139.18±5.63	152.00±7.31	154.86±12.33	162.53±8.07	161.25±8.30
	Range	99.00-117.00	107.00-120.00	107.00-132.00	120.00-137.00	125.50-145.50	123.50-159.50	131.00-147.00	139.00-162.00	136.00-176.00	153.00-179.00	151.00-168.00
	SEM	2.07	1.58	1.96	1.70	2.52	3.15	1.99	2.11	3.71	2.23	4.15

Values are Mean ±SD, n=20 in each age. Range is from lowest value to highest value.

Table-3. Statistical profile of PEFR in L/Sec in Male and Female Subjects

Age (Years)	Statistics	5	6	7	8	9	10	11	12	13	14	15
Males (n= 99)	Mean ± SD	2.05±0.28	2.46±0.60	2.51±0.66	3.28±0.78	3.36±0.55	3.96±0.54	4.94±2.23	4.78±0.73	5.13±0.71	6.93±1.50	6.82±1.10
	Range	1.74-2.40	1.21-3.34	1.06-3.30	2.23-4.66	2.92-4.28	3.05-4.60	3.34-8.82	3.55-6.13	4.24-5.95	4.79-10.37	6.02-8.40
	SEM	0.14	0.18	0.23	0.23	0.20	0.17	0.99	0.18	0.23	0.40	0.55
Females (n= 101)	Mean ± SD	2.37±0.48	2.53±0.49	2.58±0.60	3.28±0.67	3.01±0.84	4.00±0.45	4.18±0.61	4.85±0.50	5.68±1.08	5.80±0.50	6.18±0.91
	Range	1.63-3.34	1.84-3.05	1.80-3.97	2.23-4.12	1.80-4.55	3.55-4.96	3.34-5.23	3.94-5.49	4.24-8.09	4.79-6.66	5.52-7.50
	SEM	0.17	0.16	0.19	0.21	0.31	0.15	0.21	0.14	0.32	0.13	0.45

Values are Mean ±SD; Range is from lowest value to highest value. SEM is standard error of mean=SD/ √n

Table-4. Regression Equations for PEFR with anthropometric parameters for Boys

Dependent variables	Regression Equation	R	R^2	F-value	SEE
PEFR	PEFR = 0.50*Age -0.82	0.83	0.68	214.87**	1.66
	PEFR =0.11*Weight +0.88	0.83	0.69	220.81**	1.00
	PEFR =0.08*Standing Height–7.34	0.90	0.81	427.75**	0.77
	PEFR =0.20*Sitting Height-9.22	0.89	0.79	381.15**	0.81
	PEFR =0.13*Chest (R) -4.08	0.75	0.57	129.83**	1.18
	PEFR =0.13*Chest(F)-4.70	0.78	0.61	154.90**	1.12
	PEFR =5.11*BSA-1.31	0.87	0.77	329.09**	0.86
	PEFR =0.08*Arm Span-6.65	0.90	0.81	425.28**	0.78

Table-5. Regression Equations for PEFR with anthropometric parameters for girls

Dependent variables	Regression Equation	R	R^2	F-value	SEE
PEFR	PEFR = 0.42*Age -0.12	0.88	0.78	351.77**	0.68
	PEFR =0.10*Weight +1.08	0.91	0.69	224.46**	0.81
	PEFR =0.08*Standing Height – 6.38	0.89	0.80	416.41**	0.64
	PEFR =0.17*Sitting Height-7.23	0.87	0.77	332.87**	0.70
	PEFR =0.11*Chest(R) -3.01	0.82	0.68	217.27**	0.82
	PEFR =0.11*Chest(F)-3.34	0.82	0.68	217.07**	0.82
	PEFR =4.76*BSA-0.92	0.88	0.77	345.61**	0.69
	PEFR =0.07*Arm Span-5.01	0.88	0.77	338.60**	0.69

** Significant i.e. $P < 0.01$

- F-value i.e. variance ratio is calculated from the method of one way ANOVA
- R is the regression coefficient. Above table gives linear regression which gives the equation of the straight line that describes how the y-variable increases (or decreases) with an increase (or decrease) in x variables.
- R^2 is called coefficient of determination.
- Standard error of estimate (SEE) measures the probable error of estimate between independent and dependent variables.

4. DISCUSSION

In country like India, with varying geography, ethnic origin and dietary habits, it is important to establish regression equation on regional basis to predict various normal lung function measurements. This study was aimed to derive normative standard for PEFR in the school children aged 5-15 years residing in central India and to calculate prediction equation as well as to elucidate the correlation of PEFR with some anthropometric parameters.

A significant positive correlation was observed between PEFR and all the anthropometric indices. We observed lower values of PEFR in females as compared to males. Its strongest correlation in male was found with standing height and Arm span ($r = 0.90$) and in female with weight ($r=0.91$).

Our findings are in accordance with study by Leiner, et al. [7] who found in males, high correlation of PEFR with age and height and Elebute and Femi-Pearse [8] who found positive correlation between PEFR and anthropometric parameters. Observation of Singh and Meenakshi [9] who found highly significant positive correlation of PEFR with height, weight and BSA, are comparable with our findings. Positive correlation between PEFR and height, age, weight was also shown by Malik, et al. [10] upto 16 years of age. Swaminathan, et al. [11] reported highly significant ($P< 0.001$) correlation of PEFR with height, age and weight in both sexes; strongest correlation of PEFR, they found with height. This goes hand in hand with our findings. Similar findings were also reported by Ebomoyi and Iyawe [1] and Azah, et al. [12] who observed significant correlation ($P < 0.05$) between PEFR and height, weight and chest circumference. Significant correlation between PEFR and anthropometric parameters was also reported by Rajkappor, et al. [13] and Vijayan, et al. [14]. Faridi, et al. [15] reported positive correlation of PEFR with BSA, sitting height and chest circumference. These observations also are in agreement with our findings.

Rajkappor, et al. [13] observed poor correlation of PEFR with weight in girls ($r=0.59$) and with height in boys ($r=0.58$). This goes in contrast to our finding of strong correlation of PEFR with height ($r=0.90$) in male and with weight ($r = 0.91$) in female. Kivastik and Kingisepp [16] observed greater influence of sitting height on PEFR ($r =0.88$) as compared to standing height especially in boys, however this finding goes against our observation where in both male and female, we found greater influence of standing height ($r =0.90$ and 0.89 in male and female respectively).

Boys have better pulmonary function test (PFT) values as compared to girls, the likely physiological explanation for this may be better height and physical performance in boys [17]. Smaller body growth rate and smaller body size is observed in girls. There is abrupt increase in PFT values at adolescence probably due to association of adolescence with increase rate of growth and other profound changes including increased rate of pulmonary physiological development.

Thurlbeck and Haines [18] observed that with increasing age boys tended to have larger lungs per unit of stature. This may be responsible for better PFT in boys. Similarly there is increase in weight of girls than boys in 10-15 years due to increased adiposity during pubertal growth spurt to give feminine look. This causes increase in body weight but no increase in bodily cavity. This can also be the reason for lower PFT values in girls at that age. In age group of 5-10 years, reporting of lower values of PFT might be because of technical reason as poor cooperation and easy distraction in small children [15]. PFT values are lower in Indian than Western population. Probable reason for this is the difference in body size which depends upon racial, genetic, climatic and nutritional factors. Weight because of fat has adverse effect on lung function and growth of lung more nearly follow height than weight. Development of pulmonary functions and growth of physical parameters go hand in hand in children. Independent variable like age, height, weight, BSA, chest circumference, arm span appear to each reflect the same body growth. This may be the likely physiological explanation for the significant correlation of anthropometric parameters with pulmonary parameters. Warner [19] quoted that increase PEFR at puberty is due to increased testosterone level at that age. Thus, this study contributes in existing literature by establishing reference standards for predicting PEFR values in normal healthy Central Indian children.

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