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Study Of Peak Expiratory Flow Rates In Healthy School-Going Children Aged 10-14 Years And Creation Of Corresponding Nomograms

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Abstract

Background

PEFR is considered to be a simple and reliable method to assess the pulmonary function as well as the ventilatory functions of the lung. Unlike adults, PEFR in children varies according to weight, height, and age. In order to evaluate the airway disorders at the earliest, we need to have the nomograms of children at different ages for comparison. The aim of this study was to determine the PEFR of healthy school-going children studying in urban schools in Guntur district.

Methodology

This study was conducted on 719 healthy school-going children aged 10-14 years of both sexes, in the Guntur District of Andhra Pradesh, India using a miniWright peak flow meter. The data was analyzed to know the normal PEFR values of different ages, and sex and their association with anthropometric parameters, like weight, height, and BMI.

Results

On univariate analysis, Height had the highest and BMI had the least positive correlation and gender was not found to have a significant correlation However, of the four parameters, on performing multivariate regression analysis after eliminating confounding factors, only height had the most positive correlation. Based on these observations, regression equations were derived.

Conclusion

PEFR is a simple, safe, and reliable method to predict lung capacity, and is found to have a most statistically significant positive correlation with the height of the child and the least positive correlation with BMI. The nomograms and the PEFR values obtained may be considered for further reference for the children of Guntur district, Andhra Pradesh.

Keywords: Anthropometry, BMI, Healthy school-going children, Height, PEFR, Weight

Introduction

Diseases affecting the lower respiratory tract are one of the common causes of morbidity and mortality in children in both the developed and developing world [1]. Children are particularly vulnerable to respiratory diseases for a number of reasons which include

features of their developmental stage, the physical difference from adults, and other aspects of their behaviour [2]. Among the airway diseases affecting children, Bronchial asthma is an important entity. The prevalence, as well as morbidity due to asthma, has been increasing with increasing industrialization. Early diagnosis and appropriate management can not only reduce and prevent acute exacerbations but also may prevent the chronic effects allowing the child to lead a healthy, normal life.

Pulmonary function testing in children is different from that of an adult, largely because lung volume changes from birth to adulthood. There are different methods of testing lung function in children. Most of them are cumbersome, expensive, and not well reproducible. PEFR measurement by mini wrights peak flow meter is an easy and reproducible office procedure to know the lung function in children [3,4]

The peak expiratory flow rate is the person's maximum speed of expiration. It is the flow of air in larger airways within 100-200ms of the start of forced expiration. It remains at its peak for about 10 milliseconds. It's a subjective and effort-dependent measure and its accuracy needs the cooperation of the child**.**

The measured PEFR value is compared with the predicted value from a nomogram or the patient's personal best. A value of less than 80% of the baseline indicates airway obstruction. PEFR varies from time to time in a day. It is minimum in the early morning and maximum in the early afternoon. If the diurnal peak expiratory flow rate variability in a person is more than 20% the diagnosis of asthma is suggested. If there is a 15-20% increase in PEFR from its baseline, when measured after an inhaled dose of bronchodilator, it indicates a significant degree of reversible airway obstruction, a characteristic feature of asthma.

Children belonging to different countries and races should have different nomograms[5]. Unfortunately, specific nomograms showing PEFR values for normal children are not available in all parts of India. If such nomograms for children in different areas of India are made available, it would be immensely helpful in diagnosing, monitoring, and managing asthma in children, which has been on an increasing trend in recent times. So we have planned to measure PEFR in healthy school-going children between 10 and 14 years in the Guntur district of Andhra Pradesh and correlate PEFR against various parameters such as height, weight, sex, and age and create a nomogram for them that would be useful for future reference.

Subjects And Methods

It's a descriptive study carried out on 719 healthy school-going children from 4 urban schools in the Guntur district of Andhra Pradesh. All those children with a history of chronic illnesses, cough, or any respiratory illness in the preceding 7 days were excluded from the study. The study was conducted after taking approval from the ethics committee and after obtaining consent from the parents. Weight was recorded with the child on light clothing to the nearest kilogram, height was recorded to the nearest centimeter using a stadiometer with the child standing in the Frankfurt plane without shoes. PEFR was measured with a mini wright peak flow meter after thoroughly explaining the procedure to the children ; 3 readings were recorded and the best of the three was taken as the child's PEFR. The data was recorded on the proforma and then on the MS EXCEL spreadsheet, and analyzed by using SPSS (Statistical Package for Social Sciences) version 21.0.

Statistical Analysis

Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean ± SD and median.

Statistical Tests Were Applied As Follows-

PEFR was correlated using the Unpaired t-test/Mann-Whitney Test (when the data sets were not normally distributed) between males and females. Pearson correlation coefficient / Spearman rank correlation coefficient (for non-parametric data) was used to correlate quantitative variables with PEFR. Univariate and multivariate linear regression was used using age, weight, and height, as independent variables and PEFR as the dependent variable. P value <0.05 was considered to be statistically significant.

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Results

Table I : Distribution of anthropometric variable

Age	*Number*		*Weight(kg)*		*Height(cm)*		*Body mass index(kg/m²)*		*PEFR(L/min)*	
	Boys	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*
9 years	0	1	-	31 ± 0	-	137 ± 0	-	16.51 ± 0	-	240 ± 0
10 years	85	88	36.53 ± 9.54	35.62 ± 9.9	138.42±7.44	136.9 ± 6.61	18.84 ± 3.75	18.81 ± 4.23	253.18 ± 48.14	240.68 ± 43.49
11 years	105	95	38.69 ± 10.62	39.83 ± 9.03	141.27±6.84	141.24 ± 7.08	19.14 ± 4.06	19.79 ± 3.38	253.81 ± 41.52	243.37 ± 44.45
12 years	52	68	40.83 ± 12.23	46.13 ± 11.03	143.83 ± 8.02	147.41 ± 7.09	19.46 ± 4.68	21.21 ± 4.69	285.19 ± 60.18	275 ± 60.48
13 years	40	63	49.88 ± 12.93	47.9 ± 9.76	155.25 ± 8.5	152.32 ± 5.72	20.48 ± 4.42	20.55 ± 3.99	351.5 ± 83.5	327.62 ± 70.11
14 years	62	59	53.81 ± 11.18	53.47 ± 10.37	157.82 ± 6.81	155.27 ± 5.56	21.66 ± 4.51	22.21 ± 4.25	365.32 ± 64.01	350.17 ± 56.28
15 years	1	0	80 ± 0	-	155 ± 0	-	33.29 ± 0	-	360 ± 0	-

Age was taken as completed years, and children between 10 -11 years were taken as 10 completed years. In our study, the mean age of the children was 11.72 ± 1.41 years. In this study, there were 52.02% female children and 47.98% male children. Mean height at 10 years of age was found to be 137.74 ± 7.13 cm and at 14 years of age was 156.58 ± 6.34 cm. Mean weight at 10 years of age was found to be 36.29 ± 10.22 kg and at 14 years of age was 53.64 ± 10.75 kg. In this study, a significant increasing trend in height and weight was noted with the age of children up to 14 years of age as shown in Table I.

Table II: PEFR (L/ min) in relation to height in boys and girls.

Height (cm)	*Boys*		*Girls*	
	Number	*PEFR(L/min)*	*Number*	*PEFR(L/min)*
110-120	1	320 ± 0	1	320 ± 0
121-130	18	215.56 ± 34.68	18	229.44 ± 51.96
131-140	104	242.6 ± 41.2	107	233.64 ± 44.86

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141-150	115	283.48 ± 41.8	124	280 ± 48.29
151-160	75	324.67 ± 57.85	107	310.19 ± 60.5
161-170	30	419.67 ± 67.29	16	413.75 ± 85.78
171-180	2	550 ± 0	1	560 ± 0

Table II shows that PEFR is increasing with an increase in height of the child.

Table III: Univariate linear regression of different parameters for predicting PEFR

PEFR as dependent variable		*Unstandardized coefficients*	*Standardized coefficients*	*P value*	*95%confidence interval for B*	
	B	*Std error*	*Beta*		*Lower boundary*	*Upper boundary*
Age boys	29.713	2.201	0.589	<0.0001	25.383	34.043
Girls	28.750	2.049	0.588	<0.0001	24.722	32.778
Total	29.092	1.508	0.585	<0.0001	26.132	32.052
Weight						
Boys	2.542	0.268	0.456	<0.0001	2.016	3.069
Girls	2.525	0.273	0.432	<0.0001	1.988	3.061
Total	2.516	0.191	0.441	<0.0001	2.140	2.892
Height						
Boys	5.053	0.249	0.738	<0.0001	4.563	5.544
Girls	4.175	0.309	0.574	<0.0001	3.568	4.783
Total	4.651	0.199	0.658	<0.0001	4.261	5.051
BMI						
Boys	2.834	0.879	0.172	<0.0001	1.106	4.562
Girls	3.700	0.827	0.226	<0.0001	2.073	5.327
Total	3.175	0.603	0.193	<0.000	1.990	4.359

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From Table III, on performing univariate linear regression on boys, girls separately as well as on total subjects all the variables were significantly affecting PEFR (P<.05). Of all the study variables, height had shown the most positive correlation with PEFR.

TABLE IV : Multivariate linear regression of different parameters for predicting PEFR

PEFR as dependent variable	*Unstandardized coefficients*		*Standardized coefficients*	*P value*	*95%confidence interval for B*	
	B	Std error	Beta		Lower bound	Upper bound
Age						
Boys	7.578	2.526	0.150	0.003	2.610	12.546
Girls	18.028	2.870	0.369	<0.0001	12.835	23.671
Total	12.718	1.923	0.256	<0.0001	8.942	16.494
Weight						
Boys	-1.011	1.874	-0.181	0.590	-4.696	2.675
Girls	-0.704	2.469	-0.121	0.776	-5.560	4.152
Total	-1.327	1.519	-0.232	0.383	-4.310	1.656
Height						
Boys	4.978	1.294	0.727	0.0001	2.434	7.523
Girls	3.700	1.612	0.509	0.022	0.531	6.869
Total	4.645	1.013	0.657	<0.0001	2.656	6.634
BMI						
Boys	1.899	4.317	0.115	0.660	-6.593	10.391
Girls	2.885	5.347	0.176	0.590	-7.629	13.399
Total	3.689	3.372	0.224	0.274	-2.932	10.310

Table IV shows that on performing multivariate linear regression in both boys and girls separately and in total subjects after adjusting for confounding factors, age and height were significantly affecting PEFR(P<.05).Of the 2 study variables, height had shown the most positive correlation with PEFR. With the increase in height by 1 cm, PEFR significantly increases by 4.978 in boys, 3.7 in girls, and 4.645 in total subjects respectively

After analyzing the data the following regression equations were derived for various anthropometric parameters.

The average PEFR was calculated using the regression equation as given below

AGE : BOYS : PEFR =-57.807+age*29.713

GIRLS : PEFR =-59.212+age*28.750

TOTAL SUBJECTS: PEFR= -70.987+30.337*Age

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HEIGHT : BOYS : PEFR =-446.708+Height*5.053

GIRLS: PEFR=-328.431+height*4.175

TOTAL SUBJECTS : PEFR = -407.993+4.76*Height

WEIGHT: BOYS: PEFR=180.681+weight*2.542

GIRLS: PEFR=168.951+weight*2.525

TOTAL SUBJECTS: PEFR = 172.695+2.598*Weight

BMI: BOYS: PEFR= 233.251+2.874*BMI

GIRLS: PEFR= 204.842+3.675*BMI

TOTAL SUBJECTS: PEFR= 220.699+3.185*BMI

From the data collected, after analysis, the following nomograms are prepared. As the sample involves children of ages 10-14 years and also from different socio-economic strata the present study suggests that these nomograms may be considered as a reference baseline for future studies.

Table V :- Comparison With Various Studies Done At Various Points Of Time And In Different Regions

Study PEFR	*120 CM*		*140 CMS*		*160 CMS*	
	BOYS	*GIRLS*	*BOYS*	*GIRLS*	*BOYS*	*GIRLS*
Mallik et al [10]	222	216	320	314	418	412
S.Kashyap et al [14]	202.33	175.10	303.73	263.30	405.13	351.50
Swaminathan et al [11]	205	193	286	272	368	350
Sharma R et al [17]	199.2	186.7	285.88	273.90	372.50	361
Taksande A et al [16]	217.4	178.9	311.4	251.7	405.4	324.5
Thangavel et al [18]	162.6	156.1	224.9	213.3	287.4	278.9
Carson JWK et al [19] (Dublin)	250	244	344	332	469	457
Present study			273.33	245.33	380	290

Figures

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Figure 1: nomogram for PEFR (L/MIN) with age

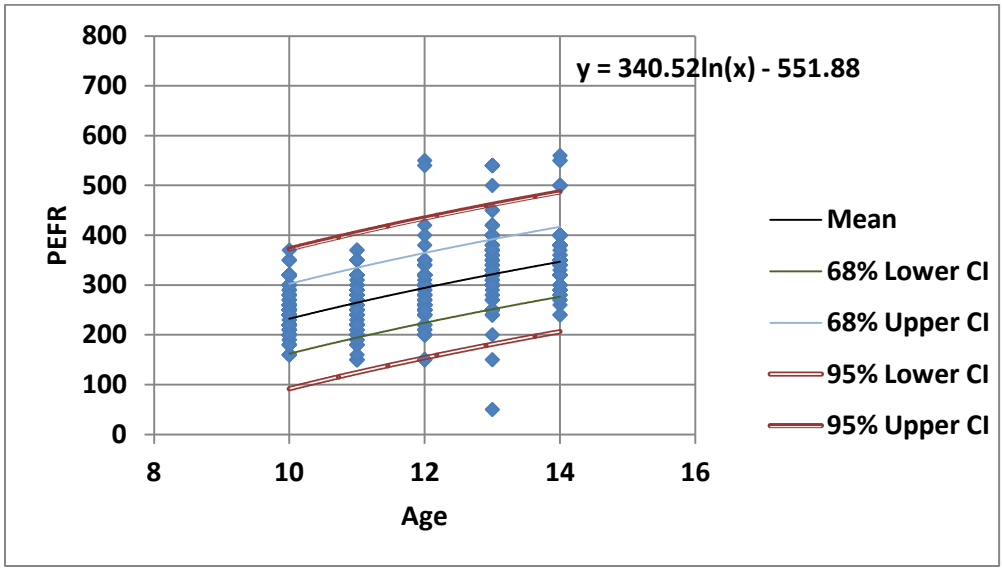

Figure 2: nomogram for PEFR (L/MIN)with weight

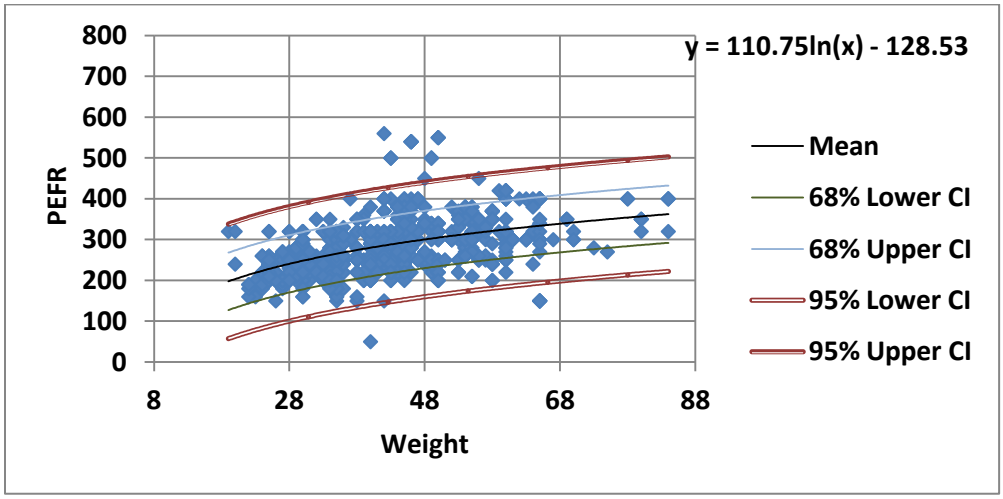

Figure 3: nomogram of PEFR (L/min) with height (cm)

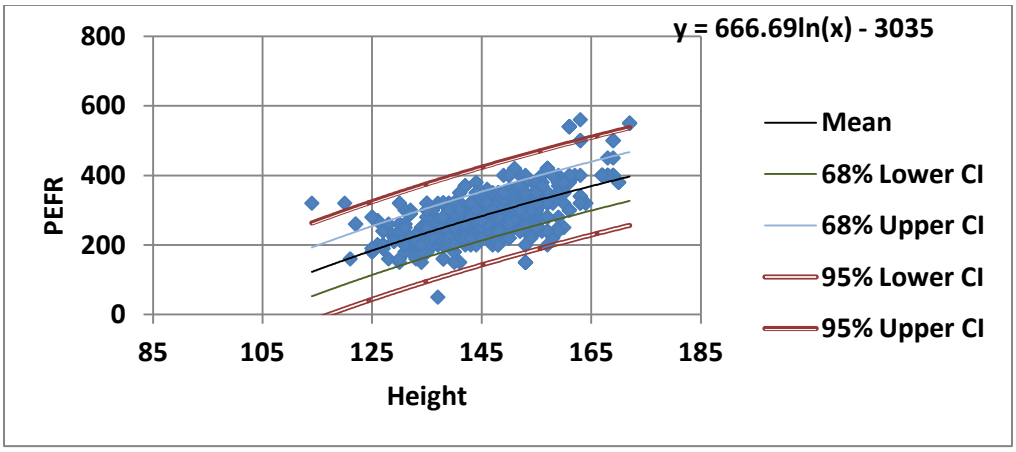

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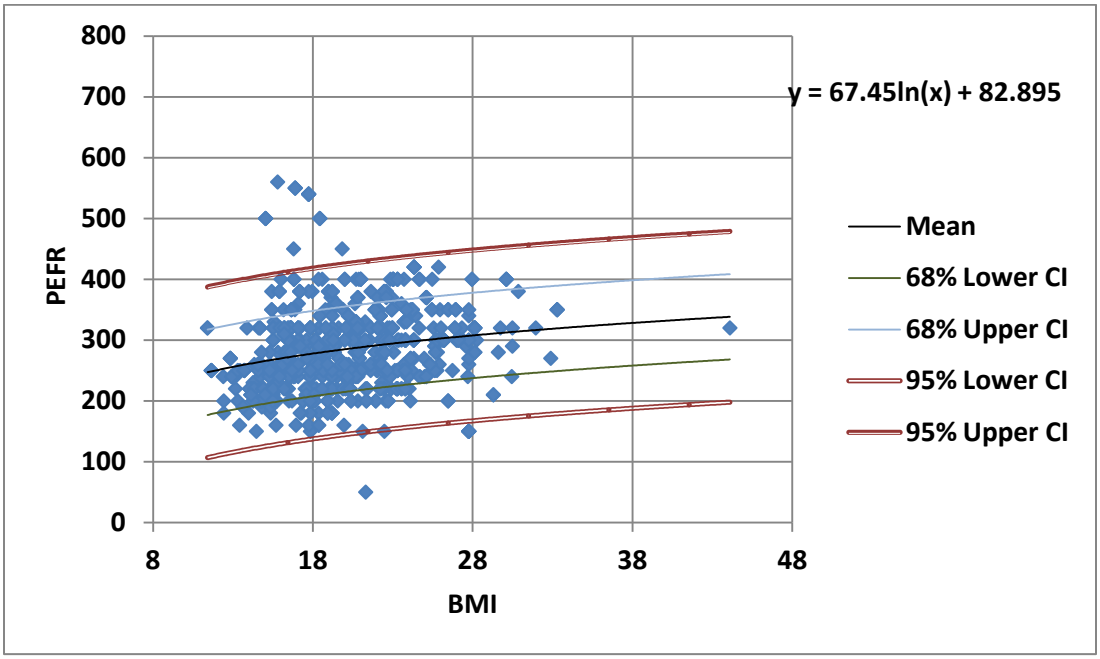
Figure 4: Nomograms of PEFR with body mass index.



Discussion

PEFR Correlation with Gender

In the present study, PEFR in male children was slightly higher than in females but this relation was not statistically significant with a p-value of >0.05. A similar conclusion was given by Abraham B et al [6], and Durairaj P et al [7].

However, Pandhi N et al [8], reported a statistically significant positive correlation between PEFR and sex. According to them, the mean PEFR in boys was higher than that of girls in all the age groups, which they concluded could be due to better height, weight, and rapid growth of airway passages among boys which enhances their expiratory capacity.

PEFR Correlation with Age

In our study, there was a significant positive correlation between PEFR with age in both boys and girls separately as well as combined together.

Studies done by Abraham B et al [6], Durairaj P et al [7], Pandhi N et al [8], also had similar observations which could possibly be justified due to the rapid growth of airway passages and increase in muscularity as age advances.

PEFR correlation with weight

In our study, on univariate regression analysis there was a statistically significant positive correlation of PEFR with weight among boys, girls, and combined together, However, on multivariate regression analysis weight was not found to have a statistically significant correlation. This emphasizes that being overweight may have a negative impact on PEFR. So nutrition advice is very crucial in maintaining optimal weight and thereby PEFR among school children.

Pandhi N et al [8], Lu Y et al [9], Abraham B et al [6], Durairaj P et al [7] reported that PEFR increased with weight. Correlations between PEFR value and weight were found to be positive and significant ($P<0.001$).

PEFR correlation with height

In our study, there was a statistically significant positive correlation between PEFR with height both on univariate regression analysis and multivariate regression analysis. With the increase in height by 1 cm, PEFR significantly increases by 4.978 in boys, 3.7 in girls, and 4.645 in total subjects respectively.

As shown in Table V; studies done by Abraham B et al [6], Durairaj P et al [7], Mallik et al [10], Swaminathan et al [11], S.K.Joshi et al [12], Pande J.N. et al [13], S.Kashyap et al [14], Sanz J et al [15,21,22], also showed a strong positive correlation between height and PEFR.

PEFR correlation with BMI

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In our study, on univariate regression analysis, there was a statistically significant positive correlation between PEFR and BMI. However, on performing multivariate regression analysis and eliminating other confounding parameters, it was observed BMI was not having a positive correlation.

Even on univariate regression analysis, among all the anthropometric variables BMI was found to have the least positive correlation with PEFR as compared to other variables like weight, and height, in both genders separately as well as combined together. So we need further studies to comment if BMI is having a rather negative correlation with PEFR. As of now in our present study, BMI is having least positive correlation on univariate analysis, whereas it is not showing a positive correlation on multivariate analysis. This emphasizes that high BMI may have a negative impact on PEFR.

Taksande A et al [16], reported that the PEFR values increased in statistically significant positive linear relation to BMI. However, Abraham B et al [6], mentioned that there was no significant correlation between PEFR and BMI ($p > 0.05$). This difference in observation could possibly be due to a lack of multivariate regression analysis in the above studies, as the present study also showed a similar positive correlation on univariate analysis which was lost on performing multivariate regression analysis.

Though PEFR is showing maximum correlation with height, each study has got its own regression equation which were showing a significant positive correlation with their own population but was not comparable to other populations. This shows that environmental factors, nutritional status, as well as socioeconomic factors, are also equally important. This has been described by different authors at different points in time as well as from different parts of the world [5]. Table V shows that for similar heights the values of PEFR are different, which again emphasizes the need for region-specific reference values of PEFR.

Heterogenicity of PEFR

The various observation of different authors from different regions

Swaminathan et al [11] measured PEFR in 345 healthy school-going children aged 4-15 years and found that the PEFR of South Indian Children was found to be lower than that of Caucasian children but similar to North Indian children of the same height. It reemphasises the fact that the values from one region cannot be used as references for others. Pande J.N. et al [13] measured the peak expiratory flow rate in 783 children aged 6-7 years from a school in urban Delhi and 523 children aged 6 - 15 years from another school in Nellore, Andhra Pradesh. It was found that PEFRs of children from Delhi were similar to those from Nellore, but on comparison was found to be lower than those reported for American white children. Dawood et al [20] measured PEFR in 1312 children from Al-Khobar city of Saudi Arabia and found that the PEFR of children from Al Khobar was less than that of children from Riyadh. In the present study, it was found that the PEFR of the children in Guntur is different from other studies reemphasizing the need for different nomograms for different geographical regions. All the other studies also echoed the same need.

The nomograms created in this study are shown below.

Conclusion

In our study, all the study variables showed a statistically significant linear correlation to PEFR when evaluated individually. A maximum positive correlation was seen for height. This shows that PEFR and thereby pulmonary function is mainly dependent on height. With the increase in height by 1 cm, PEFR significantly increases by 4.645.

This study also shows the importance of anthropometric evaluation of healthy school children and advises the necessary intervention at the earliest if the children were faltering in their growth, especially in height. This study probably reinforces the need for regular growth monitoring in children for early detection of growth faltering, as well as obesity in the children and associated changes in PEFR. So, school health programs should include growth monitoring in their curriculum.

The main limitation of this study is that as this study was conducted on children from urban schools and the same may not be applicable to children from rural areas. Also, the study does not include children aged less than 10 years and above 14 years. Further studies including these groups may add more holistic data and information.

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