MEASUREMENT OF PEAK EXPIRATORY FLOW RATE VALUES IN HEALTHY SCHOOLGOING CHILDREN BETWEEN 6 AND 12 YEARS ATTENDING URBAN SCHOOLS IN CHENNAI

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CERTIFICATE

Certified that this dissertation entitled "**MEASUREMENT OF PEAK EXPIRATORY FLOW RATE VALUES IN HEALTHY SCHOOLGOING CHILDREN BETWEEN 6 AND 12 YEARS ATTENDING URBAN SCHOOLS IN CHENNAI**" is a bonafide work done by **Dr.D.PRABAKAR**, Postgraduate student of Pediatric Medicine, Institute of Child Health and Hospital for Children, Egmore, Chennai–8 attached to Madras Medical College, during the academic year 2004-2007.

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DECLARATION

I declare that this dissertation entitled "**MEASUREMENT OF PEAK EXPIRATORY FLOW RATE VALUES IN HEALTHY SCHOOLGOING CHILDREN BETWEEN 6 AND 12 YEARS ATTENDING URBAN SCHOOLS IN CHENNAI**" has been conducted by me at the Institute of Child Health and Hospital for children, under the guidance and supervision of my unit chief **Prof. Dr.C.D.NATARAJAN M.D., D.C.H.,** and overall supervision of director & superintendent **Prof.Dr. KULANDHAI KASTHURI, M.D., DCH.**

It is submitted in part of fulfillment of the award of the degree of M.D [Pediatrics] for the March 2007 examination to be held under The Tamil Nadu Dr. M.G.R. Medical University, Chennai. This has not been submitted previously by me for the award of any degree or diploma from any other university.

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CONTENTS

INTRODUCTION

Asthma is a leading cause of chronic respiratory illness in childhood [1] .It affects persons of all ages and is a major health problem. The prevalence of Asthma is steadily increasing in developing as well as developed countries due to environmental pollutions as result of industrialization. However, with early diagnosis and proper treatment satisfactory control of symptoms is possible.

Asthma may be regarded as “a diffuse, obstructive lung disease with (1) hyper reactivity of the airways to a variety of stimuli and (2) a high degree of reversibility of the obstructive process, which may occur either spontaneously or as a result of treatment”. Also known as reactive airway disease, asthma complex includes wheezy bronchitis, viral associated wheezing, exercise induced asthma and atopic – related asthma. In addition to broncho constriction, inflammation is an important pathophysiologic factor. Mast cells, eosinophils, activated T-lymphocytes, macrophages and neutrophils have key roles in the chronic inflammation of asthma.

Although the exact cause of asthma has not been pinpointed contemporary research implicates an interplay between genetic and environmental factors strong association of common childhood asthma with concomitant allergies suggest that environmental factors influence immune development towards asthmatic phenotype in susceptible individuals.

Asthma may have its onset at any age; 30% of patients are symptomatic by 1 year of age, whereas 80 – 90% of asthmatic children have their first symptoms before 4 – 5 years of age. The majority of affected children have only occasional attacks of mild to moderate severity. A minority experience severe intractable asthma, usually perennial. It is incapacitating and interferes with school attendance, play activity and day-to-day functioning. These children may have growth retardation, chest deformity secondary to chronic hyperinflation and persistent abnormalities on pulmonary function testing. Both prevalence and morbidity from asthma have increased during the last three decades.

Recurrent episodes of coughing and wheezing especially if aggravated or triggered by exercise, viral infection, inhaled or ingested allergens or cold exposure are highly suggestive of asthma.

Asthma can also cause persistent coughing in children with no history of wheezing because flow rates are insufficient to generate wheezing, airway obstruction is relatively mild or caretakers are unable to recognize wheezing. Another variant of asthma called cough variant Asthma is also seen where persistent or recurrent cough is the only manifestation of asthma.

Thus asthma is now considered an important respiratory illness of increasing prevalence in children, which can cause restriction of day-to-day activities including play and study with immense discomfort to the children. It has adverse effects on growth and development and occasionally may even be life-threatening. But early diagnosis and appropriate management can reduce and prevent acute effects and prevent chronic adverse effects of the disease and allow the child to lead a healthy, normal life.

Diagnosis of asthma is more difficult in children than in adults. A diagnosis of asthma should be considered if the following features are present.

History

- Presence of atopy i.e. history of asthma, allergic rhinitis, atopic dermatitis, eczema or urticaria in the family

- Dyspnoea with wheezing which may be episodic or continuous.
- Unexplained cough with / without wheezing or viscid sputum.
- Past diagnoses of frequent “allergic bronchitis”, “asthmatic bronchitis” or “eosinophilia”.
- Improvement in symptomatology occurring with bronchodilator therapy.

Clinical Examination

- Hyper inflated chest with increase in AP diameter; Harrison’s sulci, which indicate that airway obstruction, may be occurring for quite sometime.
- The characteristic cough in a child especially when the child stays for sometime in the air-conditioned consultation rooms.
- Breathlessness along with activity of accessory muscles if the obstruction is significant.
- Presence of nasal discharge, mucosal congestion, polyps, areas of eczema/dermatitis should confirm the presence of atopy in the child.
- On auscultation, wheeze is the predominant sign in an asthmatic unless the child is having severe airway obstruction.

Investigations which may be helpful in diagnosing asthma are

HEMOGRAM

In asthma as in other atopic states mild eosinophilia is very common diethyl carbamazepine is often irrationally prescribed in the setting of wheezy illness with mild eosinophilia.

XRAY Chest

A baseline X-ray chest is advisable in every case to exclude other diagnostic possibilities mimicking asthma Ex. Congenital anomalies, foreign body. Repeat X-rays at frequent intervals with every exacerbation is not required. in most cases the chest X-ray is normal in between the episodes.

Serum IgE, RAST, Skin allergy testing

This test may help to confirm atopy but not asthma. The various allergies have not been well standardized and skin allergy testing is cumbersome expensive and not widely available. Results of these tests seldom contribute additionally to pharmcotherapy in managing most asthmatics. Hence these test are not routinely recommended in diagnosis of asthma.

Pulmonary function test

Pulmonary function tests assessing the ventilatory function of lungs are invaluable in evaluation of children in whom asthma is suspected. They are highly helpful both in diagnosis and management.

a) <u>Spirometry</u>

Spirometry gives the following three readings, which help in assessing airway obstruction. They are

- FEV_1 (Forced expiratory volume in 1 sec)
- FEV_1/FVC (Forced Vital Capacity) ratio and
- $FEF_{25-75\%}$ (Forced Expiratory flow between 25–75% of FVC)

A fall in FEV_1 below 80%, or a ratio of FEV_1/FVC of less than 80% indicates the presence of airway obstruction. Spirometry is a costly, more difficult, inpatient procedure, which is available only in a few selected hospitals.

b) <u>Peak expiratory flow rate</u>

Peak expiratory flow rate (PEFR) measurement by peak flow meter and Spirometry are the two preferred methods of assessing pulmonary function. Peak flow rate measurement is rapid, repeatable, adaptable and the apparatus is portable and is the single most valuable measurement of lung function in childhood. It is the easiest and most commonly performed. This is the pulmonary function test, which can be made available in the clinic, the outpatient department of hospital or even at home. It correlates well with Forced Expiratory Volume in 1 sec (FEV_1) derived from spirometry.

PEFR is defined as “the maximum rate at which a child can blow exhaled air after taking a maximum inspiration”. The best of the three readings should be taken after giving two initial practice blows. The PEFR of any child is dependant on variables such as sex, age, height, weight etc. Children belonging to different communities may have different ranges of PEFR.

Nomograms are available to know the normal PEFR range for a particular child with specific height, age and sex. An individual patient’s personal best reading may also be used as the baseline optimum value.

The personal best peak flow is “the highest measurement that can be achieved in the middle of a good (asymptomatic) day after using inhaled bronchodilator”.

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 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 15-20% increase in PEFR from its baseline, when measured after inhaled dose of bronchodilator, it indicates a significant degree of reversible airway obstruction, a characteristic feature of asthma.

Peak expiratory flow rate measurement is done using a peak flow meter. Though many types of peak flow meters are available, the commonly used type is the mini-Wright’s peak flow meter. Use of this small, portable hand held device provides an objective measure of lung function that can indicate airway hyperresponsiveness, warn of impending asthma exacerbation and can assess the severity of disease activity(5). Action plans based on symptoms and PEFR readings to guide treatment of acute asthma can be life saving(1).

Advantages of Peak Flow Meter

1. It is small and portable
2. Easy to Use
3. Cheap
4. Can be used at clinic, hospital and at home
5. Measurement takes only a few seconds
6. Good guide to severity of airway narrowing.

Disadvantages of Peak Flow Meter

1. Cooperation of the child is necessary.

2. Difficult to use in children < 6 years of age.

3. Results can be manipulated by some children (purposefully showing lower PEFR values – for example to avoid school attendance).

4. Instrument may malfunction (may go undetected at home)

5. Mainly measures obstruction of larger airways (similar to FEV_1 in spirometry) and does not give any idea of obstruction of smaller airways. (in contrast to $FEF_{25-75\%}$ of spirometry).

PEFR, which correlates well with FEV_1 has practically replaced spirometry in the day to day management of asthmatic children. Monitoring of PEFR can even be done at home which is not possible with spirometry.

The internationally recommended guidelines for the classification of asthma severity and step-wise management based upon it, further stress the importance of PEFR measurement in asthma.

Severity of Asthma	**Symptoms**	**Night-time symptoms**	**PEF**
STEP 4 Severe Persistent	Continuous Limited Physical activity	Frequent	≤ 60% predicted Variability > 30%
STEP 3 Moderate Persistent	Daily Use of ß2 – Agonist. Attacks affect activity	> 1 time a week	> 60% - < 80% predicted Variability > 30%
STEP 2 Mild Persistent	≥ 1 time a week but < 1 time a day	> 2 times a month	≥ 80% predicted Variability 20-30%

STEP 1 Intermittent	< 1 time a week Asymptomatic And normal PEF Between attacks	≤ 2 times a month	≥ 80% predicted Variability < 20%
The presence of one of the features of severity is sufficient to place a patient in that category(27).			

The various application of PEFR measurement in asthmatic children are as follows (28).

Clinician's Office (Chronic Asthma and Acute Episodes)	**Clinician's office / Emergency Department (Acute Episode)**	**Hospital**
1	2	3
1. Classify severity of patient's asthma	1. Assess severity of episode on arrival	1. Follow course of asthma episode and therapy
2. Follow trends in patients (seasonal episodes, increase or decrease, medications, effect of new medication)	2. Measure response to therapy	2. Predict hospital discharge
3. Exercise testing to determine exercise induced asthma	3. Assess the need for hospitalization	
4. Utilize objective information to guide theraphy over telephone.		

Home	School	Work place
4	5	6
1. Self-monitor asthma to increase or decrease therapy	1. Guide decisions by school personnel when student has acute episodes of asthma of school	1. Detect occupational exposures inducing or exacerbating asthma
2. Detect increase in circadian variation in PEF that predict stability of asthma	2. Identify exercise induced asthma	
3. Detect decrease in PEF that indicate early deterioration of asthma	3. Increase sports participation in asthmatic children by using PEF as a guide	
4. Identify triggers of asthma (e.g., seasons, environmental exposures, viral infections, exercise)	4. Detect asthma that is not under control	
5. Report changes in PEF to physician for guidance over the phone		

Thus PEFR measurement by Peak flow meter plays a very important role in diagnosis, management and monitoring of asthma in children.

Management

After a diagnosis of asthma in any child one should quantify the symptoms over a period of time to assess the severity. After this start the regime appropriate to grade assessed and titrate upward if control is not achieved.

Grade	First Choice	Other Options
Mild intermittent	No daily medications	
Mild persistent	Low dose inhaled steroid	Cromolyn, LTRA, SR theopylline*
Moderate persistent	Low dose inhaled steroid + LABA* or Medium dose inhaled steroids** If recurring severe exacerbations Medium dose inhaled steroid + LABA*	Low/medium dose steroid + Leukotriene receptor antagonist/SR theophylline*
Severe persistent	Medium to high dose inhaled steroid + LABA If needed Add oral steroid	***

*For children above 5 years only

**For children below 5 years

***Evidence to date does not support using a third long-term control medication added to inhaled corticosteroids and long-acting inhaled β –agonists in order to avoid using systemic corticosteroid therapy.

REVIEW OF LITERATURE

We have attempted to measure peak expiratory flow rate in healthy school going children of South India at Chennai and correlate the values with variables such as age, sex, height, weight and chest circumference.

A search in previous literature reveals many studies conducted in Caucasian and South East Asian Children but very few were conducted in Indian children.

D.Behera et al(7) measured peak expiratory flow rate of school going tribal children between 9 and 15 years of age from Orissa. 197 boys and 72 girls were studied using mini-Wright peak flow meter. Positive correlation was seen between age, height, weight and PEFR. It was observed that the tribal boys had higher values of PEFR when compared with those of North Indian children, though the observation was not statistically significant ($p > 0.05$). On the other hand tribal girls showed lower values of PEFR when the data was compared with those in girls from Chandigarh and Punjab. The authors believed that this small but important difference in the PEFR could be possibly due to active physical habits of the tribal boys. The authors have successfully pointed out the need for different reference values of PEFR for children coming from different communities.

S.K.Malik et al(8) measured peak expiratory flow rates in 227 urban boys and 246 rural boys from Punjab. They used the standard Wright's peak flow meter. The urban boys had better weights and heights. Mean values of peak expiratory flow rates of the urban boys were significantly higher than the rural boys especially over the age group of 109-132 months. However, when the results were standardized for height, the peak expiratory flow rates in urban and rural boys showed no statistical difference. The study showed the influence of height on PEFR and that the nutritional status indirectly influences the lung function tests in children.

The authors opined that the measurement of peak expiratory flow rate was a simple test of respiratory function and was widely used in assessment of children with obstructive pulmonary disease, especially asthma. The study gave the impression that nutritional standards are a major determinants of ventilatory capacity in growing children.

S.K.Malik et al(8) in their second study, measured the peak expiratory flow rate in 643 school going girls aged 5-16 years using the standard Wright's peak flow meter. Positive correlation was seen between age, weight, height and PEFR, rural, semi urban and urban school girls were studied. Although statistically there was no significant difference between the three different groups, the regression line drawn for the rural girls showed slight skewed deviation to the right especially in the older age group girls. The authors explained that the older rural girls might not have given their best performance during the test or they might have been exposed to cow dung and wood smoke during their house-hold work and have a subtle grade of asymptomatic airways obstruction. They compared the PEFR values of boys from their previous study with PEFR reading of girls and showed slight differences between the two. They concluded that the PEFR testing was useful when used serially as in monitoring the course of asthma patients or response to drug therapy. For single evaluation, such as in epidemiology of airways obstruction, the observed values should be interpreted by comparing with the predicted values.

Swaminathan et al (6) measured PEFR in 345 healthy school going children aged 4-15 years using the mini Wright peak flow meter. All children were first tested using the low range pediatric flow meter (range 0-350 L/min) and if the PEFR exceeded the upper limit, they were then tested on the standard flow meter (range 60-800 L/min). All children were tested in standing position. The manoeuvre was explained and demonstrated to them. Each child was given two trials and the next three readings were noted down. The highest reading was accepted in each case. Statistical analysis was done using age, height and weight as independent variables and PEFR as dependent variable. It was found that 75% of the variability in PEFR could be explained by height alone. Prediction equations for PEFR using height alone or height, age and weight were determined for both sexes. The PEFR measurements in South Indian Children were found to be lower than those reported for Caucasian children but similar to North Indian children of the same height. They predicted that the lower PEFR values in Indian children could be an effect of lower lung volumes due to a smaller chest size.

Veena Rani parmar et al (10) in their study showed that PEFR values increased in linear relation to age, weight and height and the coefficient of correlation obtained for all the three variables was significant. They constructed a regression equation for predicting PEFR using height because it was a convenient measurement and could be assessed easily and accurately.

Peak expiratory flow rates were measured in healthy North Indian School children. 255 girls and 340 boys of age between 6-16 years were studied using Wright's peak flow meter. The authors pointed out that while other instruments were available for measuring expiratory flow rate, their size as well as the complexity of procedure does not allow them to be used as tools at bedside, office and the field. The peak expiratory flow rate had compared well with other lung functions like maximum breathing capacity, forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV_1).

As the instrument was easy to use, children above 5-6 years of age could cooperate and reliable readings obtained.

S.K.Joshi et al (11) studied carpet-weaving children to assess the adverse influence of carpet weaving on lung functions and the nutritional status. They compared the peak expiratory flow rate of the study group with controls of similar socio-economic status and correlated it with anthropometric values. 110 boys of ages between 6 and 15 years were studied. PEFRs of carpet weaving children were significantly lower ($p < 0.05$) than controls for all except 6-7 years groups. The height, weight and chest circumference of these children were also lower ($P<0.05$). PEFR did not show significant difference when children were grouped according to their height. They concluded that children working in carpet weaving industries were shorter and lighter when compared to normal school going children. As a consequence of growth retardation, their PEFR values were also lower as compared to normal children.

Pande J.N. et al(12) measured 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. A mini Wright's peak flow meter was used for the study. In all the children age in completed years, sex, height, weight, chest circumference at full inspiration and maximum chest expansion were recorded. For the same height and age, boys had higher PEFR than girls. In the females, the PEFR seemed to have a plateau effect after the age of 14 years. Such an effect was, however, not seen in the boys in the age group studied. The PEFRs of children from both parts of the country were similar, but were lower than those reported for American white children.

Jepegnanam V et al(13) measured the peak expiratory flow rate in 1315 healthy persons with a wide range of age from 7 to 67 years. Wide variation in parameters in Indian subjects was observed and was attributed to regional variation in population and climate. Also, the data collected on highly selected groups like students, sportsmen was not found to be truly representative of average population. This study stressed the importance of different reference values for people of different communities, occupations living in varying climatic conditions.

S.Kashyap et al(14) measured peak expiratory flow rates of 237 healthy tribal children living at or above 3000 meters from sea level. The mean age, height and PEFR for boys were 10.7 years, 130.7 cms and 245.5 ± 74 L/min respectively. The values of these parameters in girls were 10.5 years, 128.2 cms and 222.3 ± 78.6 L/min. PEFR had linear positive correlation to height, age and weight. The authors suggested that altitude may play an important role in determining the size of the lungs; other factors like hypoxia and low ambient pressure at high altitude may also be contributing to the Overall pattern of lung function tests in highlanders. In the present study, the PEFRs of the healthy highlander tribal children were similar to healthy children of the west or lowlander urban North Indian children. Slightly lower PEFR values were observed in girls.

Primhak RA et al(15) measured PEFR in 339 British school children and 569 Greek school children aged 7 – 16 years. A strong correlation was found between PEFR and height which was expressed by the equation PEFR = 5.640 x Ht – 472.5 (r = 0.89). Sex of the child and recent history of cold were not found to be statistically significant. The study revealed that age had an effect on PEFR independent of height. The authors suggested that significant error in prediction of PEFR would result if the effect of age was ignored, especially in pubertal boys.

Sanz J et al(16) established pediatric reference values for PEFR using mini Wright's peak flow meter. The study was based on 1566 Mediterranean white children aged 7 to 14 years from Valencia, (Spain) Schools. Height was the biometric variable with the greatest correlation to PEFR in both sexes. Significant differences were noted between males and females. The performance of the mini Wright's peak flow meter was compared with that of a spirometer and it was concluded that PEFR measurement with a peak flow meter was an effective and simple alternative to FEV_1 of spirometry.

Nathan RA et al(17) studied two first line therapies in the treatment of mild asthma using peak expiratory flow rate variability as a predictor of effectiveness. 287 patients were included in the study. Their objective was to evaluate the effectiveness of zafirlukast and cromolyn sodium compared with placebo as first-line therapy for mild asthma using a retrospective analysis, which stratified patients according to PEF variability. They concluded that zafirlukast and cromolyn were effective first line therapies for mild asthma, with both therapies showing greater benefits in patients whose PEFR variability was ≥ 10%.

The study clearly showed the importance of including PEFR variability with a 10% cutoff either as an inclusion criterion or as a tool for subset analysis in all prospective trials to evaluate therapies in patients with mild asthma.

Linno O(18) studied the sensitivity of PEFR for diagnosing bronchial obstruction on methacholine inhalation challenge in school-aged asthmatic children. The study compared forced expiratory volume in 1 sec (FEV_1) with peak expiratory flow rate for the diagnosis of bronchial reactivity by means of the methacholine inhalation challenge test. The 64 children who had a reduction of 20% in FEV_1 showed a corresponding drop in PEFR that varied from 1.8 to 28.8% including 9 children for whom measurement of PEFR can be used for diagnostic purposes in asthmatic children instead of the complex lung function tests but the reference values for the test would have to be different.

Tokuyama K et al(19) studied the diurnal variation of peak expiratory flow in children with cough variant asthma. The authors defined cough variant asthma as variant form of asthma in which cough is the sole clinical manifestation of airways hyperresponsiveness, a characteristic feature of asthma. Another characteristic feature of asthma included the increased diurnal variation of PEFR compared to normal subjects. To examine whether diurnal variability of PEFR might also increase in children with cough variant asthma, they have examined the degree of diurnal variation of PEFR in these children by serial measurements of PEFR for a week and compared with those in mild to moderate asthma and control children. In both the children with asthma and cough variant asthma, there was a significant increase in the PEFR variability compared to that in control children. The results showed that mild but significant airway obstruction occurred in children with cough variant asthma, although clinical wheezing was not recognized. Serial measurements of PEFR showed increase in diurnal variation and therefore should definitely be used in the diagnosis of cough variant asthma in children.

Lippmann M et al (20) compared mini Wright peak flow meter readings with spirometric peak expiratory flow rates in 91 children aged 8 – 15 years exposed to ambient air at a summer camp in northwestern New Jersey. Mini Wright peak flow meter measurements immediately preceded the spirometry and mWPF – PEFR differences were regressed on spirometric PEFR of the child. The authors concluded that mWPF, with an overall underestimation of approximately 2% was a useful surrogate for spirometric values of PEFR and the portable mini Wright peak flow meter was definitely a convenient and effective tool for characterizing changes in PEFR in children.

Brand PL et al(21) in their study examined whether correction of peak expiratory flow rate values for the inaccuracy of the meter would affect asthma management in 102 asthmatic children (7 – 14 years old). PEFR was recorded twice daily for 2 weeks with a mini Wright's peak flow meter. As expected, measured PEFR overestimated PEF level and asthma control in these children on many diary days. The actual numerical differences between measured and corrected PEFR on these days were very small (>5% only in five patients, maximum 10%). It was unlikely that such small changes in PEFR justified changes in asthma care. The study showed that the clinical importance of the inaccuracy of portable PEF meters was negligible and thereby strongly highlighted the importance of PEFR measurements in day to day management of asthmatic children.

Brand P.L. et al(22) examined the relationship of PEF variation, expressed in various ways, to symptoms, atopy, level of lung function and airways hyperresponsiveness in school children with asthma. 102 asthmatic children aged 7 – 14 years recorded symptoms and PEFR (twice daily) in a diary for 2 weeks after withdrawal of all anti-inflammatory maintenance medication. Expressing peak expiratory flow rate variation as low expressed as percentage of best was found easy to perform and appeared to be clinically relevant. It was concluded that peak expiratory flow rate variation in children with stable, moderately severe asthma was significantly related to symptoms and airway hyperresponsiveness.

Herguner M.O. et al(23) conducted a study on 1359 healthy, non-smoking Turkish children with ages from 6 to 17 years. 727 boys and 632 girls were studied in order to determine the normal values of peak expiratory flow in Turkish children and to compare various peak flow meters. The peak expiratory flow rate values increased with age and height in boys and girls. The relative increase in boys was significantly higher at puberty ($P<0.01$). The values of Turkish children were found to be similar to those of Europeans. The results obtained from the three peak flow meters were closely correlated.

Jaja S.I et al (24) measured peak expiratory flow rate using the Wright's peak flow meter in 263 school boys and 275 school girls living in Lagos, Nigeria. The age of the study group ranged from 6 to 19 years. In both, PEFR values correlated positively and significantly with age, height, weight and body surface area. When compared with values derived from previous Nigerian and Caucasian studies, observed values were significantly higher in the 6-10 years and 16-19 years age groups in boys and 11-15 years and 16-19 years age groups in girls. The study suggested that the higher levels of observed PEFR in the newer generations of Nigerian children may be due to enhanced stature resulting from improved genetic and environmental factors.

Deng C.T. et al(25) evaluated the agreement between three different peak flow meters. The Wright's mini Wright's and the pocket peak flow meters were evaluated in 50 children attending a pediatric outpatients clinic. It was found that there was close agreement between the pocket and mini Wright peak flow meters. Less agreement was noted between both of them against with the Wright's peak flow meter. The authors concluded that an asthmatic child should be monitored using the same type of peak flow meter instead of interchanging them.

Host A et al (26) measured peak expiratory flow rate in a cross-sectional study in 861 healthy Danish school children aged 6 to 17 years using a mini Wright peak flow meter. A strong correlation was found between PEFR and height, age. The PEFR values in boys and girls were significantly different. Among healthy children without previous asthma, earlier episodes of recurrent wheezing were reported in 8.8% and a significantly lower PEFR was found in this group. This study further confirmed the importance of PEFR measurement using a peak flow meter in the diagnosis of asthma.

	1	2	3	4
Author	D.Behera et al(7)	Kashyap et al(14)	SK Malik et Al(8)	Veenarani Parmar et al
Place	Orissa	Himalayas	Punjab	Chandigarh
Instrument	MWPFM	MWPFM	Standard	Wrights peak

			WPFM	flow
Study Population	Healthy School Going tribal Children between 9-15 years	Healthy tribal Children living at or above 3000 meters from sea level ages from 7-14 years	Healthy school going boys between 5-16 years	Healthy north indian schoolgoing children from 6 to 16 years
Sample Size	197 boys 72 girls	139 boys 98 girls	227 urban boys and 246 rural boys	340 boys 255girls
Number of Attempts With PFM	5	3	-	3
Conclusion	Tribal boys had Higher values of PEFR when Compared with North Indian Children though The observation was not statistically significant.	Altitude might play an important role in lung function.	Normal values of **PEFR** for urban & rural boys of Punjab Mean values of **PEFR** were Higher in urban boys	Normal values of PEFR in healthy north Indian children had positive correlation of PEFR with age weight and height

	5	6	7
Author	Swaminathan et Al[6]	S.K. Joshi et al[11]	Jose Sanz et Al[16]
Place	Chennai	Jaipur	Valencia (Spain)
Instrument	MWPFM & Adult WPFM	MWPFM	MWPFM – Spirometer
Study Population	Healthy School going children between 4-15 years	Boys working in Carpet weaving Factors against Boys attending School age group 6 - 15 years	Mediterranean White children
Sample Size	345	110 boys from carpet weaving factories 290 – control	1566
Number of Attempts With PFM	3	5	3
Conclusion	Reference values of **PEFR** for 4-15	Significantly Lower **PEFR** Values in carpet	Normal values are obtained for Mediterranean

	Years old healthy South Indian Children. Maximum positive correlation Of PEFR with Height.	weaving boys compared to control group along with lower weights and heights. Influence of environment on growth and lung function established	white children

STUDY JUSTIFICATION

Wheezing in children is relatively frequent problem, which has been found to be increasing in prevalence in recent times.

Diagnosis of childhood asthma or a wheezing complex should be made early and treatment initiated to prevent chronic morbidity and acute life threatening complications.

Easily available, cost effective diagnostic methods are necessary for early diagnosis of asthma. Peak Expiratory Flow Rate measurements by Peak Flow Meter, which is now increasingly being recognized as "The Thermometer for Asthma" is a reliable, cost effective, outpatient procedure for diagnosing asthma and monitoring response to treatment.

To diagnose a child as having asthma from his or her PEFR reading, normal PEFR measurements of healthy children at various heights, age, weight, and chest circumference are necessary to compare and correlate.

Ideally children of different countries, belonging to different races should have different nomograms. 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 in an increasing trend in recent times.

So we have planned to measure PEFR in healthy school going children between 6 and 12 years and correlate PEFR against various parameters such as height, weight, sex, age and chest circumference.

AIM

1. To study the peak expiratory flow rate in healthy school going children between 6 – 12 years and

2. To study the correlation between PEFR and age, sex, height, weight and maximum chest circumference and to construct a nomogram

SUBJECTS AND METHODS

Study Design

Descriptive study

Study Place

Urban schools in Chennai.

Study Period

February 2005 – August 2006

Study Population

Healthy children between 6 and 12 years of age attending urban schools in Chennai.

Exclusion Criteria

1. History of wheeze, nocturnal cough, allergy, TB contact
2. History of Acute Respiratory tract illness in the preceding 7 days
3. Family history of asthma, tuberculosis, allergy.
4. Presence of any major illness affecting CVS, Respiratory system, CNS, GIT etc.
5. Presence of cough with/without fever
6. Presence of structural anomalies of chest, chest retractions.
7. Presence of rales, wheeze on auscultation

SAMPLE SIZE: 1440

MINI WRIGHT'S PEAK FLOW METER

DESCRIPTION OF THE PEAK FLOW METER

The instrument used for measuring peak expiratory flow rate in children is a mini-Wright peak flow meter made in England (Clement Clarke). It consists of a cylindrical body and a cylindrical mouthpiece. The cylindrical body has a spring piston that slides freely on a red within the body of the instrument. When the child blows through the mouth piece the piston is pushed forward and it drives an independent sliding indicator (pointer) along a slot marked with a scale graduated 60 – 800 L/min. The indicator records the maximum movement of the piston and remains in that position until returned to zero by the operator. The mouthpiece is detachable. The instrument is cleaned regularly during use. In use, the instrument is to be held horizontally.

MANOEUVRE

All the children in the specified age group attending the school who satisfy the study criteria were studied. A questionnaire was sent on the previous day to the parents in which information regarding the family history and the past history of the child were collected.

The children were taken as a group into a separate place for examination. The age to the completed years and sex of each child was noted.

The following measurements were taken:

- Weight to the nearest Kilogram while standing with light clothing.
- Height to the nearest Centimeter while standing with out shoes.
- Chest circumference in maximum inspiration to the nearest centimeter.

The child was clinically examined for the presence of cough, fever, chest retractions, chest deformities, wheezing, rales or any major illness affecting the Cardiovascular, Respiratory, Gastrointestinal and Central Nervous systems.

The procedure of Peak Expiratory Flow rate measurement using the Mini Wright peak flow meter was demonstrated to the child. The procedure consisted of the following steps.

- Move the pointer to the bottom of the reading scale
- Stand up straight
- Hold the meter horizontally with fingers away from the indicator and not covering the slot.
- Take a deep breath slowly through the mouth.

- Place the mouthpiece in the mouth and close your lips around it. Do not put your tongue in the hole of the mouthpiece.
- Blow out as fast and hard as you can in one sharp blast into the mouthpiece – similar to making a hard "Huff" sound.
- The reading obtained from the scale is noted down.
- The pointer is moved back to the bottom of the reading scale and the procedure is repeated.

The child was given two trials and the next three readings were noted down. The best of three readings was taken as the PEFR of the child. If the difference between any two readings was large, the probability of a faulty procedure was considered. The procedure was demonstrated again to the child and a new set of readings was taken. During the procedure if a child develops cough, child was considered as having a respiratory problem and therefore excluded from the study.

STATISTICAL ANALYSIS

Statistical analysis was done using the SPSS (Statistical Package for Social Science). Statistical methods used were Karl Pearson's correlation coefficient, student t-test, p-value and linear regression analysis. Linear regression analysis was performed using age, weight, height and chest circumference as independent variables and PEFR as the dependent variable. Since the difference in PEFR between boys and girls at any given height in the age group studied was small but statistically significant, data was analyzed both as a whole sample and separately for boys and girls. Hence separate nomograms relating PEFR to height for boys and girls were constructed using the data.

PROFORMA

Name :

Age :

Sex :

Address :

Socio-economic status :

History of Present illness :

Wheeze

Cough

Fever

Allergy

TB contact

URI in the preceding 7 days

Any major systemic illness

History of Past illness :

Wheeze

Chronic/Nocturnal cough

Allergy

TB contact

Any major systemic illness

Family History

Asthma

Allergy

Tuberculosis

Anthropometry

Wt	-	Kgs
Ht	-	cms
Chest circumference (in maximum inspiration at xiphisternum)	-	cms

Clinical Examination

1. Any major illness affecting the CVS, Respiratory, CNS, GIT	Yes	No
2. Presence of cough with/without fever	Yes	No
3. Presence of structural anomalies of chest Or chest retractions	Yes	No
4. Presence of rales, wheeze	Yes	No

PEFR readings

1. L/min
2. L/min
3. L/min

OBSERVATIONS

The study sample consisted of 1470 healthy children aged 6 to 12 years attending school in Chennai. 735 boys and 735 girls were studied totally. The children came from a mixed background although most of them were from a lower socioeconomic status.

TABLE 1

DESCRIPTIVE STATISTICS OF WEIGHT OF GIRLS ACROSS DIFFERENT AGE LEVELS

Age	Weight					
	N	Mean	Median	Minimum	Maximum	S D
6	105	18.9	18.8	17.4	20.8	0.6
7	105	19.5	19.4	17.9	22.1	0.9
8	105	20.1	20.2	17.5	23.0	1.4
9	105	23.8	24.5	20.0	25.5	1.6
10	105	24.7	24.8	21.0	26.5	1.3
11	105	29.0	29.1	26.2	31.1	1.3
12	105	32.1	32.1	29.2	35.8	1.5

TABLE 2

DESCRIPTIVE STATISTICS OF WEIGHT OF BOYS ACROSS DIFFERENT AGE LEVELS

Age	Weight					
	N	Mean	Median	Minimum	Maximum	S D
6	105	18.5	18.5	17.0	19.8	0.7
7	105	20.2	20.2	18.4	22.5	0.7
8	105	21.4	21.5	18.8	23.8	1.1
9	105	25.2	25.0	20.8	28.0	1.3
10	105	25.0	25.2	22.0	28.0	1.3
11	105	28.7	28.6	23.0	31.5	1.4
12	105	32.0	32.1	29.0	35.0	1.8

TABLE 3

DESCRIPTIVE STATISTICS OF HEIGHT OF GIRLS ACROSS DIFFERENT AGE LEVELS

Age	HEIGHT					
	N	Mean	Median	Minimum	Maximum	S D
6	105	106.2	106.2	102.1	110.4	2.0
7	105	113.9	113.2	110.0	118.3	2.3
8	105	115.8	116.2	111.4	119.2	2.0
9	105	124.8	125.3	121.0	128.6	2.4
10	105	130.9	130.7	128.0	135.5	1.9
11	105	134.1	134.1	131.1	137.0	1.6
12	105	142.1	142.1	138.0	146.0	2.1

TABLE 4

DESCRIPTIVE STATISTICS OF HEIGHT OF BOYS ACROSS DIFFERENT AGE LEVELS

Age	HEIGHT					
	N	Mean	Median	Minimum	Maximum	S D
6	105	106.9	107.1	102.1	112.4	2.4
7	105	113.8	113.2	111.0	117.2	1.9
8	105	120.0	120.2	114.2	125.2	2.0
9	105	130.6	130.7	125.0	135.7	3.2
10	105	131.9	132.1	129.0	134.7	1.2
11	105	135.7	135.2	132.1	140.1	1.6
12	105	144.9	145.2	142.6	147.5	1.4

TABLE 5

DESCRIPTIVE STATISTICS OF CHEST CIRCUMFERENCE OF GIRLS ACROSS DIFFERENT AGE LEVELS

Age	Chest circumference					
	N	Mean	Median	Minimum	Maximum	S D
6	105	53.2	53.2	52.1	54.5	0.6
7	105	54.0	53.4	52.7	54.9	0.9
8	105	55.4	56.0	53.1	59.2	1.2
9	105	59.8	59.6	56.0	63.0	1.6
10	105	61.2	61.6	60.0	63.2	1.4
11	105	64.6	64.8	62.6	66.2	0.8
12	105	69.4	69.4	66.2	72.4	1.0

TABLE 6

DESCRIPTIVE STATISTICS OF CHEST CIRCUMFERENCE OF BOYS ACROSS DIFFERENT AGE LEVELS

Age	Chest circumference					
	N	Mean	Median	Minimum	Maximum	S D
6	105	53.2	53.2	51.2	55.2	0.7
7	105	53.4	53.4	51.9	55.5	0.8
8	105	56.6	56.2	54.0	59.2	0.9
9	105	59.3	60.0	60.5	63.1	1.2
10	105	61.1	62.0	61.6	63.2	0.8
11	105	65.0	65.1	62.1	66.4	0.7
12	105	68.4	68.8	63.8	70.6	1.9

TABLE 7

DESCRIPTIVE STATISTICS OF PEFR OF GIRLS ACROSS DIFFERENT AGE LEVELS

Age	PEFR					
	N	**Mean**	**Median**	**Minimum**	**Maximum**	**S D**
6	105	165.9	166	157	183	4.7
7	105	185.5	185	179	193	3.4
8	105	212.4	213	202	218	3.6
9	105	226.0	225	215	236	6.8
10	105	262.9	262	254	276	6.4
11	105	281.7	282	272	290	5.4
12	105	305.7	311	311	324	9.0

TABLE 8

DESCRIPTIVE STATISTICS OF PEFR OF BOYS ACROSS DIFFERENT AGE LEVELS

Age	PEFR					
	N	**Mean**	**Median**	**Minimum**	**Maximum**	**S D**
6	105	176.5	177	159	186	5.2
7	105	202.2	202	194	210	4.4
8	105	244.6	227	118	226	5.6
9	105	251.6	250	234	265	8.1
10	105	272.9	272	265	282	4.5
11	105	307.6	309	276	321	8.4
12	105	324.8	325	313	338	6.8

Tables **1 to 8** shows the statistical descriptions of all the variables studied. Among all variable analyzed, the PEFR value is the prime variable. The mean PEFR values were higher in boys when compared to girls across all the age groups.

The correlation between the independent variables such as age, height, weight and maximum chest circumference and the dependent variable i.e. PEFR was assessed both individually and as a group. The correlation analysis was done separately for boys and girls and for the whole sample also. The presence of a linear correlation was observed between all the four independent variables and the dependent variable. The coefficient of correlation (r) was calculated for all the variables. The statistical significance of the correlation was assessed using the p-value.

TABLE 9

CO-EFFIECIENT OF CORRELATION BETWEEN THE STUDY VARIABLES FOR THE WHOLE SAMPLE

Study variable	Outcome variable (PEFR)	
	Coefficient of Correlation (r)	Statistical Significance (p)
Age	0.785	< 0.001
Weight	0.712	< 0.001
Height	0.847	< 0.001
Chest circumference	0.689	< 0.001

Table 9 shows linear positive correlation between the study variables such as age, weight, height and chest circumference and the outcome variable PEFR in the whole study sample. There is highly statistically significant positive correlation between the variables as suggested by the r-value and the p-value ($p < 0.001$).

TABLE 10

COEFFIECIENT OF CORRELATION FOR STUDY VARIABLES IN GIRLS

Study variable	Outcome variable (PEFR)	
	Coefficient of Correlation (r)	Statistical Significance (p)
Age	0.787	< 0.001
Weight	0.711	< 0.001
Height	0.849	< 0.001
Chest circumference	0.690	< 0.001

TABLE 11

CO-EFFIECIENT OF CORRELATION FOR STUDY VARIBLES IN BOYS

Study variable	Outcome variable (PEFR)	
	Coefficient of Correlation (r)	Statistical Significance (p)
Age	0.781	< 0.001
Weight	0.701	< 0.001
Height	0.848	< 0.001
Chest circumference	0.689	< 0.001

Tables 10&11 show linear positive correlation between the studies variables – age, height, weight and chest circumference and the outcome variable PEFR both in boys and girls. The correlation is highly statistically significant in both the study groups.

The above tables show that the higher values of age, weight, height and chest circumference are statistically significantly associated with the higher values of PEFR within the age group studied. In other words, as the age, weight, height and chest circumference increased, the values of PEFR also increased and vice versa.

Though the correlation between age, weight, chest circumference and PEFR was found to be significantly positive, highest positive correlation was obtained for height and PEFR in whole sample ($r = 0.847$) and also both in boys ($r = 0.848$, $p<0.001$) and girls ($r = 0.849$, $p<0.001$).

Regression analysis was done for all the variables studied in the whole sample and also separately for boys and girls. The regression or prediction equations were obtained for all the independent variables i.e. age, weight, height and chest circumference after calculating the regression coefficient. The significance of the regression co-efficient was evaluated with the help of t-value. The statistical significance was given by the p-value, which was found to be <0.001 for all the regression coefficients derived. The variabilities in the PEFR values were explained by the R-square values.

TABLE 12

REGRESSION ANALYSIS OF AGE TO PEFR

	Regression Equation	t-value	p value	R^2
Whole sample	PEFR = 27.94 + 24.04 (age in yrs)	33.78	< 0.0001	43.1%
Girls	PEFR = 21.40 + 23.65 (age in yrs)	23.48	< 0.0001	58.5%
Boys	PEFR = 34.48 + 24.42 (age in yrs)	17.84	< 0.0001	30.3%

Table 12 shows regression analysis of age to PEFR and that the co-efficient of regression derived were highly statistically significant. 43.139.4 % of variability in PEFR was explained by age alone in the whole study sample, whereas it explained 30.3 % of variability in boys and 58.5% of variability in PEFR among girls.

TABLE 13

REGRESSION ANALYSIS OF WEIGHT TO PEFR

	Regression Equation	t-value	p value	R^2
Whole sample	PEFR = 11.21 + 9.63(wt)	33.78	< 0.0001	39.4%
Girls	PEFR = 13.16 + 9.21(wt)	33.66	< 0.0001	49.8%
Boys	PEFR = 12.21 + 9.91 (wt)	16.37	< 0.0001	26.8%

The co-efficient of regression derived was statistically significant. Weight alone explained 39.4 % of variability in PEFR in the whole study sample, 26.8% of variability among boys and 49.8 % of variability among girls.

TABLE 14

REGRESSION ANALYSIS OF CHEST CIRCUMFERENCE TO PEFR

	Regression Equation	t-value	p value	R^2
Whole sample	PEFR = -145.41 + 6.54 (CC)	26.43	< 0.0001	32.3%
Girls	PEFR = -119.71 + 5.95 (CC)	34.85	< 0.0001	62.4%
Boys	PEFR = -178.25 + 7.26 (CC)	15.15	< 0.0001	23.8%

A statistically significant co-efficient of regression was obtained for chest circumference. Of all the study variables, this had shown the least positive correlation with PEFR. 32.3 % of the variability in PEFR was explained by chest circumference in the whole sample and 23.8% and 62.4 % of variability in the boys and girls groups respectively.

TABLE 15

REGRESSION ANALYSIS OF HEIGHT TO PEFR

	Regression Equation	t-value	p value	R^2
Whole sample	PEFR = -244.83 + 3.91 (height)	33.49	< 0.0001	43.3%
Girls	PEFR = -250.71 + 3.91 (height)	58.49	< 0.0001	57.8%
Boys	PEFR = -228.63 + 3.82 (height)	17.21	< 0.0001	28.8%

Of all the study variables, height had shown the maximum positive correlation to PEFR in both boys and girls. The co-efficient of regression derived for height was found to be highly statistically significant both in boys and girls. 43.3 % of variability in PEFR could be explained by height alone in the whole study sample, whereas 28.8 % and 57.8 % of variability in PEFR were explained by height in boys and girls respectively.

Of all the 4 study variables, height showed the maximum positive correlation to PEFR both in boys and girls. Age had the second highest positive correlation in the age group studied, so a common regression equation derived consisting of both height and age. Both height and age together explained about 79.9%and81.4% of the variability in PEFR in boys and girls.

Common regression equation using height and age as study variables:

Girls

PEFR = -35.72 + 0.736 (Ht) + 19.95 (Age)

Boys

PEFR = -27.05 + 0.735 (Ht) + 20.65 (Age)

But since height showed maximum positive correlation and also the best co-efficient of regression, a regression equation was used based on height to draw a line diagram with height in x-axis and PEFR in y-axis. Two separate nomograms were derived for boys and girls as the mean PEFR values derived from regression equations showed significant difference between them. The PEFR value predicted from the equation or derived from the graph can be used as the normal baseline value for that particular child with a specific height.

Graph 1 depicts a nomogram showing relation of PEFR to height in girls. Mean, 90 % and 80 % mean values are shown. The regression equation relating height to PEFR in boys between 6 and 12 years of age is given in table 15.

Graph 2 depicts a nomogram showing relation of PEFR to height in boys. Mean, 90 % and 80 % of mean values are shown. The regression equation relating height to PEFR in girls between 6 and 12 years of age is given in table 15.

The 80 % of derived value gives the lower limit of the range in PEFR, which a normal child can have. A child with a PEFR less than 80 % of the normal for his particular height is diagnosed to have obstructive airways disease. Further confirmation of asthma in that child can be obtained from observing the diurnal variation in PEFR > 20 % and the documentation of increase in PEFR from its baseline by more than 15-20 % after a dose of inhaled bronchodilator.

DISCUSSION

The early detection of asthmatic exacerbations by means of objective measurement can provide a solution to these problems and stimulate the development of self-management and self-control techniques. The lack of perception of degree of pulmonary obstruction is an important cause for delay in the initiation of treatment. This is supported by recent reports of failure of parents to recognize the severity of the episode resulting in death of some children before arriving at the hospital, especially in children with difficult to control asthma. Early recognition of these asthmatic exacerbations can be made by measuring PEFR and also it is useful in assessing the response to therapy

Though many types of peak flow meters are available to measure the peak expiratory flow rate, the mini Wright peak flow meter is now internationally accepted as the ideal instrument to measure the PEFR in children

The mini Wright peak flow meter is cheap, easily available small, portable and is now being used extensively in western countries for all asthmatic children. It plays a very important role in home monitoring of asthmatics. It is now mandatory for all asthmatics to have a baseline PEFR recorded when they are asymptomatic and clinically free from wheezing. But the first reading of PEFR taken in a child should be compared with the PEFR value that is normal for the particular child with a specific age, height, weight, etc. Such a normal value will be obtained from nomogram or regression prediction equations derived from analyzing PEFR values of large number of children. The daily monitoring of the disease is made easy by observing the daily variations in PEFR that serve as a guide to the severity of asthma, the effectiveness of current therapy and the need for any additional treatment

Various studies done in different parts of the globe showed that there was significant racial and ethnic difference in PEFR.

In the present study PEFR values was measured in a large number of children between 6 and 12 years, so that resulting PEFR values would have a higher significance. So the final average values of PEFR derived would be better representation of the widely variable peak expiratory flow rates that occur in different children belonging to the same age group.

The study showed that PEFR values varied significantly between boys and girls in the age group 6 to 12 years.

All the study variables showed statically significant linear correlation to PEFR when evaluated individually. Maximum positive correlation was seen for height, followed by age, weight and the least positive correlation was found for maximum chest circumference. The coefficient of correlation between height and PEFR was 0.847 (whole sample), 0.848 for boys and 0.849 for girls

In the same way, coefficient of correlation

I. Between age and PEFR is 0.785(whole sample), 0.781 for boys and 0.787 for girls
II. Between weight and PEFR is 0.712(whole sample), 0.701 for boys and 0.711 for girls
III. Between chest circumference and PEFR are 0.689(wholesample) 0.689 for boys and 0.690for girls.

The correlation is statically significant ($p<0.001$) for all study variables.

The variability in PEFR in any child is explained by height to the maximum extent 43.3% in whole sample, 57.8% in boys and 28.8% in girls) age explained the variability in PEFR in any child up to 43.1% in whole sample and 30.3%in boys and 58.5% in girls .Both height and age could explain the variability in PEFR up to 60% .Thus showing that PEFR and thereby the pulmonary function is mainly dependent on height . This finding is similar to that given in many studies done both in India and western countries(6,8,9,16,23,24,26). This is probably dependent on the fact that lung volumes correspond well to height in child.

In the present study, children have PEFR values slightly lower when compared with children in western countries(15,16,23,26). Most of western studies show that height is the main predictor of lung function in normal children. So most of the authors have derived a regression or prediction equation for PEFR based on height alone(6,7,10,11,14.15), while some authors have given prediction equation based on both height, and age(15,16) . Most of the studies show that there is statistically significant difference between boys and girls and therefore different regression equations are given for boys and girls(6,7,8.9,10,14). Present study also showed similar findings, so different regression equations are derived for both boys and girls based on height alone, Since age also seems to explain the variability in PEFR to a significant extent, a regression equation is given including both height and age as the independent variables.

TABLE 14

COMPARATIVE ANALYSIS OF PEFR IN CHILDREN OF DIFFERENT STUDIES

Height	Sex	Swaminathan et al [6]	S.k.Malik et al [8,9]	Present study
110 cms	Boys	164.25	173.21	191.57
	Girls	154.19	167.2	179.39
120 cms	Boys	205.05	222.41	229.99
	Girls	193.39	216.2	218.49
130 cms	Boys	245.85	271.61	267.97
	Girls	232.59	265.2	257.59
140 cms	Boys	286.65	320.81	306.17
	Girls	271.79	314.2	296.69

The above table shows the PEFR values of both boys and girls at various heights in a study from South India, [6] a North Indian study [8,9] and present study. These PEFR values have been derived from prediction equations put forward in the studies.

Swaminathan et al [6]

Boys : PEFR = -284.55 + 4.08 (Ht in cms)

Girls : PEFR = -277.01 + 3.92 (Ht in cms)

S.k.Malik et al [8,9]

Boys : PEFR = -368.89 + 4.92 (Ht in cms)

Girls : PEFR = -371.8 + 4.9 (Ht in cms)

Present study

Boys : PEFR = -228.63 + 3.821(Ht in cms)

Girls : PEFR = -250.71 + 3.914 (Ht in cms)

The above table shows that PEFR values of children in the present study are higher when compared to both the previous studies. The difference is more in the lower age group and gradually decreases as the child's height increases. At a height of 140 cms, the boys and girls in our study have PEFR values slightly lower than the those in the North Indian study [8.9] but still higher than those in the South Indian study.[6] This gives a conclusion that the lung volumes in children of the present study are better than in children of the previous studies [6,8,9]

These two studies (**Swaminathan et al** [6], **S.k.Malik et al** [8,9] have also shown that PEFR is dependent mainly on height similar to that seen in the present study. So we have derived regression equations for boys and girls for prediction of PEFR from height.

CONCLUSION

- Large population size helped to establish reference values for PEFR in south Indian children at Chennai aged between 6 and 12 years.

- Baseline values of PEFR, established can be useful in diagnosing and following asthmatic children. Prediction formulas derived from statistical analysis can serve the same purpose.

- Significant correlations are found between PEFR and biological variables like age, weight, height and chest circumference.

- The correlation is more robust with regard to height.

- Boys have more PEFR values than girls across all age groups.

- Regression analysis gives prediction of PEFR based on the height and also for age and height. 80% value of the mean PEFR at different heights is also given in nomogram for easy diagnosis.

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