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Screening asymptomatic school children for early asthma by determining airway narrowing through peak expiratory flow rate measurement

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Abstract:

BACKGROUND: Peak expiratory flow rate (PEFR) is widely used as a predictor of treatment of asthma patients. Peak expiratory flow and forced expiratory volume in first second (FEV_1) are the most useful parameters for the diagnosis of asthma. Spirometry is not often available in the primary care setting, and economic factors may limit its testing. Mild airway narrowing may be present in asymptomatic children, which can be identified by determining their PEFR. This will enable us to initiate early treatment.

MATERIALS AND METHODS: We selected 200 asymptomatic children at the age of 10–15 years without a history of smoking, tuberculosis, or other respiratory illness. A family history about asthmatic symptoms was sought. PEFR values of all children were recorded, and 40 children showed PEFR values less than 80% of their predicted values. To confirm whether the low observed values were because of airway obstruction, their spirometry was performed.

RESULTS: Nine out of 47 (19.14%) children from asthmatic families and 31 out of 153 (20.26%) from nonasthmatic families showed PEFR values <80% of the predicted value ($P > 0.05$). Considering a decrease in the FEV_1/forced vital capacity (FVC) ratio to <80% for the diagnosis of obstructive disease, only two out of 35 children were found to have it. Correlation between PEFR and FEV_1/FVC ratio was not significant ($r = 0.314$ and $P = 0.065$).

CONCLUSIONS: Asymptomatic children with low PEFR values may not show abnormal lung functions on spirometry. However, these children, particularly those having the risk of family history of asthma, may be followed for the development of airway obstruction.

Keywords:

Airway obstruction, asthma, peak expiratory flow rate, spirometry

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Introduction

Asthma is one of the most common chronic diseases of childhood, characterized by recurrent, reversible, airway obstruction occurring because of airway hyperreactivity, which causes the airways to narrow in response to various stimuli, including allergens, exercise, and cold air. The tendency to develop asthma is often inherited, i.e., asthma can be more common in certain families.[1]

Risk factors for developing or exacerbating childhood asthma include many environmental exposures, such as cigarette smoke, exposure to animal allergens,

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airborne agents including pollens and air pollution, and food allergens.[2,3] The exacerbations of asthma often occur without warning, and many children with asthma can breathe normally for weeks or months between flares. The identification of children at risk either before symptoms occur or at the time of early wheezing episodes might also increase early diagnosis and thus help to optimize care.[4]

A reliable objective measure of the severity of an asthma episode is a drop in peak expiratory flow rate (PEFR). A peak flow meter is a simple device that can detect airway obstruction in asthma, often prior to the appearance of clinical signs such as wheezing or shortness of breath. As PEFR is achieved after 100–120 ms of initiating a maximal expiratory effort,[5] the expiratory effort need not continue up to residual volume.

Many studies suggest that PEFR (including morning and evening) is the most important tool used for measuring airway variability[6] and predictor of the treatment of asthma patients.[7,8] Despite some limitations of this method, serial PEFR monitoring is usually the most appropriate first-line investigation in workers suspected of having occupational asthma.[9] Some studies even recommend measurement of predicted peak expiratory flow (PEF) values, as an alternative to spirometry.[10]

Spirometry, although a time consuming process requiring a special device and trained technician for its operation, confirms the diagnosis of asthma.[11] However, spirometry is not often available in the primary care setting, and economic factors may limit specialty referrals for spirometry testing.

Thus, PEFR may serve as a tool to screen and monitor airway patency, particularly in those children who have a family history of bronchial asthma.

We hypothesized that mild airway narrowing may be present in asymptomatic children, particularly those coming from asthmatic families, and that can be identified by determining their PEFR and confirmed with spirometry. It can, therefore, be used as a screening test for early diagnosis of asthma in asymptomatic children. With this, we can evaluate and start treatment at an early stage of the disease.

Materials and Methods

The study was performed after taking approval from the institute ethics committee and informed consent from the parents of the participants. It was conducted in one urban and one rural, randomly selected schools of Western Rajasthan, India from September 2017 to December 2017.

PEFR is an effort-dependent parameter, emerging from the large airways within about 100–120 ms of the start of forced expiration. It remains at its peak for 10 ms.[12] We hypothesized that children with < 80% of the predicted values of PEFR will show abnormal lung functions on spirometry which will confirm the diagnosis of obstructive disease in asymptomatic children. This will enable us to initiate early treatment.

The sample size was calculated using the software Epi Info 7.1.5.2, using the prevalence rate of asthma 10.7% and considering the nonresponse rate of 20% and confidence interval 95%. Since the prevalence of asthma varies from 3.5% to 30%, the prevalence of 10.7% was taken from a study which has the closest matched population as the population in the present study.[13]

Asymptomatic children (n = 200; 123 males and 77 females) of the age group of 10–15 years were selected by random sampling from a school, one each in urban and rural areas. The exclusion criteria were smoking, tuberculosis, or any other acute or chronic respiratory illness. Their demographic details and anthropometric parameters were recorded. For all participants, the age was calculated to the nearest completed year. Weight (kg) was measured without shoes and with light clothing on a standard calibrated bathroom scale. Height (cm) was measured with a standard portable stadiometer.

A detailed family history about asthmatic symptoms, such as shortness of breath, wheezing, cough, heaviness of chest, and night time exacerbations of symptoms, was sought. Of 200 children, 47 gave a positive family history of asthma.

PEFR values were then recorded in standing position, using the mini-Wright Peak Flowmeter. The maneuver was explained and demonstrated to them before the actual recording. Each child was asked to take a deep breath and then blow into the peak flow meter as hard and quickly as possible. They were asked to maintain a tight seal between the lips and the mouthpiece while performing the maneuver to prevent any air leak. The marker was returned to zero after every measurement. A few normal breaths were taken, and then the process was repeated two more times. Every child was encouraged to blow harder each time. Three measurements of PEFR were taken, and the highest reading was recorded on case record forms. Disposable mouthpieces were used for the purpose.

The PEFR values of all the participants were determined at almost the same time of the day to avoid any discrepancies in the values arising as a result of diurnal variation.

The predicted values of PEFR for all students were then calculated using their age, height, and gender in account, and compared them with the observed values obtained. The following formulae were used for calculating predicted values.[14]

- Females: (3.92 × Ht.)-277.01
- Males: (4.08 × Ht.)-284.55.

Forty out of 200 children showed PEFR values below 80% of their predicted value. To confirm whether the low observed values were because of airway obstruction, we performed spirometry by digital spirometer (Cosmed microQuark) of these children who showed PEFR values <80% of the predicted values. Only 35 out of 40 children gave the consent to undergo spirometry. The best of at least three technically acceptable values for forced expiratory volume in first second (FEV_1) and forced vital capacity (FVC) and forced expiratory flow 25–75 were used as measures of ventilatory function. FEV_1, FVC, and FEV_1/FVC are the most important indicators of obstructive diseases in a pulmonary function test. Obstructive airway disease was identified as a decrease in the FEV_1/FVC ratio to <80%.

Results

Table 1 shows the details of demographic, anthropometric parameters, and mean PEFR of the population under study.

Forty out of 200 children (20%) showed PEFR values below 80% of the predicted value [Figure 1]. Of the children with PEFR below 80% of predicted, four had PEFR values more than 75%; 22 had values between 65%–75%; and 14 had PEFR values below 65% of the predicted value. The lowest observed PEFR was 41.06% of the predicted value.

Of these 40 children with <80% of predicted PEFR, nine had a family history of asthma. This means that in the present cohort, 19.14% (9 out of 47) of children coming from asthmatic families and 20.26% (31 out of 153) children from families with no history of asthma, showed PEFR values below 80% of the predicted value. The difference was not found to be statistically significant.

The data of the 35 students (out of 40 students screened with low PEFR) who underwent spirometry is depicted in Table 2.

Considering a decrease in the FEV_1/FVC ratio to <80% for the diagnosis of obstructive disease, only 2 out of 35 children were found to have it. One had predicted PEFR value of 66.1% and other 61.96%. Surprisingly, the child with the lowest observed PEFR value (41.06%) did not show any abnormality in spirometry.

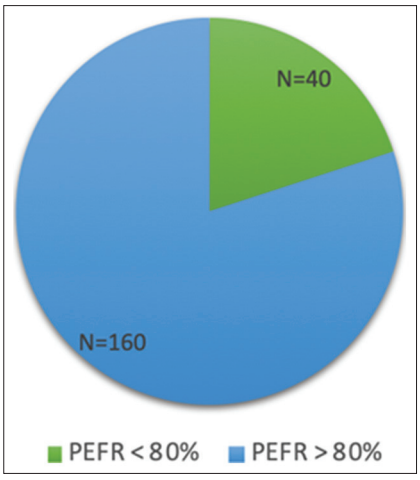

Figure 1: Peak expiratory flow rate status of the population

Table 1: Demographic and anthropometric details of students

Measures	Age (years)	Height (cm)	Weight (kg)	BP (mmHg)	HR (/min)	PEFR
Mean	12.84	151.4	40.53	115.8/71.62	91.43	287.50
SD	0.89	8.28	10.40	15.98/12.81	12.81	63.87

SD=Standard deviation, BP=Blood pressure, PEFR=Peak expiratory flow rate, HR=Heart rate

Table 2: Spirometry findings of children showing low peak expiratory flow rate

Measures	FEV1 (L)		FVC (L)		FEV1/FVC	
	n=33	*n*=2	*n*=33	*n*=2	>80% (*n*=33)	<80% (*n*=2)
Mean	2.2	1.74	2.47	2.26	89.16	76.5
SD±	0.45	0.17	0.55	0.16	4.99	1.41

FEV_1=Forced expiratory volume in 1 s, FVC=Forced vital capacity, SD=Standard deviation

The distribution of the variables was examined for normality using Shapiro–Wilk test to determine whether parametric statistics was appropriate to use. We found our data to be nonparametric. Thus, we applied Spearman's test to see correlation, if any, between PEFR and FEV_1/FVC ratio. The test was found to be not significant with $r = 0.314$ and $P = 0.065$.

Discussion

Jackson and Hubbard 2003, analyzed data from the third National Health and Nutrition Survey to investigate the usefulness of PEFR for detecting people with chronic obstructive pulmonary disease (COPD) in the community, and found that PEFR of <80% detected more than 90% of people with COPD in the community, including all of those with moderate or severe disease.[15]

In the present study, predicted PEFR in 200 asymptomatic school children was determined, and it was found that 40 children (20%) had values <80%. It is well documented that the measurement of PEF and FEV1 are the most

useful parameters for the diagnosis and exclusion of asthma.[11] Thus, the results may be suggestive of asymptomatic mild airway obstruction in these 40 children. These results are supported by the data which reported overall asthma prevalence in Indian children from 3.5% up to 29.5%.[16]

We also found that of these forty children with PEFR with <80%, 19.14% of children had a positive history of familial asthma whereas 20.26% were without any family history of asthma ($P > 0.05$).

Indian data suggest that overall 10.9% of asthmatic children have a positive family history.[16] A study published in 2016 also showed that 30.76% of children with family history of airway obstruction had PEFR < 80% of the predicted values, and the association was significant.[17] A positive family history can be used to target individuals for prevention efforts, but its sensitivity ranges from 4% to 43%. The low positive predictive value (11% to 37%) and high negative predictive value (86% to 97%) also restricts its value as a means of screening modality.[18]

International consensus guidelines suggest that in asthma and COPD, measurements of percentage predicted FEV1 and PEF are equivalent in the assessment of the degree of airflow obstruction. However, Llewellin *et al.* in 2002, found that percentage predicted values of PEF and FEV1 were not equivalent, and across the spectrum of the severity of airflow obstruction there was considerable variability such that the FEV1 may be as much as 15% higher or up to 35% lower than the PEF for patients with obstructive lung diseases.[19]

To identify the false-positive results, we performed spirometry in the children (n = 35) with PEFR values < 80% and found that two children had low spirometric results. Surprisingly, none of these (n = 2) had a family history of asthma. Thus, a positive family history though predicts an increased risk of asthma; it identifies a minority of children at risk. In our cohort, the child with the lowest PEFR value did not show any abnormality on spirometry which might be because PEFR predominantly measures the status of large airways and is effort dependent while FEV_1 reflects both large and peripheral airways function and is determined by effort dependent as well as independent portion of forced expiratory maneuver.[19,20]

Most of the asthma screening and thus preventive measures till date have been directed with an intent to identify such (positive family history) at-risk children. However, our study shows that the prevalence of children with low values (<80%) of PEFR is almost equal in both children with or without family history of asthma. Rather, it was observed that 1% (n = 2) of the total sample size which had confirmatory obstructive findings through spirometry (FEV1/FVC <80%) had no family history of asthma. Although 1% of population (age group of 11–15 years) may appear insignificant but not to forget the total prevalence, which varies between 3.5% and 30% (0–15 years). As per the 2011 census, 32.5% of the population of Rajasthan is comprised of children aged 0–15 years which is 3% higher than the national average of 29.5%.[21]

One percent asymptomatic children without any family history of asthma, showing obstructive changes, may be alarming, and we propose that further studies with suitable sample sizes should be performed in this respect. The policymakers should take serious cognizance of the situation. In the present study, the two children (1%) who showed abnormality in spirometry are although asymptomatic but with impending asthma. Early management in these children will reduce their period of absenteeism from school and quality of life in these children. Thus, the presence of mild airway narrowing would be asymptomatically present in children not only from asthmatic families but also from those with no family history. PEFR can be used as a screening test for early diagnosis of asthma in all asymptomatic children. This is because determining PEFR is a cost-effective procedure that does not require a trained technician to perform it; even a teacher in the school can measure it. Spirometry, on the other hand, is a costly, time-consuming procedure hence unsuitable for screening.

The study thus concludes that all the asymptomatic children with low PEFR values may not show abnormal lung functions on spirometry. However, these children, irrespective of the family history of asthma, should be followed for the development of airway obstruction.

Conclusion

Asymptomatic children with low PEFR values may not show abnormal lung functions on spirometry. However, these children, particularly those having the risk of family history of asthma, may be followed for the development of airway obstruction.

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Conflicts of interest

There are no conflicts of interest.

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