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Original Article

Internal Medicine Section

Comparison of Forced Oscillometric Technique and Spirometry in Stable Asthmatic Patients in Central India: A Cross-sectional Study

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ABSTRACT

Introduction: Asthma is an airway disease, the diagnosis of this disease still continues to be clinical based. Although, there are several tests that can be useful for asthma, but no one can be considered as a standard test and search for better test is still on. Spirometry being the most commonly used test but it involves effortful manoeuvre, whereas Forced Oscillometric Technique (FOT) is a lesser studied technique with no special manoeuvre.

Aim: To compare between spirometry and FOT in adults asthmatic patients for assessing the utility of FOT.

Materials and Methods: The present cross-sectional study was conducted at School of Excellence in Pulmonary Medicine at Netaji Subhash Chandra Bose Medical College, Jabalpur, Madhya Pradesh, India, in 50 clinically diagnosed bronchial asthma patients between August 2020 to July 2021. These patients were sequentially assessed with spirometry and FOT. The patients were categorised into clinical severity and airflow limitation severity on spirometry. The baseline parameters Forced Expiratory Volume ($FEV)_1$, Forced Vital Capacity (FVC), FEV_1/FVC, Forced Expiratory Flow (FEF) 25-75, R5, R20, R5-R20, X5, Z5 were obtained by both the tests were analysed and compared for detecting the utility of FOT by using BlueSky statistical software-10.0.0-Beta2 version.

Results: Among 50 enrolled patients (21 males and 29 females) with asthma, 42 (84%) were mild and 8 (16%) were moderate. The mean age of patients was 27.5±6.6 years. The total airway resistance (R5) was the most consistent FOT parameter that was statistically different in asthma severity groups as well as in spriometry severity group (p-value=0.01). Peripheral airway resistance (R5-R20), and impedance Z5 were other variables that were significant between airflow limitation groups with a p-value of 0.01. A significant correlation was found between spirometry and FOT parameters including FEV_1, FVC, FEV_1/FVC with R5 (r>-0.5 at p-value of <0.01 for each parameter) and R20 (r>-0.5 at p-value of <0.05). Area Under Curve (AUC) was not able to differentiate between severity groups using FOT parameters with p-value of >0.05.

Conclusion: The FOT parameters correlated with spirometric indices therefore this technique may be a useful measure in asthma diagnosis. Further studies are needed to derive cut-off values of FOT parameters.

Keywords: Airway obstruction, Airway resistance, Forced expiratory volume, Lung capacity, Lung volume, Reactance

INTRODUCTION

Diagnosis of bronchial asthma relies mainly on the history and clinical findings, since there is lack of any single, reliable and practical diagnostic tool [1]. The clinical features of the disease can be described according to the definition of Global Initiative for Asthma (GINA guidelines) that includes wheeze, shortness of breath, feeling of chest tightness, and cough that varies in duration and intensity [2]. Another important part of this definition consists of variable expiratory airflow limitations. These symptoms and the airflow limitations vary over time and intensity. They may be triggered by many factors such as exercise, allergens or irritant exposure, change in weather, or viral respiratory infections. Asthma is a disease affecting about 1-18% of the population [2]. About 30% of patients of the Outpatient Department (OPD) in chest clinics constitute asthma patients [3]. The prevalence rates from India have been generally reported between 2-5% [4]. Lung function testing can contribute to the management of bronchial asthma patients in multiple ways such as in the diagnosis, proper treatment, and also in the follow-up. The repeated test done over the time during follow-up visits helps in the monitoring of respiratory parameters, that allow early intervention, and help in the improvement of the prognosis [5].

Therefore, measurement of lung functions is an important part of decision-making for the treatment of bronchial asthma. Spirometry is currently the most commonly performed lung function test in clinical practice of asthma and is hence considered to be the standard diagnostic test that may help in measuring variable airflow limitation. With the better availability of compact, portable testing equipment, spirometry tests are becoming more commonly available and feasible for patients [6].

But the spirometry may not be considered as a single absolute test that is a reliable or practical diagnostic tool for all cases of bronchial asthma [7]. Spirometry has many disadvantages, most of the parameters of spirometry are effort dependent and they require great cooperation from patients in performing the manoeuvre adequately. Also, this test can be considered as a difficult test for some patients such as, smaller children, mentally ill patients and elderly frail patients, who cannot comprehend or perform test manoeuvre. Moreover, Spirometry may not show abnormalities in all patients with bronchial asthma [2]. Hence, these patients with asthma are likely to be diagnosed only by clinical suspicion or are often evaluated for other abnormalities. Therefore, in such patients, there is a need for other investigative modalities that can detect early changes in asthmatic patients.

In 1956, DuBois AB et al., described a new lung function technique known as FOT as a lung function test [8]. This test used sound waves generated by a loudspeaker passing through the lungs during tidal breathing that non invasively measures respiratory

system impedance by the superimposition of oscillatory pressure or flow waves at the mouth. The parameters gave the measure of airway calibre in the form of respiratory system resistance (R), elastic and inertive properties of the respiratory system as reactance (X) at various sound frequencies ranging from 3-30 Hz [9]. Impulse Oscillometry (iOS) is a further advancement of the same FOT principle in lung function test [10], but was not used here in present study. Forced oscillometry test has many advantages such as it is a much simpler and non invasive type of test. It is effort-independent no complex manoeuvre is required by the patient, thereby requiring minimal patient cooperation. The test can distinguish between the degree of obstruction in central and peripheral airways [11-14]. Various studies have shown relationships between the spirometry parameters such as Forced Expiratory Volume $(FEV)_1$, FEV_1/Forced Vital Capacity (FVC), Forced mid-expiratory Flow (FEF) 25-75, and forced oscillometric parameters such as R5 [15,16]. There was fair consistency between spirometry and FOT parameters during bronchodilator reversibility testing [17]. The FOT was found to be comparable in assessing Asthma control [18].

FOT has shown to be more sensitive than FEV_1 test of spirometry [1]. In most of the previous studies, the comparison of FOT and spirometry has been conducted in mainly the paediatric population [14,16-18]. Only few studies have reported that oscillometric parameters (done using iOS) can be used as an alternative for spirometry in obstructive lung diseases and can be a useful measure for diagnosing asthma and its follow-up [18,19]. Therefore, the aim of the present study was to assess the utility of FOT in bronchial asthma as a potential diagnostic tool. An effort was made to compare the baseline parameters generated in both these lung function techniques in assessing the severity of asthma and to find out if FOT parameter cut-off values can be obtained to define asthma severity.

MATERIALS AND METHODS

In the present cross-sectional study, 50 adult Asthmatic patients visiting Respiratory Medicine Outpatient Department (OPD) of School of excellence in Pulmonary Medicine at Netaji Subhash Chandra Bose Medical College, Jabalpur, Madhya Pradesh, India, were evaluated. The study participants were enrolled between the period of August 2020 to July 2021. Informed consent was obtained from all the patients after properly explaining the details of the study and test procedure. The study was approved by Institutional Ethics Committee in its meeting held on 17 December 2019 vide letter number IEC/2021/598.

Sample size calculaton: Sample size calculaton was done using formula $n=z^2 \times p(1-p)/e^2$, where n=sample size, 'z' is z score of confidence interval 95% is 1.96, 'p' is population proportion of 5% [4] and 'e' is margin of error 5%, so by using above formula a minimum sample size of 38 was obtained.

Inclusion criteria: Asthamatic patients greater than 18 years, were eligible if they were not on any bronchodilator medications for atleast 12 hours before testing and all tests were successfully completed in a single visit, to avoid the effect of bronchodilator medications on lung function parameter values during the tests were involved after taking informed consent.

Exclusion criteria: The patients with exacerbation of asthma symptoms, other respiratory disorders such as tuberculosis, chronic obstructive pulmonary diseases, interstitial lung diseases and chest wall diseases, those with known cardiac co-morbidities such as heart failure, recent coronary artery disease and who had undergone major surgeries of eye, ear, brain, thorax and abdomen in the last four weeks and those patients aged less than 18 years and pregnant women and patients who were not able to perform the test manoeuvre correctly were excluded for the study purpose.

Study Procedure

The clinical diagnosis of asthma was made by a history of wheezing, shortness of breath, chest tightness, or cough with a consensus of two respiratory physicians. The stable patients of asthma with controlled symptoms were selected. The history of factors that may affect asthma such as history of smoking, exposure to dust or fumes daily, any associated respiratory or skin allergies, uricaria, drugs kown to cause asthma-like symptoms was also recorded.

Asthmatic patients were classified on the basis of severity into three groups as per Global Initiative for Asthma (GINA) guidelines as tabulated below as [Table/Fig-1] [2].

Asthma severity	Type of medication through which symptoms were well-controlled
Mild	Step 1 or 2 treatment (with as-needed Inhaled Corticosteroid (ICS) plus Formoterol (LABA) alone or Low dose ICS, Leokotriene Receptor antagoist or chromones
Moderate	Step 3 or 4 treatment (low or medium-dose treatment with ICS-LABA
Severe	When asthma remains uncontrolled despite optimised treatment with ICS plus LABA or that requires high dose ICS plus LABA

[Table/Fig-1]: Classification on the basis of severity as per GINA guidelines [2].
LABA: Long-acting beta-agonist

The test manoeuvres were explained in detail to the patients in their native language. The FOT parameters were measured using a commercially available FOT device (COSMED Quark i2 m). The patients were explained the technique that, during the test procedure, patient should sit in a chair with legs uncrossed and nose clips were worn. The mouthpiece was placed at a comfortable height, so that neck was slightly extended. A tight seal was maintained between the mouthpiece and lips. Patient cheeks were supported firmly by the patient himself or by an assistant with hands. The patient was asked to breathe normal tidal breathing into a mouthpiece for atleast 30-45 seconds. The artefacts such as leaks, cough, glottis closure, or unusually large breaths were excluded.

A minimum of three such tests were performed. The parameters recorded for the study were resistance at 5 Hz (R5), resistance at 20 Hz (R20) and their percent predicted. The difference between resistance at 5 Hz and 20 Hz (R5-R20), reactance at 5 Hz (X5), and impedance at 5 Hz (Z5) were also recorded in the FOT test. The resistance at 5 Hz (R5) represents the total airway resistance upto the peripheral part of the lung. The resistance at 20 Hz sound frequency (R20) represents the resistance of the larger airway. When R20 is subtracted from R5 (R5-R20) it infers resistance of the small airways. Reactance at 5 Hz (X5) is the sum of inertance and elastance and has a relationship with pulmonary compliance and viscoelastic properties of lungs [9].

The spirometry was then recorded after FOT in the same setting. Spirometry was performed according to the method described in the American Thoracic Society and Europian Respiratory Society (ATS/ERS) guidelines [Table/Fig-2] [20] using spirometry device (COSMED micro quark PFT). Pulmonary function indices, including Forced Vital Capacity (FVC), Forced Expiratory Volume in the first second (FEV_1), ratio of FEV_1/FVC, and Forced Expiratory Fraction 25-75% (FEF 25-75%) were measured by spirometry. Predicted normal values for FVC, and FEV_1 were calculated by machine itself using the Global Lung Function Initiative (GLI) equation [21].

STATISTICAL ANALYSIS

Statistical analysis was done by using BlueSky (ver.10.0.0 Beta 2) statistical software. The comparison of means between the groups was done using the Student's t-test and the Analysis of Variance (ANOVA) test. The homogeneity of variance was ascertained by using the Levene test for confirming the certainty of the ANOVA

Degree of severity of airflow limitation	FEV_1 percentage predicted (in %)
Mild	>70
Moderate	60-69
Moderately severe	50-59
Severe	35-49
Very severe	<35

[Table/Fig-2]: The severity of airflow obstruction graded as per the ATS/ERS criteria [20].
FEV1: Forced vital capacity in 1st second

test. The correlation between FOT and spirometry measurement was determined by the Pearson's correlation coefficient. The Receiver Operating Characteristic (ROC) curves were used to discriminate mild and moderate cases of bronchial asthma on basis of oscillometric variables.

RESULTS

A total of 50 patients with the clinical diagnosis of bronchial asthma were enrolled for the study. They underwent FOT and spirometry sequentially. According to the severity of asthma [2], 42 (84%) were mild and 8 (16%) were moderate. No patient of severe asthma got enrolled for the study. In these 50 patients 17 (34%) had completely normal spiromertic values and all of them belonged to mild category of asthma as per severity classification mentioned in [Table/Fig-1]. Out of these 17 patients with normal spirometry, 13 had abnormal oscillometry values. A total of 46 (92%) patients had abnormal oscillometry test.

In the present study, 21 patients were males (42%) and 29 were females (58%) [Table/Fig-3]. In the 50 adults with both lung function tests available, baseline spirometric indices were abnormal for FEV_1 in 21 (42%), FVC in 13 (11%), FEV/FVC in 33 (66%), and FEF 25-75% in 20 (40%) cases.

Characteristics	Values
Total subjects	50
Sex(n), Male/female	21/29
Age mean±SD (years)	27.5±6.6
Smoking(n), Present/Absent	8/42
Allergies(n), Present/Absent	31/19
Exposure to dust or fumes(n), Present/Absent	12/38
Clinical severity(n), Mild/Moderate [2]	42/8
Spirometry test (Mean+SD)	
FEV_1 (in litres)	2.07±0.62
% Pre FEV_1 (in percentage)	67 ±13.7
FVC (in litres)	2.49±0.76
% Pre FVC (in percentage)	71.4±16.56
FEV_1/FVC (ratio in percentage)	70.34± 12.81
%Pre FEF 25-75	54.9±23.08
Airflow limitation (n) based on spirometry classification [20]	
No obstruction	17
Mild	17
Moderate	12
Moderately severe	04
FOT test (Mean±SD)	
R5	6.33±2.22
% Pre R5	196±63.8
R20	3.84±1.9
%PreR20	167±49.7
R5-R20	2.49±1.93
X5	-3.45±2.82
Z5	2.89±1.35

[Table/Fig-3]: The demographics and pulmonary function test of patients.
SD: Standard deviation; FEV1: Forced expiratory volume in 1st seconds; FVC: Forced vital capacity FEF 25-75; Forced Expiratory Flow at 25-75% of FVC
R5=Resistance at 5 Hz, R20=Resistance at 20 Hz, X5=Reactance at 5 Hz, Z5=Impedance at 5 Hz

Also, 17 of these patients were found to have mild airflow limitation by spirometry, 12 fit into moderate airflow limitation and four fit into moderately severe airflow limitation, whereas no obstruction was seen in 17 patients.

The demographic profile and parameters of the lung function test and FOT of the study subjects are shown in [Table/Fig-3]. When oscillometric variables were compared with clinical severity of asthma, the value of R5 ($p<0.048$) and X5 ($p<0.032$) showed statistical significance as in [Table/Fig-4]. The results of the study showed, that there was an increase in the value of R5 and more negativity in the value of X5 with severity progressing.

Clinical severity	Mild (mean±SD) n=42	Moderate (mean±SD) n=8	p-value
R5	6.22±2.12	7.01±3.46	**0.048***
PR5	193.83±66.01	208.38±52.78	0.740
R20	3.85±2.08	4.15±1.99	0.922
PR20	168.88±52.42	162.88±45.94	0.952
R5-R20	2.93±1.71	2.86±2.47	0.175
Z5	3.27±3.39	3.83±2.92	0.231
X5	-3.51±3.05	-3.18±1.24	**0.032***

[Table/Fig-4]: Comparison of FOT parameters in various severity groups of asthma (n=50) [2].
*Statistically significant
R5=Resistance at 5 Hz, R20=Resistance at 20 Hz, X5=Reactance at 5 Hz, Z5=Impedance at 5 Hz

A similar comparison between the oscillometric variables with severity classification on basis of spirometry was done. There was a significant difference among the four groups of airflow limitation with R5, $F(3,46)=25.05$, $p<0.001$, $n^2_{partial}=0.62$. Similarly, a statistically significant difference was also found in FOT parameters R5-R20, Z5, and X5 in spirometrically classified airflow limitation groups as shown in [Table/Fig-5] [19].

FOT parameters	No airflow limitation (n=18)	Mild airflow limitation (n=17)	Moderate airflow limitation (n=11)	Severe airflow limitation (n=4)	p-value (In ANOVA test)
R5	4.51+1.52	6.11+1.24	8.83+1.66	8.6+0.25	**0.001***
Pre R5	177.2+63	180.5+43.8	2.28.27+25.9	259+19.6	**0.02***
R20	314+1.14	3.76+2.02	4.95+1.84	4.21+26.5	0.09
Pre R20	158+54	166.7+50.9	175+48.6	187.2+29	0.68
R5-20	1.36+1.38	2.34+1.60	3.88+1.57	4.39+2.88	**<0.001****
Z5	1.82+0.5	3.01+1.97	5.76+3.01	3.62+1.48	**<0.001****
X5	-3.69+3.67	-3.10+2.06	-3.07+2.74	-4.98+1.37	0.637

[Table/Fig-5]: Comparison of FOT parameters in various groups of airflow limitation as per spirometry (n=50) [19].
ANOVA (Analysis of variance)
*statistically significant
**statistically highly significant

But the posthoc testing revealed that there was a significant difference in R5 value between-group paired as normal (mean 4.51, SD=1.52) with mild obstruction (mean 6.11, SD=1.24) and moderate (mean 8.83, SD=1.66) with severe obstruction (mean 8.6, SD=0.25), suggesting that the R5 parameter could differentiate normal to mild case from moderate to severe cases of airflow limitation. The posthoc testing also showed that the parameter R5-R20 was able to differentiate between those without airflow limitation from those having airflow limitation. The authors noted that the resistance value at 5 Hz (R5) and R5-R20 can be a valuable parameter in bronchial asthma patients comparing their clinical and spirometric values.

The available spirometric variables i.e., FEV_1, FVC, FEV_1/FVC, % predicted values of FEV_1 and FVC were compared with R5, R20, R5-R20, X5, Z5 obtained by oscillometry. A significant negative correlation was obtained between many variables. The oscillometric parameters R5 correlated significantly with all the spirometric parameters such as: FEV_1 (r=–0.529, p<0.001), FVC (r=-0.523, p<0.001), and % predicted FEV_1 (r=-0.64, p<0.001) and % predicted FVC (r=-0.492, p<0.001) FEV_1/FVC (r=-0.553, p<0.01). The R20 also correlated well with FEV_1, FVC and their predicted values, but did not correlate significantly with FEV_1/FVC ratio. The correlation between the predicted R5 and predicted R20 was not uniform with the spirometry tests. Other oscillometric parameters correlated with only few spirometric parameters as shown in the correlation matrix [Table/Fig-6]. The parameter R5 correlated moderately, where as R20 strongly correlated with FEV1 of spirometry.

Variables		R5	Predicted R5	R20	Predicted R20	R5-R20	Z5	X5
FEV_1	Pearson's correlation	-0.529*	-0.248	-0.661*	-0.91	0.044	-0.018	0.383*
	p-value	**0.01**	0.08	**0.01**	0.5	0.76	0.90	**0.01**
%pre FEV_1	Pearson's correlation	-0.645*	-0.372*	-0.632*	-0.162	-0.426*	-0.386	0.286*
	p-value	**0.01**	**0.01**	**0.01**	0.26	**0.01**	0.21	**0.01**
FVC	Pearson's correlation	-0.523*	-0.311*	-0.584*	0.009	-.026	-0.046	0.345*
	p-value	**0.01**	**0.02**	**0.01**	0.95	0.859	0.752	**0.01**
%pre FVC	Pearson's correlation	-0.492*	-0.280*	-0.522*	0.053	-0.05	-0.153	0.196
	p-value	**0.01**	**0.04**	**0.01**	0.715	0.731	0.289	0.173
FEV_1/FVC	Pearson's correlation	-0.553*	-0.380*	-0.222	-0.252	-0.417*	-0.359*	0.005
	p-value	**0.01**	**0.01**	0.12	0.07	**0.03**	**0.01**	0.97

[Table/Fig-6]: Correlation between FOT and spirometric variables.
Bold p-values are significant; Symbol * shows a statistically significant coefficient of correlation(r) with p-value less than 0.05

The area under the curve (ROC analysis) was done to discriminate clinical asthma severity of mild and moderate cases of bronchial asthma on basis of oscillometric variables and it was observed that no significant cut-off values could be designated on basis of severity as shown in [Table/Fig-7].

FOT parameters	AUC of ROC	95% confidence interval	p-value
R5	0.57	0.41-0.73	0.39
Pre R5	0.487	0.31-0.65	0.84
R20	0.608	0.44-0.76	0.19
Pre R20	0.499	0.33-0.66	0.99
R5-R20	0.47	0.30-0.63	0.71
Z5	0.501	0.33-0.66	0.99
X5	0.601	0.44-0.76	0.22

[Table/Fig-7]: The ROC analysis of oscillometric variables with clinical severity of asthma.
AUC: Area under the curve; ROC: Receiver operating characteristic; p-value less than 0.05 as statistically significant

DISCUSSION

Asthma patients can be effectively managed on, as needed, low doses Inhaled Corticosteroids (ICS) or bronchodilators. It was seen that patients belonging to moderate persistent groups have the maximum number of OPD visits and the patients with regular OPD visits have a lesser number of exacerbations and admissions [22]. In the present study, the fraction of mild cases (n=42, 84%) was more as compared to the moderate cases (n=8,16%), probably due to the centre being a state owned hospital offering free medications, so even mild cases visited the hospital frequently.

A significant point to be noted was that 18 (36%) of clinically diagnosed patients were labelled as normal by spirometry. The clinical and spirometric classification of severity failed to show a definite overlap in the present study. This finding is similar to a study conducted by Dhar R and Ghoshal A which found that spirometric findings correlated with clinical parameters in 4% of patients with severe asthma and 86% of patients with moderate asthma [23]. They concluded that more the severe asthma based on spirometry, less was the correlation with symptomatology and exacerbations. This finding suggests the need for other definitive tools for the identification of airway abnormality in asthma, so in such circumstances, there may be a role of FOT. In the present study oscillometry parameters were found abnormal in 13 out of 18 cases who has normal spirometry findings.

The obstructive lung diseases such as Coronary Obstructive Pulmonary Disease (COPD) and asthma have been most often researched using oscillometry technique. It has been found that the oscillometry parameters have correlated well with spirometry parameters. In a study by Vink GR et al., done on children with asthma the FEV_1 parameter of spirometry correlated with the oscillometry parameters of lower frequencies i.e. R5 (r=-0.71) and R10 (r=-0.73) [24]. Similarly, the study by Batmaz SB et al., had found that airway obstruction detected by spirometry parameters of FEV_1 and FEV_1/FVC could also be detected by oscillometry parameters such as R5, R20, R5-R20, and X5 in children with asthma [14]. Saadeh C et al., have reported a correlation between R5 (r=-0.478), R20 (r=-0.401), X5 (r=0.267) with FEV_1 [17].

In a study by Miyoshi S et al., it was seen that a linear relationship between FOT and spirometry was strongest in baseline indices describing peripheral obstruction, i.e., R5 with FEV_1 (r=-0.502, p<0.001), R5 with FVC (r=-0.525, p<0.001), X5 with FEV1 (r=0.546, p<0.001) and X5 with FVC (r=0.518, p<0.001) in asthma patients [25]. Another study by Nair A et al., found that, in adult asthmatics and healthy subjects, the iOS parameter R5 was found to be correlating with FEV_1 (r=-0.40, p<0.001) [26]. Oscillometric parameters at low frequency (R5 and X5) have been found as a significant common variable in assessing the severity of bronchial asthma, both clinically and based on spirometrically in the present study also [25].

In the present study, also it has been found that FOT parameters R5, R20 correlated negatively with the FEV_1 and FVC spirometric parameters and X5 correlated positively with FEV1 and FVC. But the literature comparing oscillometry and spirometry in adult patients of asthma is limited. Furthermore, such studies comparing the utility of both these types of tests are very scarce in Indian adult asthmatics.

Airway resistance increases (especially in small airways) in the case of patients with asthma having bronchoconstriction, mainly during exacerbations [27]. Gonem S et al., had found an increased values of R5, R20, and X5 [28]. Since R5-R20 values indicate the health of lower/peripheral airways, they may not be good parameters of diagnosis of asthma per se, since asthma has predominantly airways obstruction. But, R5-R20 has been shown to predict future

asthma exacerbations [29]. In the present study, also R5-R20 did not correlate well with FEV_1 or FVC, the reason behind this may be that the patients who got enrolled in the present study were not in exacerbation and were stable. This may be the reason behind the R5-R20 parameter not correlating well with the spirometer parameters in the present study.

Oscillometry is also a useful tool in evaluating the control level of asthma. Poor control of the disease can also be suspected when parameters R5-R20 and AX are increased [30]. Bronchodilator reversibility test to judge the control of asthma with medication has been studied using both these tests. The parameters X5 and AX, but not R5, were associated with spirometric bronchodilator reversibility and correlated with asthma control in a study done by Miyoshi S et al., [25]. King GG et al., in their study, concluded that there were important parameter differences in case of uncontrolled, poorly controlled, and uncontrolled asthma, but patients cannot be organised correctly into control categories only based on oscillometry [31]. They had found associations between oscillometric values and spirometry but no cut-off values of FOT could be demarcated for the diagnosis or defining the severity of asthma. The present study also could not detect the cut-off values of FOT parameters that may help in severity assessment of lung function. The clinical use of FOT parameters for severity assessment and bronchodilator reversibility in adult asthma patients needs to be studied in greater detail in future studies.

Presently there is lack of well-defined predicted equations for FOT parameters commonly suitable for all regions worldwide. There is an emerging need for clinically useful predicted equations for the Indian population concerning anthropometric indices, hence the clinical reliaitilty of percent predicted values of various FOT parameters in this study can be debatable.

Limitation(s)

The present study was limited by a small sample size that could be drawn given the Coronavirus Disease-19 (COVID-19) pandemic that struck during the period of study. Further, clinically severe asthma patients did not get enrolled in the present study, as such patients were not able to perform forced breathing manoeuvres adequately. A well-established FOT test with reliable predicted equations may be the test of choice in such patients. This emphasises the need for further research on the utility of these oscillometry-based tests (FOT/iOS) in adult patients with chronic respiratory disorders like asthma.

CONCLUSION(S)

It was observed that the FOT variables such as R5, R20, X5 have been able to detect significant changes in airway characteristics of bronchial asthma. The FOT parameters R5, R20 correlated well with the spirometry parameters of FEV1 and FVC, that can suggest that this technique may be used hand in hand with spirometry for diagnosis of bronchial asthma in adults, but a definite cut-off values for FOT parameters couldn't be defined in the present study to classify asthma severity. Subsequent studies with a greater sample size may provide further clarity on these tests variables.

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