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Reliability of Peak Expiratory Flow Rate Versus FEV_1 Reversibility in Assessing Bronchodilator Response in Asthma: A Cross-Sectional Study

Dr. Vignesh Nagalingam[1], Dr. Nethra Dinakaran[2], Dr. Prasanth Gururaj[3*], Dr. Swetha Sasikumar[4], Dr. Anbumaran Parivakkam Mani[5]

[1]Assistant Professor, Department of Respiratory Medicine, Sri Venkateswaraa medical College and research institute, Chennai
[2] Assistant Professor, Department of Otorhinolaryngology, Sri Venkateswaraa medical College and research institute, Chennai
[3]Associate Professor, Department of Respiratory Medicine, Sri Venkateswaraa medical College and research institute, Chennai
[4]Associate Professor, Department of Respiratory Medicine, Sri Venkateswaraa medical College and research institute, Chennai
[5]Professor and HOD, Department of Respiratory Medicine, Sri Venkateswaraa medical College and research institute, Chennai
[*]Corresponding Author: Dr. Prasanth Gururaj

ABSTRACT:

Background: Background: Peak expiratory flow rate (PEFR) is cheap and portable, but it is unclear whether PEFR reversibility can replace FEV_1 reversibility when assessing bronchodilator response in asthma.
Objective: To compare bronchodilator response measured by PEFR with that measured by FEV_1 spirometry, and to assess the diagnostic accuracy of PEFR against an FEV_1 reference standard.
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Methods: In this cross-sectional study at a tertiary hospital in Chennai (January–June 2025), 120 stable patients with asthma aged 8–63 years underwent spirometry and peak flow measurement before and 15–20 minutes after salbutamol 200 mcg by metered-dose inhaler with spacer. A significant FEV_1 response was defined as an increase of ≥12% and ≥200 mL.

Results: Mean age was 35.7 ± 14.1 years and 76 patients (63%) were female. FEV_1 rose from 1.64 ± 0.70 L to 1.84 ± 0.71 L (mean change 0.20 L, 95% CI 0.17–0.23; 15.0 ± 12.4%). PEFR rose from 295.3 ± 124.6 to 334.8 ± 120.6 L/min (mean change 39.5 L/min, 95% CI 35.8–43.2; 16.3 ± 10.4%); both changes had $p < 0.001$. Percentage reversibility in PEFR correlated only weakly with that in FEV_1 ($r = 0.27$, $p = 0.04$). Forty-two patients (35%) met the FEV_1 criterion. A PEFR increase of ≥15% detected them with sensitivity 52% (95% CI 32–72) and specificity 62% (95% CI 46–75); the area under the ROC curve was 0.53.

Conclusion: Both PEFR and FEV_1 rise after bronchodilator in asthma, but PEFR

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reversibility agrees poorly with FEV_1 reversibility in this sample. PEFR should not replace spirometry for bronchodilator reversibility testing, although larger studies are needed.

INTRODUCTION

Asthma is a chronic inflammatory airway disease characterised by variable, usually reversible airflow obstruction [1,2]. It is common in India, where a large population-based survey of adults documented a considerable burden of asthma and chronic respiratory symptoms [3].

Because the diagnosis rests on demonstrating variable expiratory airflow limitation, objective lung function testing is central to both diagnosis and monitoring. Spirometry is the reference method, performed to standardised technique [4,5], and an increase in forced expiratory volume in one second (FEV_1) of at least 12% and 200 mL after an inhaled bronchodilator has long been the accepted marker of significant reversibility [6]. More recent ERS/ATS guidance has moved towards expressing the response relative to the predicted value [7], but the 12% and 200 mL convention remains widely used in clinical practice and research. Spirometry, however, requires equipment, calibration and trained staff that are not available in every clinic.

Peak expiratory flow rate (PEFR) is the maximum flow reached during a forced expiration from full inflation. It is measured with an inexpensive, portable handheld meter and is widely used for home monitoring and in primary care where spirometry is unavailable. Indices of PEFR variability are related to airway hyperresponsiveness, although less closely to symptoms or baseline airflow obstruction [8,9]. PEFR is reached early in the manoeuvre, depends strongly on patient effort and on the calibre of the larger airways, and may miss obstruction that affects smaller airways [10]. For these reasons, guidelines advise that it should not replace spirometry for diagnosis [2,4].

Whether a change in PEFR after a bronchodilator can stand in for the FEV_1 response has been examined in several settings, with discordant conclusions. In general-practice patients with asthma or chronic obstructive lung disease, an absolute PEFR rise of at least 60 L/min identified FEV_1 reversibility with high specificity but moderate sensitivity, and the authors proposed it as a simple diagnostic technique [11]. In primary care patients with persistent cough, relative PEFR increases of 10–20% had low positive predictive values and PEFR was judged unsuitable for assessing bronchodilator response, although it reliably excluded it [12]. In children with asthma, a PEFR rise of 20–25% was highly specific but insensitive [13], and in adults a peak flow meter compared with spirometry showed a sensitivity below 50% [14].

These studies differ in age group, setting, reference standard, and in whether the PEFR threshold was absolute or relative, so it is unclear which threshold, if any, applies to patients attending a tertiary hospital in India, where children and younger adults make up a large share of asthma patients. Evidence from South Indian hospital populations is limited.

We therefore measured PEFR and FEV_1 before and after salbutamol in patients with stable asthma, quantified the percentage reversibility in each, and assessed how well PEFR reversibility agreed with, and could identify, a significant FEV_1 response.

METHODS

Design and setting. Cross-sectional observational study in the Department of Respiratory Medicine, Saveetha Medical College and Hospital, Chennai, India, from 1 January to 30 June 2025. Ethics committee approval and written informed consent were obtained.

Participants. Patients with a confirmed diagnosis of bronchial asthma attending the outpatient or inpatient department were enrolled by non-probability purposive sampling; 120 patients met the criteria; the sample was the number of eligible patients seen during the six-month study period. Inclusion criteria were stable asthma without acute exacerbation, ability to perform reproducible spirometry and peak flow manoeuvres, and written informed consent. Exclusion criteria were coexisting chronic lung disease (COPD, interstitial lung disease, bronchiectasis), respiratory infection within two weeks, severe cardiac disease or uncontrolled hypertension, neurological or cognitive impairment preventing cooperation, pregnancy, and any contraindication to bronchodilator.

Procedure. Age, sex, height, weight, symptoms (breathlessness, cough, wheeze), dust allergy, comorbidities and modified MRC (mMRC) dyspnoea grade were recorded. Patients withheld bronchodilators for 6–12 hours before testing. A trained respiratory technician measured FVC, FEV_1, FEV_1/FVC and FEF_{25-75} by spirometry, and PEFR with a standardised peak flow meter, taking the best of at least three efforts. Salbutamol 200 mcg (two puffs) was given by metered-dose inhaler with spacer, and measurements were repeated with the same equipment after 15–20 minutes of rest.

Outcomes. Percentage reversibility was calculated as (post − pre) / pre × 100 for FEV_1 and PEFR. The reference standard for a significant bronchodilator response was an FEV_1 increase of ≥12% and ≥200 mL [6]. Because no PEFR threshold was prespecified, diagnostic accuracy of PEFR was assessed post hoc at increases of ≥10%, ≥15% and ≥20%.

Statistical analysis. Continuous data are mean ± SD and categorical data n (%). Pre- and post-bronchodilator values were compared with paired t-tests (Wilcoxon signed-rank tests as a sensitivity check). The association between PEFR and FEV_1 percentage reversibility was assessed with Pearson (and Spearman) correlation. Sensitivity and specificity, with Wilson 95% confidence intervals, and the area under the receiver operating characteristic curve were calculated against the FEV_1 criterion. Two-sided $p < 0.05$ was considered significant. Analyses were run in SPSS version 25.0.

RESULTS

Participants. One hundred and twenty patients were analysed (Table 1). Mean age was 35.7 ± 14.1 years (range 8–63) and 76 (63%) were female. Breathlessness was reported by 92 (77%), wheeze by 86 (72%), cough by 58 (48%) and dust allergy by 76 (63%). Sixty patients (50%) had at least one comorbidity.

Characteristic	n = 120
Age, years, mean ± SD	35.7 ± 14.1
Age ≤40 / 41–60 / >60 years, n (%)	76 (63) / 40 (33) / 4 (3)
Female sex, n (%)	76 (63)
Body mass index, kg/m², mean ± SD	24.8 ± 5.7
mMRC grade 0–1 / 1–2 / 2–4, n (%)	8 (7) / 44 (37) / 68 (57)
Breathlessness, n (%)	92 (77)
Wheeze, n (%)	86 (72)
Cough, n (%)	58 (48)
Dust allergy, n (%)	76 (63)
Any comorbidity, n (%)	60 (50)
Diabetes mellitus, n (%)	34 (28)
Hypertension, n (%)	20 (17)
Thyroid disease, n (%)	6 (5)

Table 1. Baseline characteristics. Percentages may not sum to 100 because of rounding.

Bronchodilator response. Both measures rose significantly after salbutamol (Table 2, Figure 1). Mean FEV_1 increased by 0.20 L (95% CI 0.17–0.23; paired $t = 12.35$, df 59, $p < 0.001$) and mean PEFR by 39.5 L/min (95% CI 35.8–43.2; $t = 21.20$, $p < 0.001$). Wilcoxon tests agreed (both $p < 0.001$). Mean percentage reversibility was 15.0 ± 12.4% for FEV_1 and 16.3 ± 10.4% for PEFR.

Measure	Pre-bronchodilator	Post-bronchodilator	Mean change (95% CI)	Reversibility, %
FEV_1, L	1.64 ± 0.70	1.84 ± 0.71	0.20 (0.17–0.23)	15.0 ± 12.4
PEFR, L/min	295.3 ± 124.6	334.8 ± 120.6	39.5 (35.8–43.2)	16.3 ± 10.4

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Table 2. Lung function before and after bronchodilator (mean ± SD).

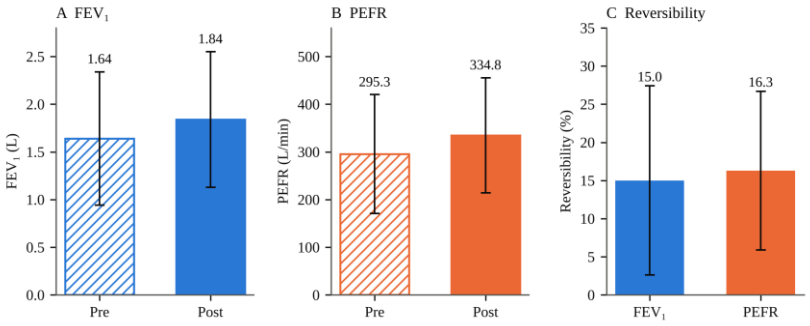


Figure 1. Lung function before and after salbutamol. (A) FEV_1 and (B) PEFR, mean ± SD before (hatched) and after (solid) bronchodilator; (C) mean percentage reversibility ± SD for FEV_1 and PEFR. Values are those in Table 2.

Agreement between PEFR and FEV_1. Percentage reversibility in PEFR correlated weakly with that in FEV_1 (Pearson $r = 0.27$, $p = 0.04$; Spearman $\varrho = 0.23$, $p = 0.08$). Baseline PEFR and FEV_1 correlated moderately ($r = 0.41$, $p = 0.001$).

Diagnostic accuracy. Twenty-one patients (35%) met the FEV_1 criterion (≥12% and ≥200 mL). Accuracy of PEFR reversibility against it varied with the threshold (Table 3, Figures 2 and 3). At ≥15%, sensitivity was 52% and specificity 62%. The area under the ROC curve was 0.53, indicating discrimination little better than chance.

PEFR increase threshold	Sensitivity, % (95% CI)	Specificity, % (95% CI)	TP / FN / TN / FP
≥10%	67 (45–83)	28 (17–44)	14 / 7 / 11 / 28
≥15%	52 (32–72)	62 (46–75)	11 / 10 / 24 / 15
≥20%	33 (17–55)	74 (59–85)	7 / 14 / 29 / 10

Table 3. Post hoc diagnostic accuracy of PEFR reversibility against FEV_1 reversibility (≥12% and ≥200 mL; 21 reference-positive, 39 reference-negative patients). TP, true positive; FN, false negative; TN, true negative; FP, false positive.

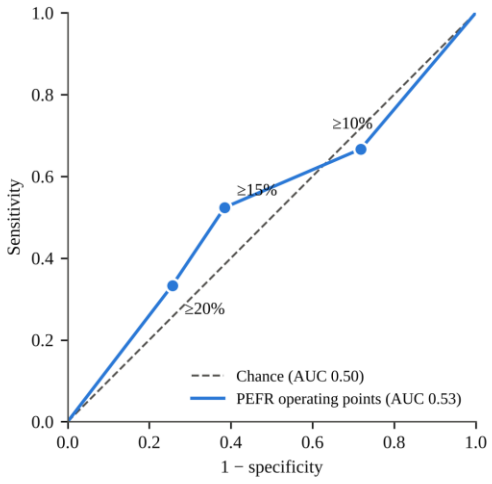


Figure 2. Receiver operating characteristic space for PEFR reversibility against the FEV_1 criterion (≥12% and ≥200 mL). Points show the three post hoc thresholds (≥10%, ≥15%, ≥20%) calculated from the counts in Table 3; the dashed line is chance. The reported area under the curve was 0.53.

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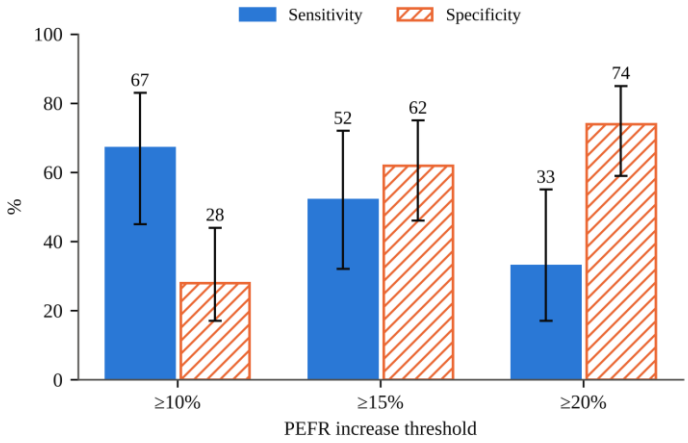


Figure 3. Sensitivity and specificity of PEFR increase thresholds for detecting an FEV_1 response (≥12% and ≥200 mL), with Wilson 95% confidence intervals (Table 3).

DISCUSSION

Principal findings. In 120 patients with stable asthma, both FEV_1 and PEFR rose significantly after salbutamol, but the size of the PEFR response tracked the FEV_1 response only weakly (r = 0.27), and PEFR reversibility identified FEV_1-defined responders little better than chance (AUC 0.53). Whatever threshold was used, PEFR traded sensitivity for specificity without reaching useful accuracy on both. Baseline PEFR and FEV_1 correlated moderately (r = 0.41), whereas their reversibility correlated much less (r = 0.27, about 7% shared variance), which suggests that the change scores carry different information from the baseline levels.

Comparison with previous studies. Published evidence is not uniform. Dekker et al. found that an absolute PEFR rise of at least 60 L/min identified FEV_1 reversibility with a specificity of 93–94% and a sensitivity of 56–68% in older general-practice patients, and concluded that absolute PEFR change could be used as a simple technique [11]. By contrast, Thiadens et al., studying 240 primary care patients with persistent cough, reported positive predictive values of only 36%, 52% and 67% for relative PEFR increases of 10%, 15% and 20%, and judged PEFR unsuitable for assessing bronchodilator response while noting that it reliably excluded it [12]. In 271 children with asthma, a PEFR rise of 20–25% had a specificity of 96% but a sensitivity of only 51–53% [13], and in 150 adults a peak flow meter compared with spirometry had a sensitivity of 47% and a specificity of 87%, with a best reversibility cut-off of 8% (AUC 0.70) [14]. Our sensitivity (33–67% across thresholds) lies within this range, but our specificity (28–74%) was lower than that reported by Dekker, Slieker and Herrera-Sánchez and their colleagues, and our AUC (0.53) was lower than that of Herrera-Sánchez et al.

Part of this heterogeneity is explained by design. Dekker et al. used an absolute threshold in older patients with asthma or chronic obstructive disease, and an FEV_1 criterion of ≥9% of predicted or ≥190 mL [11]; Slieker and van der Ent studied children [13]; we tested relative thresholds in a younger sample that included children, against the ≥12% and ≥200 mL criterion [6]. Predictive values also depend on how common reversibility is. In the cohort of Thiadens et al. 13% of patients had a positive bronchodilator response [12], whereas about one-third of our patients, all with established asthma, met the FEV_1 criterion. Calculated from Table 3, the positive predictive value of PEFR was 33%, 42% and 41%, and the negative predictive value 61%, 71% and 67%, at thresholds of ≥10%, ≥15% and ≥20%, respectively. The high negative predictive value that supports PEFR as a rule-out test in low-prevalence populations [12,13] was therefore not reproduced here: in patients with asthma, a small PEFR response did not reliably exclude an FEV_1 response.

Possible explanations. Several factors may explain why a rise in PEFR does not mirror a rise in FEV_1 in an individual patient. First, the two indices describe different parts of the manoeuvre. PEFR is a brief, effort-dependent flow generated early in expiration and largely determined by the larger airways, whereas FEV_1 integrates the first second of expiration and is influenced by smaller airways and lung volume; a bronchodilator may change these components to different degrees. In

children with asthma, about 30% of those with a normal PEFR still had an abnormal FEV_1 or FEF_{25-75}, and the ability of PEFR to predict normal FEV_1 fell as air trapping increased [10]; the relationship between FEV_1 and PEFR, each as a percentage of the predicted value, also varies with the degree of obstruction [15]. Second, percentage reversibility is a ratio of two noisy measurements, so ordinary measurement error in either the pre- or post-bronchodilator effort attenuates the correlation between the two change scores. Peak flow, a single-point measure that depends on the effort of the best of several blows, is probably more vulnerable to this, which is one reason spirometric standards emphasise standardised technique and quality-controlled effort [4,5]. Third, the FEV_1 criterion combines a relative and an absolute requirement, whereas the PEFR thresholds were purely relative. In smaller patients, including the children in our sample, a 12% rise may be less than 200 mL, so a patient with a proportionally large rise in both measures can still be classified as a non-responder by the reference standard. Because the current ERS/ATS standard expresses the response relative to the predicted value [7], the classification of reference-positive patients, and so the apparent accuracy of PEFR, might differ under the newer definition.

A significant mean rise in PEFR, as seen here, does not mean that an individual patient's PEFR response can stand in for the FEV_1 criterion. Both measures rose significantly and by similar mean percentages (15.0% for FEV_1 and 16.3% for PEFR), yet the individual changes were only weakly correlated: the two can rise together on average yet disagree patient by patient. Tests of mean change are not a measure of agreement.

Clinical implications. PEFR remains useful for tracking trends and supporting self-management, including where spirometry is scarce. Variability indices derived from serial home readings are related to airway hyperresponsiveness [8] and describe something different from a single acute response to a bronchodilator; they are not interchangeable with other physiological tests either, since in one comparison in suspected asthma none of the peak flow variation indices correlated significantly with methacholine challenge results [16]. Our data do not support using a single-session PEFR change to confirm or exclude bronchodilator reversibility, in line with guidance that spirometry remains the diagnostic test [1,2]. Where spirometry is unavailable, a PEFR response can be recorded, but a small response should not be taken to exclude reversibility, and patients in whom the diagnosis matters should be referred for spirometry. Given the burden of asthma in India [3], these findings strengthen the case for wider access to spirometry in primary and secondary care rather than reliance on PEFR thresholds.

Strengths. Strengths of this study are a standardised protocol with the same equipment and a trained technician for all measurements, bronchodilator delivery by metered-dose inhaler with a spacer at a fixed dose, a reference standard defined in advance according to international criteria [6], confidence intervals that show the imprecision of the accuracy estimates, and non-parametric sensitivity analyses that agreed with the parametric tests.

Limitations. It is a single-centre, non-random study with no sample size calculation, and the estimates are imprecise: the 95% confidence intervals for sensitivity spanned about 40 percentage points at every threshold. The PEFR thresholds were chosen after the data were seen and the ROC analysis rests on only three thresholds, so the accuracy estimates should be regarded as exploratory. The sample included children (age 8–17) and adults analysed together using the same fixed criterion, and the age groups were not analysed separately. Peak flow and spirometry were done by the same technician in one session, so effort and learning effects may affect both, and the repeatability of PEFR was not assessed. Only salbutamol response was tested, and asthma severity and treatment status were not analysed and may modify the relationship between the two measures. We used the 12% and 200 mL criterion [6] rather than the predicted-value-based definition of the current ERS/ATS standard [7]. Finally, only patients with confirmed asthma were studied, so the findings concern agreement of bronchodilator response and not the use of PEFR to distinguish asthma from other conditions. Larger multicentre studies with a prespecified threshold, including absolute as well as relative PEFR changes, stratified by age group and severity and using current ERS/ATS definitions, are needed.

CONCLUSION

Both PEFR and FEV_1 increased significantly after bronchodilator in 120 patients with asthma, but PEFR reversibility correlated weakly with FEV_1 reversibility and was a poor detector of a significant FEV_1 response. PEFR is useful for monitoring but should not replace spirometry for bronchodilator reversibility testing. Larger studies with a prespecified PEFR threshold are needed.

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