

Evaluation of FEV1/FVC Ratio and FEF25-75% Among Patients Performing Spirometry in a Tertiary Care Centre: A Descriptive Cross-Sectional Study

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Abstract

Introduction: Chronic obstructive pulmonary disease is a major health burden in developing countries such as Nepal. Though spirometry has been used as essential tool in diagnosing the disease, the early identification of involvement of small airway obstruction still remains a significant clinical challenge. So, this study therefore aimed to evaluate spirometry parameters, specifically FEV1/FVC ratio and FEF25–75%, and to explore their clinical implications.

Methods: Patients who attended the Pulmonary Function Test (PFT) outpatient department at Western Regional Hospital, Pokhara, from September 2025 to December 2025 were enrolled in this study. Ethical approval was obtained from the Institutional Review Committee of Pokhara Academy of Health Sciences. Forced vital capacity (FVC) and related parameters were measured and recorded according to American Thoracic Society/European Respiratory Society guidelines, fulfilling both acceptability and repeatability criteria.

Results: Of 370 participants, 149 (40.27%) had a decreased FEV1/FVC ratio and 159 (42.16%) had a decreased FEF25–75%. Both FEV1/FVC and FEF25–75% tended to be lower in older age groups than younger age groups ($p < 0.001$). Among those with a normal FEV1/FVC ratio (≥ 0.70), 10.50% showed a decreased FEF25–75% ($p < 0.001$).

Conclusions: The findings indicate that a decreased FEV1/FVC ratio is usually accompanied by a low FEF25–75%, and a normal FEV1/FVC ratio is usually accompanied by a normal FEF25–75%; however, 10.50% of individuals with a normal FEV1/FVC had a decreased FEF25–75%. A reduced mid expiratory flow (FEF25–75%) despite a preserved FEV1/FVC ratio suggests early or isolated small airways dysfunction.

Keywords: pulmonary function test; small airway obstruction; FEF25-75%.

Introduction

Traditionally, the primary focus of spirometry evaluation has been on measurements such as forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and their ratio (FEV1/FVC). FEV1/FVC ratio of less than 0.7 is the gold standard to confirm the diagnosis of COPD,¹ and a decrease in FEV1 as a predictor of COPD development.²

However, recent studies suggest that forced expiratory flow between the 25% and 75% (FEF25-75%), is widely accepted as a measure of small airways (diameter < 2 mm) obstruction,³ which values decrease before FEV1, and could be an indicator of early disease.^{4,5}

Despite advances in pulmonary diagnostics, the early identification of small airway disease remains a significant clinical challenge. As a result, many patients with early-stage airway disease are overlooked entirely. This study primarily aimed to provide a descriptive analysis of spirometric parameters, with particular emphasis on FEF25–75% values and their clinical implications.

Methods

This hospital-based descriptive cross-sectional study using consecutive sampling was conducted in the Pulmonary Function Test (P.F.T.) outpatient department at Western Regional Hospital (WRH) between September 2025 to December 2025. Ethical

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approval was taken from institutional review committee of Pokhara Academy of Health sciences (ref no: 24/082).

Patients who visited the hospital with respiratory complaints such as wheeze, exertional dyspnea, or chronic cough and were referred for PFT were considered eligible. Age ≥ 16 years, presence of respiratory symptoms such as wheezing, exertional dyspnea, or chronic cough, spirometry performance fulfilling the acceptability and repeatability criteria of the ATS/ERS 2022 guidelines⁶ and patients providing written informed consent were included in the study. Age < 16 years, inadequate or poor spirometry performance that did not meet ATS/ERS 2022 acceptability and repeatability criteria, bronchodilator therapy within 6–8 hours prior to testing and patient refusing to provide informed consent were excluded from the study.

Demographic information and spirometry parameters were recorded (using a standard digital spirometer (EasyOne Pro LAB model 2500-2A)) by trained physicians. Before testing, the spirometer was checked and calibrated according to manufacturer and ATS/ERS recommendations. The procedure was explained and demonstrated, and subjects were tested in a comfortable sitting position with a nose clip applied. Each subject performed repeated forced vital capacity manoeuvres until at least three acceptable and reproducible curves were obtained (up to a maximum of eight attempts if necessary). Tests that did not meet acceptability and reproducibility criteria were excluded from the analysis. Highest acceptable values for FEV1 and FVC and other required parameters like FEV1/FVC ratio, FEF25–75% and peak expiratory flow (PEF) also recorded.

FEV1/FVC ratio below 0.70 defined as the cut-off value for airflow obstruction and FEF25–75% was interpreted using individualized predicted values generated by the spirometer software, which applies the Global Lung Function Initiative (GLI) reference equations based on age, sex, height, and, ethnicity (South Asian). The lower limit of normal (LLN) for FEF25–75% was automatically calculated by the device as the fifth percentile (z-score -1.64) of the reference distribution, and values below this LLN were classified as reduced, indicating small-airways impairment.

The sample size was calculated using the formula $n = Z^2 \times p \times (1-p) / d^2$, where n is the required sample size, Z is the standard normal deviate for a 95% confidence level (1.96), p is the prevalence (0.5), and d is the margin of error (0.05).

Substituting these values yielded a minimum required sample size of approximately 384 participants.

$$n = \{1.96^2 \times 0.5 \times (1-0.5)\} / 0.05^2$$

$$n = \{3.8416 \times 0.5 \times 0.5\} / 0.0025$$

$$n = \{3.84 \times 0.25\} / 0.0025$$

$$n = 0.96 / 0.0025$$

$$n \approx 384$$

Out of 384 samples, 14 samples were excluded who do not meet ATS/ERS guideline of acceptability and repeatability criteria, so 370 samples were included for the study.

The data were then entered in a Microsoft Excel sheet and analysed with the help Statistical Package for Social Science (SPSS) version 22.

Results

Table 1: Demographic and anthropometric characteristics of the study population

Characteristic	Value (n=370)
Female, n (%)	219 (59.2)
Male, n (%)	151 (40.8)
Age, years, mean $\pm$ SD	48.8 $\pm$ 18.4
Age range, years	16–83
Height, cm, mean $\pm$ SD	156.0 $\pm$ 8.3
Weight, kg, mean $\pm$ SD	60.0 $\pm$ 10.5
BMI, kg/m ² , mean $\pm$ SD	24.6 $\pm$ 3.8

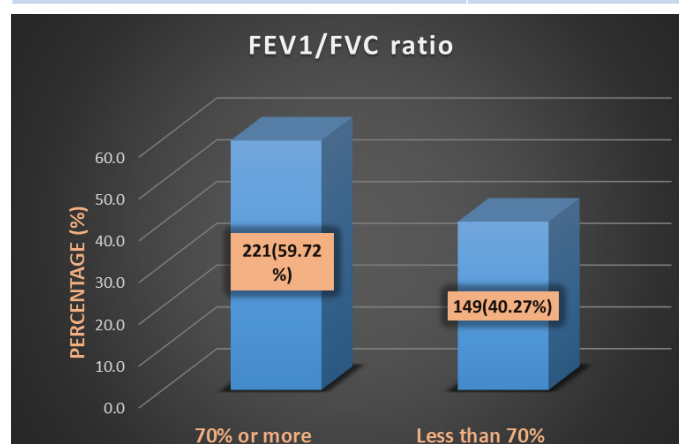


Fig 1: Distribution of participants according to FEV1/FVC ratio

FEV1/FVC ratio: Out of 370 participants, 221 (59.72%) have FEV1/FVC ratio more than 0.7, which according to GOLD's criteria were considered as normal and 149 (40.27%) have less than 0.7, which was considered to have obstructive lung disease. (Fig:1) While comparing with sex it was found that 41.72% of male and 39.26% of female has FEV1/FVC ratio less than 0.7, which shows the prevalence of obstructive lung disease on the basis of sex is statistically insignificant ($p = 0.38$). (Table 1)

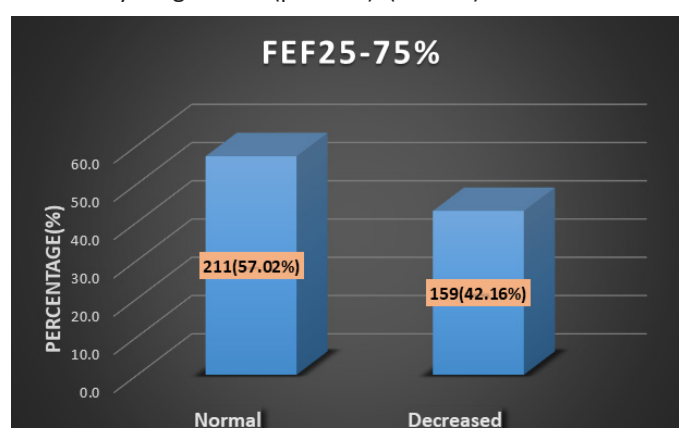


Fig 2: Distribution of participants according to FEF25-75%

FEF25-75%: Similarly, while looking at the mid expiratory flow rate i.e. FEF25-75%, Lower limit of Normal (LLN) for every individual was taken as cut off value. If the result was less than LLN then it is considered to have small airway obstruction and otherwise normal. In our study, almost 211 (57.02%) individuals were found to have FEF25-75% more than LLN (normal) whereas

159 (42.16%) have less than LLN which suggest of small airway obstruction. (Fig 2)

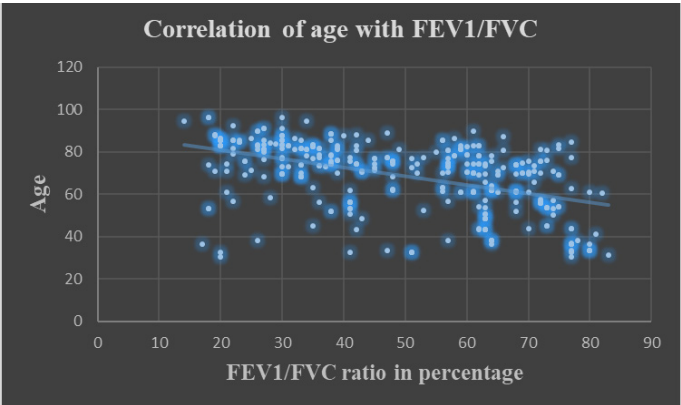


Fig 3: Scatter plot comparing age with FEV1/FVC ratio

The scatter plot illustrates the relationship between age (x-axis) and FEV₁/FVC ratio (y-axis) across a sample population. Each blue dot represents an individual data point, plotting their age against their corresponding FEV₁/FVC value. There is a general downward trend in FEV₁/FVC ratios with increasing age, indicating a negative correlation between age and pulmonary function. As age increases, the FEV₁/FVC ratio tends to decline, reflecting a higher likelihood of obstructive ventilatory patterns in older individuals.

Table 2: FEV1/FVC ratio and FEF25-75% in comparison with sex and age group.

Sex	FEV1/FVC ratio (N)		P value	FEF25-75% (N)		P value
	Normal (>0.7) N (%)	Obstructive (<0.7) N (%)		Normal (>LLN) N (%)	Obstructive (<LLN) N (%)	
Male	88(58.27%)	63(41.72%)	0.38	81(53.64%)	70(46.35%)	0.8
Female	133(60.73%)	86(39.26%)		129(58.90%)	90(41.09%)	
Age- group			P value			P value
Less than 29 years	50(81.96%)	11(18.32%)	0.00	43(70.49%)	18(29.50%)	0.00
30-39 years	59(80.82%)	14(19.17%)		57(78.08%)	16(21.91%)	
40-49 years	29(64.44%)	16(35.55%)		23(51.11%)	22(48.88%)	
50-59 years	26(70.27%)	11(29.72%)		23(62.16%)	14(37.83%)	
60-69 years	31(40.25%)	46(59.74%)		35(45.45%)	42(54.54%)	
More than 70 years	14(24.56%)	43(75.43%)		19(33.33%)	38(66.66%)	

The analysis of FEV₁/FVC ratio across age groups revealed a progressive increase in the prevalence of obstructive patterns with advancing age. Obstruction was observed in 18.32% of participants under 29 years, 19.17% in the 30–39 age group, 35.55% in 40–49, 29.72% in 50–59, 59.74% in 60–69, and 75.43% among those aged 70 years and above. The trend highlights a statistically significant rise in obstructive impairment with age ($p < 0.001$), with individuals aged 60 years and above showing a predominance of obstructive changes.

Similarly, analysis of FEF_{25–75}% values across age groups also revealed a statistically significant association between advancing age and the prevalence of small airway obstruction ($p < 0.001$). The proportion of participants exhibiting obstruction increased progressively with age: 29.50% in those <29 years, 21.91% in the 30–39 age group, 48.88% in 40–49, 37.83% in 50–59, 54.54% in 60–69, and 66.66% among individuals aged ≥70 years. These findings underscore a notable age-dependent rise in small airway impairment, with the highest burden observed in the elderly population.

Table 3: Comparison of FEV1/FVC ratio with FEF25-75% subgroup.

FEV1/FVC ratio	FEF25-75%		P value
	Normal (>LLN) N (%)	Decreased(<LLN) N (%)	
Normal (≥0.7)	187(89.05%)	22(10.50%)	0.00
Decreased (<0.7)	13(9.20%)	128(90.80%)	

The above table showed that participants with a decreased FEV₁/FVC ratio (<0.7) almost always had reduced FEF₂₅₋₇₅% (<LLN) which was found to be 90.80%. Conversely, among those with a normal FEV₁/FVC ratio (≥0.7), 10.50% had decreased FEF₂₅₋₇₅% (<LLN). The association between FEV₁/FVC category and FEF₂₅₋₇₅% was statistically highly significant (<0.001)

Discussion

This study mainly aims to study the descriptive pattern of various spirometric indices on population group who visits P.F.T outpatient department. We focused on FEV₁/FVC ratio to diagnose large airway obstruction and FEF₂₅₋₇₅% as indicator of small airway obstruction. Our objective was to find out the prevalence of population who has decreased FEF₂₅₋₇₅% value despite having normal FEV₁/FVC ratio, to emphasize that FEF₂₅₋₇₅% value can be used as important marker to diagnose small airway obstruction or an early indicator of developing

obstructive airway disease.

Out of 370 participants (48.8±18.4 years), 40.27% have FEV1/FVC ratio <0.7, which suggests signs of obstructive airway disease and about 42.16% had decreased FEF25-75%, which signifies reduced small airway flow. While comparing with sex, our study reveals no any significant changes in spirometric parameters between male and female. 41.72% male and 39.26% female has decreased FEV1/FVC ratio than normal but this result is statistically insignificant (p=0.38). In a longitudinal study done by Chang C-H et.al, they investigated sex specific differences in changes in lung function of 9059 Taiwanese participants, found that the male participants had a faster decrease in FEV1/FVC than the female participants.⁷ Also, Enright et al. reported a greater decrease in maximal inspiratory pressure in male than in female, between the age of 65 and 85 years.⁸ In accordance to our study, Heraganahally SS et. al. in a study done in 485 adults after adjustment in age, body mass index and smoking status, showed no significant difference of FEV1/FVC ratio and FEF25-75% among male and female but found out males displayed significantly higher absolute values of Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV1).⁹

In our study both FEV1/FVC ratio and FEF25-75% decreases significantly (p<0.01) as age increases, suggesting a higher prevalence of both large and small airway obstructive pattern in older individuals when compared to younger age group. Multiple cohorts and cross-sectional studies report progressive decline in spirometric indices with age, including reductions in FEV1/FVC and mid expiratory flows. A study done by Solanki S. et. al. in Rajasthan, India found that FEV1/FVC ratio up to 50 years of age was not much different but later on in 60-86 years age group it was found to be significantly decreased. On analysing the result for FEF25-75% in relation to age also found to be significantly decreased.¹⁰ Similar observations have been made by Jagia GJ¹¹ and Girdla KK¹² which showed P.F.T parameters decline as age progresses.

Systematic reviews and longitudinal cohort studies describe a normal age-dependent fall in FEV1 and FEV1/FVC and emphasize higher prevalence of obstructive patterns in older adults. Our finding of sharply increased obstruction prevalence from the sixth decade onward is consistent with these reports. Advanced age alone impairs pulmonary physiologic function even in the absence of disease. Lung maturation and function peak between 18–25 years of age, remain steady with minimal change up to 35 years of age, and gradually decline thereafter, manifested by progressive loss of alveolar surface area, dilation of air spaces, reduced mucociliary clearance, and changes in elasticity.¹³ Using atomic force microscopy, investigators identified age-related increases in stiffness of parenchymal and vessel compartments,¹⁴ highlighting the changes in biomechanical properties in the aged lung. This is concordant with data showing that the degradation of elastin, a key protein in the lung connective tissue that provides elasticity and resilience, is enhanced with age and in chronic obstructive pulmonary disease (COPD).^{15,16} However, the precise mechanisms that drive this phenotype are unclear.

Our study showed that almost all participants with a low FEV1/FVC (<0.70) also had low FEF25–75% (90.80%, 128/141). However, 10.50% (22/209) of those with a normal FEV1/FVC (≥0.70) had decreased FEF25–75% below the LLN. These

findings indicate that a low FEV1/FVC is usually accompanied by low mid-expiratory flow, and a normal FEV1/FVC is usually accompanied by normal FEF25–75%. But the finding that 10.50% of people with a normal FEV1/FVC nonetheless have decreased FEF25–75% is clinically important because FEF25–75% is thought to reflect flows in the smaller airways. A reduced mid-expiratory flow despite a preserved FEV1/FVC can indicate: early or isolated small-airways dysfunction that has not yet produced a fall in FEV1/FVC or phase of disease where obstruction is subtle and limited to peripheral airways.

In a study done by Yang Y and colleague, they investigated the structural features of patients with decreased FEF25-75% by quantitative computed tomography (QCT), found out no lung parenchyma destruction but potential medium and small airway changes in these patients compared to subjects without decrease maximum mid expiratory flow (MMEF).¹⁷ Nambu et al. concluded that CT images of patients with reduced MMEF showed thicker airway walls,¹⁸ similarly, Qin and colleagues found that CT scan of lumen area in fifth and sixth generation airway was significantly reduced in patients with decreased FEF25-75% compared with healthy controls.¹⁹

Chronic exposure to toxic agents (for example, cigarette smoke, viruses, or bacteria) causes the small airways to remodel and narrow.²⁰ This remodeling results from repeated injury and repair and includes thicker airway walls, more inflammatory cells, fibrosis, and increased smooth muscle. Mucus plugs, common in COPD, also block small airways and worsen airflow. Smoking-driven inflammation often comes before fibrosis and loss of lung tissue.²¹ These processes can produce small-airway dysfunction—and reduced FEF25–75%—before standard measures of lung function become abnormal, potentially identifying subclinical COPD earlier. We speculated that compared to FEV1, FEF25-75% is a better predictor for the development of COPD in the comparison of ROC in patients with normal lung function. We can therefore assume that FEF25-75% can be an earlier marker for COPD than FEV1.²²

Conclusions

In the study of 370 adults found that obstructive ventilatory defect (FEV1/FVC <0.7) was present in 40.27% and small-airway impairment (FEF25–75% < LLN) in 42.16% of participants. Obstructive changes and small-airway impairment increased significantly with age (highest in those ≥60 years), while differences by sex were not significant. Most people who had an abnormal FEV1/FVC also had a low FEF25–75 (90.8%), while 10.50% of those with a normal FEV1/FVC had a low FEF25–75 alone.

Conflict of Interest: None

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