

Assessment Of Spirometry Findings In Smokers And Non-Smokers: A Cross-Sectional Study In Northeast India

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Abstract:

Background: Smoking is a major risk factor for impaired pulmonary function and the development of obstructive airway diseases. Spirometry is a simple, non-invasive, and reliable method for assessing lung function and detecting early airway abnormalities.

Objectives: 1. To compare spirometry findings among smokers and non-smokers. 2. To assess the relationship between smoking index and spirometry findings.

Materials and Methods: A cross-sectional study was conducted among 50 participants, including 25 smokers and 25 non-smokers between the age group of 18-50 years, from the premises of AGMC & GBP Hospital. Demographic variables were recorded, and pulmonary function tests were performed using spirometry. Parameters assessed included FVC, FEV₁, FEV₁/FVC ratio, expiratory flow rates (FEV_{25%}, FEV_{50%}, FEV_{70%}), PEFr, and MVV. Smoking exposure was quantified using smoking index and duration. Data were recorded in a predesigned case study format and analysed using SPSS 21. A p-value <0.05 was considered significant.

Results: The study included 25 smokers and 25 non-smokers. There was no significant difference in age, height, and weight between smokers and non-smokers. Smokers showed significantly reduced spirometric parameters including FEV₁, FEV₁/FVC ratio, FEF_{25%}, FEF_{50%}, FEF_{75%}, and PEFr compared to non-smokers ($p < 0.01$), indicating an obstructive pattern of lung impairment. FVC and MVV showed no significant difference. A negative correlation was observed between smoking index and spirometry parameters.

Conclusion: Smoking is associated with a significant impairment of spirometry parameters, particularly those reflecting airway obstruction. The decline shows a dose-dependent relationship with smoking exposure, highlighting the importance of early screening.

Keywords: Smoking, Peak Expiratory Flow Rate, Spirometry, Smoking Index, Pulmonary Function.

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I. Introduction

Smoking is a well-established global health hazard and a leading cause of preventable morbidity and mortality. It significantly contributes to the development of chronic respiratory diseases, including chronic obstructive pulmonary disease (COPD), chronic bronchitis, and emphysema. According to the World Health Organization, tobacco smoking is responsible for more than 8 million deaths annually worldwide, with a substantial proportion attributed to respiratory illnesses.¹

Cigarette smoke contains numerous toxic chemicals and free radicals that induce airway inflammation, oxidative stress, and structural damage to lung parenchyma. These changes result in narrowing of airways, loss of elastic recoil, and impaired mucociliary clearance, ultimately leading to airflow limitation.² The severity of pulmonary impairment is directly related to the duration and intensity of smoking exposure, often quantified using indices such as the smoking index or pack-years.³

Spirometry is a simple, non-invasive, and reliable tool for the assessment of pulmonary function and is widely used for early detection of airway obstruction. Key spirometric parameters such as forced expiratory volume in one second (FEV₁), forced vital capacity (FVC), and the FEV₁/FVC ratio are essential for diagnosing and grading obstructive airway diseases.⁴ In addition, parameters like peak expiratory flow rate (PEFR) and forced expiratory flow rates (FEF_{25-75%}) are sensitive indicators of small airway involvement and early functional changes.⁵

Several studies have demonstrated that smokers exhibit a significant decline in spirometric indices compared to non-smokers, even before the onset of clinical symptoms. Early identification of such changes is crucial for timely intervention and prevention of disease progression. Furthermore, understanding the relationship between smoking exposure and pulmonary function parameters can help reinforce public health measures and smoking cessation strategies.

Therefore, the present study aims to compare spirometric parameters between smokers and non-smokers and to evaluate the correlation between smoking index and pulmonary function, thereby contributing to the growing evidence on the impact of smoking on respiratory health.

II. Aims & Objectives

1. To compare spirometry findings among smokers and non-smokers.
2. To assess the relationship between smoking index and spirometry findings

III. Materials And Method

Study type: Observational study

Study design: Analytical cross-sectional study

Study duration: Three months

Study area / location: Department of Physiology, Agartala Govt. Medical College (AGMC) & GBPH

Study population: Healthy smokers and non-smokers between the age group of 18-50 years from the premises of AGMC & GBPH Hospital.

Inclusion criteria for participants:

1. Healthy smokers between the age group of 18-50 years
2. Healthy adults between the age group of 18-50 years without smoking habit.

Exclusion criteria for cases:

1. Participants who were not willing to participate were excluded
2. Patients having pneumonia, malignancy, tuberculosis or bronchiectasis on CXR
3. Known patients of bronchial asthma, COPD, ABPA, IHD, Obesity or any other respiratory condition.
4. Industrial worker working in coal or asbestos factory or any other industrial dust Exposure.
5. Patients with contra-indication to spirometry.
6. Recent thoracic-abdominal surgery
7. Recent ophthalmic surgery
8. Thoracic or abdominal aneurysm

Sampling procedure: This cross-sectional study was conducted using a convenience sampling technique. All eligible participants who fulfilled the inclusion and exclusion criteria during the three-month study period were consecutively recruited.

Study Tools

Anthropometric and pulmonary function measurements were obtained using standardized instruments:

- Stadiometer (Bio Plus) for height measurement (range: up to 200 cm)
- Weighing machine (Equinox EQ-BR-9201) with a maximum capacity of 130 kg
- Spirometer for assessment of pulmonary function parameters

Assessment of Smoking Exposure: Smoking exposure was quantified using the **Smoking Index**, calculated as: $\text{Smoking Index} = \text{Number of cigarettes smoked per day} \times \text{Duration of smoking (years)}^6$

Based on the smoking index, participants were categorized as:

- Non-smokers: 0
- Mild smokers: 1–100
- Moderate smokers: 101–200
- Heavy smokers: >200

Study Procedure: Participants were enrolled consecutively after obtaining written informed consent. A detailed history including age, sex, occupation, socioeconomic status, educational status, and medical history was recorded using a predesigned and pretested questionnaire.

Anthropometric measurements were recorded as follows:

1. **Age:** Recorded in completed years

- 2. **Height:** Measured barefoot to the nearest 0.1 cm; two readings were taken and averaged
- 3. **Weight:** Measured to the nearest 0.1 kg with minimal clothing; the average of two readings was recorded

Measurement of Spirometry: Spirometry was performed in all subjects using a standardized spirometer in accordance with the guidelines of the American Thoracic Society and the European Respiratory Society. The procedure was explained to each participant, and they were instructed to perform maximal inspiration followed by a forceful and rapid expiration into the mouthpiece. At least three acceptable and reproducible manoeuvres were recorded for each subject, and the best values were selected for analysis.

The spirometric parameters assessed included Forced Vital Capacity (FVC), Forced Expiratory Volume in the first second (FEV₁), and the FEV₁/FVC ratio, which are essential indicators of pulmonary function. In addition, Peak Expiratory Flow Rate (PEFR) was measured to assess the maximum flow achieved during forced expiration. Mid-expiratory flow rates, including Forced Expiratory Flow at 25%, 50%, and 75% of lung volume (FEF25%, FEF50%, and FEF75%), were recorded to evaluate small airway function. Maximum Voluntary Ventilation (MVV) was also assessed as an indicator of overall ventilatory capacity.

All tests were performed with the subject in a seated position, using a nose clip to prevent air leakage. Adequate rest was provided between manoeuvres to avoid fatigue. The results were expressed in absolute values and interpreted according to predicted normal values.⁷

Data Analysis: Data were analysed using SPSS version 21. Quantitative variables such as age, height, weight, and PEFR were expressed as mean and standard deviation. Qualitative variables were expressed as proportions. Statistical significance was determined using appropriate tests, with a p-value <0.05 considered statistically significant.

IV. Results

A total of 50 participants were included in the study, comprising 25 smokers and 25 non-smokers. The demographic variables of the study participants are presented in Table 1. The mean age of non-smokers was 33.16 ± 8.34 years, while that of smokers was 34.20 ± 7.93 years, with no statistically significant difference (p = 0.654). Similarly, there was no significant difference in height (169.92 ± 2.31 cm vs 170.56 ± 2.06 cm; p = 0.306) and weight (63.4 ± 6.77 kg vs 64.04 ± 6.62 kg; p = 0.675) between the two groups.

The spirometric parameters among smokers and non-smokers are summarized in Table 2. The mean Forced Expiratory Volume in 1 second (FEV₁) was significantly lower in smokers (2.17 ± 0.23 L) compared to non-smokers (2.77 ± 0.56 L) (p < 0.001). The FEV₁/FVC ratio was also significantly reduced in smokers (73.92 ± 3.35%) compared to non-smokers (90.78 ± 5.60%) (p < 0.001), indicating an obstructive pattern of lung function impairment.

Mid-expiratory flow rates were significantly decreased in smokers, with reductions observed in FEF25% (p = 0.002), FEF50% (p < 0.001), and FEF75% (p < 0.001). Peak Expiratory Flow Rate (PEFR) was also significantly lower in smokers (5.26 ± 0.44 L/sec) compared to non-smokers (6.64 ± 1.94 L/sec) (p < 0.001). However, no statistically significant difference was observed in Forced Vital Capacity (FVC) (p = 0.318) and Maximum Voluntary Ventilation (MVV) (p = 0.126) between the two groups.

Among smokers, the mean number of cigarettes smoked per day was 13.16 ± 4.94, and the mean duration of smoking was 13.68 ± 5.15 years. The mean smoking index was 203.20 ± 140.96 as mentioned in Table 3. The distribution of smokers revealed that 32% were mild smokers, 20% were moderate smokers, and 48% were heavy smokers as shown in Figure 1.

Figure 2 shows a negative correlation between smoking index and PEFR, indicating that an increase in smoking exposure is associated with a decline in expiratory flow rate. Figure 3 demonstrates a significantly lower FEV₁/FVC ratio in smokers compared to non-smokers, suggesting an obstructive pattern of lung impairment. Figure 4 illustrates reduced mid-expiratory flow rates (FEF25%, FEF50%, and FEF75%) in smokers compared to non-smokers, indicating small airway involvement. Figure 5 shows a negative correlation between smoking index and FEV₁, indicating progressive decline in lung function with increasing smoking exposure. Figure 6 demonstrates a negative correlation between duration of smoking and PEFR, suggesting that prolonged smoking leads to worsening pulmonary function.

Table 1: Demographic variables of the participants

variables	Non- smokers	Smokers	P value
AGE (years)	33.16 ±8.34	34.20 ±7.93	0.654
Height (cm)	169.92±2.31	170.56±2.06	0.306
Weight (kg)	63.4 ±6.77	64.04 ±6.62	0.675

Table 2: Spirometry parameters among Smokers and non- smokers.

Variables	Non smokers	Smokers	P value
FVC	3.06 ±0.61	2.93 ±0.19	0.318
FEV1	2.77 ±0.56	2.17 ±0.23	0.000*
FEV1/FVC	90.78 ±5.60	73.92 ±3.35	0.000*
FEF25%	6.27 ±1.77	4.23 ±0.35	0.002*
FEF50%	4.70 ±1.51	3.12 ±0.28	0.000*
FEF75%	2.53 ±1.28	1.14 ±0.20	0.000*
PEFR	6.64 ±1.94	5.26 ±0.44	0.000*
MVV	96.25 ±19.27	90 ±4.55	0.126

Table 3: Smoking Characteristics of the Study Participants (Smokers)

Variables	Mean	Std. Deviation
Cigarettes / Day	13.16	±4.94
Duration	13.68	±5.15
Smoking Index	203.20	±140.96

Figure 1: Smoking Index among Smokers

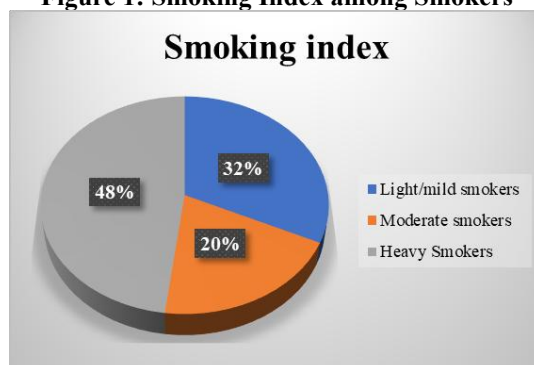


Figure 2: Correlation between PEFR and Smoking index

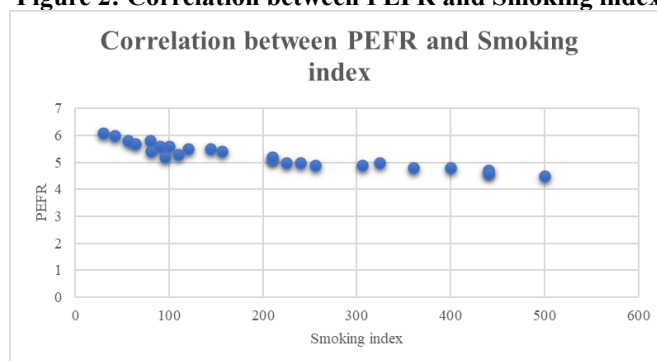


Figure 3: Comparison between non-smokers & smokers FEV1/FVC

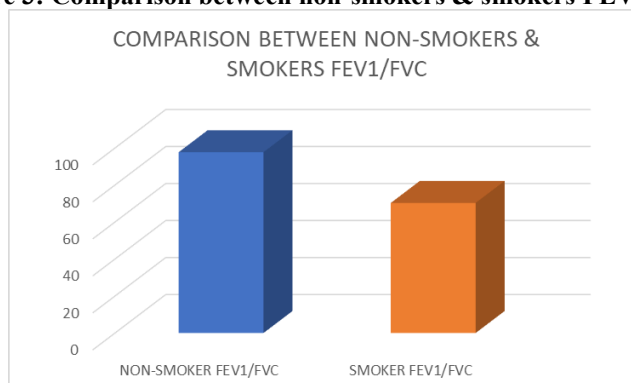


Figure 4: Comparison of Mid-Expiratory Flow Rates (FEF25%, FEF50%, FEF75%)

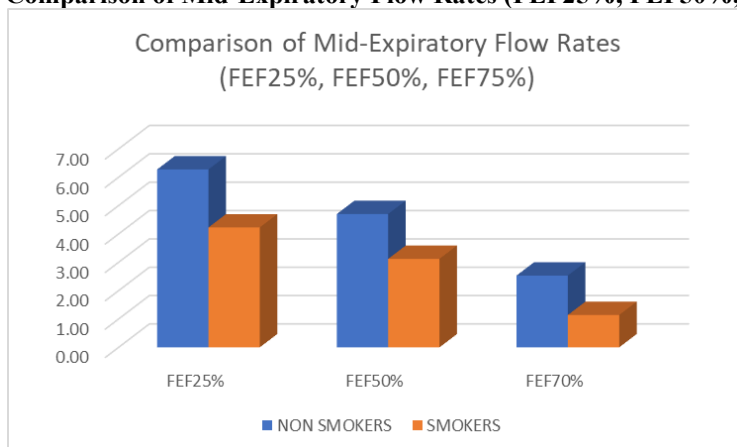


Figure 5: Comparison of Smoking Index & FEV1

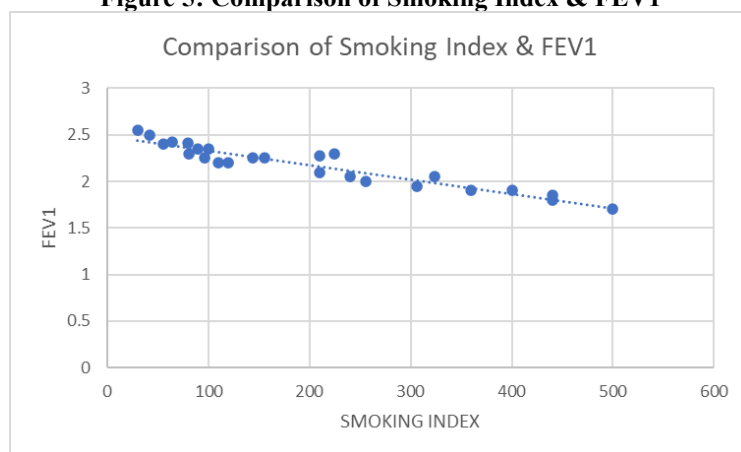
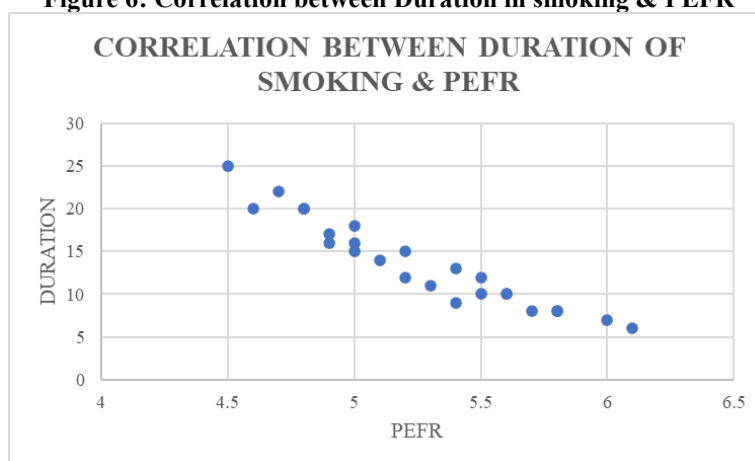


Figure 6: Correlation between Duration in smoking & PEFR



V. Discussion

The present study demonstrates a significant impairment in pulmonary function among smokers compared to non-smokers, with findings strongly suggestive of an obstructive pattern of lung involvement. Since there were no statistically significant differences in demographic variables such as age, height, and weight between the two groups, the observed alterations in spirometric parameters can be primarily attributed to the effects of smoking.

A significant reduction in FEV₁ and FEV₁/FVC ratio was observed among smokers, indicating airflow limitation. This is consistent with the findings of Anthonisen et al., who reported a progressive decline in expiratory airflow due to chronic exposure to cigarette smoke.⁸ The reduction in FEV₁ reflects increased airway

resistance, while a decreased FEV₁/FVC ratio is a classical indicator of obstructive lung disease. The concept of accelerated decline in lung function among smokers has been well established by Fletcher and Peto, who demonstrated that smoking significantly hastens the natural decline in pulmonary function.⁹

In addition to these parameters, mid-expiratory flow rates (FEF_{25%}, FEF_{50%}, and FEF_{75%}) were significantly reduced in smokers, suggesting early involvement of small airways. These parameters are considered sensitive indicators of peripheral airway function and are often affected earlier than conventional spirometric indices. Similar findings have been reported in studies by Tiwari and Sharma and Kumar et al., which showed a significant reduction in these parameters even among asymptomatic smokers, highlighting early small airway disease.^{10,11}

Peak Expiratory Flow Rate (PEFR) was also found to be significantly reduced in smokers. This decrease reflects increased airway resistance and reduced expiratory flow, likely due to airway narrowing, inflammation, and loss of elastic recoil associated with chronic exposure to cigarette smoke. Gupta et al. also reported similar findings, reinforcing the impact of smoking on expiratory flow dynamics.⁶

In contrast, no significant difference was observed in FVC and MVV between smokers and non-smokers. This suggests that lung volumes may remain relatively preserved in the early stages of smoking-induced lung damage, while airflow parameters are affected earlier. Similar observations have been documented by Pauwels et al., where FVC remained within normal limits despite significant reductions in airflow indices.³

The present study also demonstrated a negative correlation between smoking index and spirometric parameters such as FEV₁ and PEFR, indicating a dose–response relationship. This finding aligns with previous studies, including that of Anthonisen et al., which established that the rate of decline in lung function is directly proportional to smoking intensity and duration. Thus, the smoking index serves as a useful indicator of cumulative exposure.⁸

Furthermore, a negative correlation between duration of smoking and PEFR highlights the progressive nature of smoking-induced airway damage. Chronic exposure leads to persistent inflammation, oxidative stress, and structural remodelling of airways, ultimately resulting in airflow limitation. Salvi and Barnes emphasized the role of these mechanisms in the pathogenesis of chronic obstructive pulmonary disease.¹²

The findings of this study are also consistent with Indian studies such as those by Jindal et al. and Vyas et al., which reported reduced pulmonary function and increased respiratory morbidity among smokers. These observations underscore the growing burden of smoking-related respiratory diseases in developing countries.^{13,14}

Overall, the present study reinforces the evidence that smoking significantly impairs pulmonary function, particularly affecting airflow and small airway parameters. Early detection through spirometry is essential, as many smokers remain asymptomatic until significant lung damage has occurred. This highlights the need for routine pulmonary screening and effective smoking cessation interventions.

VI. Conclusion

Smoking is associated with significant impairment of spirometry parameters, particularly those reflecting airflow limitation. The observed dose–response relationship between smoking index and spirometric decline highlights the importance of early screening and smoking cessation strategies.

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