Section: Respiratory Medicine

Original Research Article

TO DETERMINE THE EFFECT OF SMOKING INDEX ON PEAK EXPIRATORY FLOW RATE AMONG SMOKERS, NON- SMOKERS AND EX- SMOKERS AND THEIR NICOTINE DEPENDENCE

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ABSTRACT

Background: Tobacco smoking is a leading cause of preventable respiratory impairment. Peak Expiratory Flow Rate (PEFR) provides a simple measure of large airway function, while Smoking Index (SI) quantifies cumulative tobacco exposure. Nicotine dependence, assessed by the Fagerström Test for Nicotine Dependence (FTND), may further affect lung function. This study evaluated PEFR across non-smokers, current smokers, and ex-smokers, and examined its relationship with smoking intensity and nicotine dependence. **Materials and Methods:** In this cross-sectional study, 240 participants (80 per group, aged 25–50 years) were recruited from Shri B. M. Patil Medical College Hospital, Karnataka. PEFR was measured using a Mini-Wright Peak Flow Meter. Smoking Index was calculated for current and ex-smokers, and FTND was administered to current smokers. Data analysis employed one-way ANOVA, independent t-tests, and Pearson correlation, with $p < 0.05$ considered significant. **Result:** Mean PEFR was highest in non-smokers (366.06 ± 60.00 L/min), intermediate in ex-smokers (346.43 ± 57.10 L/min), and lowest in current smokers (315.43 ± 50.15 L/min; $F = 16.678$, $p < 0.001$). Current smokers had a higher mean Smoking Index (396.08 ± 164.41) than ex-smokers (263.31 ± 104.21; $p < 0.0001$). Weak but significant negative correlations were observed between PEFR and Smoking Index ($r = –0.175$, $p = 0.027$) and PEFR and FTND ($r = –0.234$, $p = 0.003$). **Conclusion:** Smoking significantly reduces PEFR, with current smokers most affected and ex-smokers showing partial recovery. Higher cumulative exposure and nicotine dependence are associated with impaired lung function, highlighting the importance of cessation and addiction management.

INTRODUCTION

Tobacco smoking continues to be a major contributor to preventable diseases and mortality worldwide. The adverse effects of smoking on the respiratory system are well-documented, particularly the progressive decline in lung function.[1] One of the simplest and most accessible methods of evaluating pulmonary function is the Peak Expiratory Flow Rate (PEFR), which reflects the maximum speed of expiration and is useful in detecting large airway obstruction.[2]

The Smoking Index (SI) is a quantitative measure of smoking exposure and is calculated as the number of cigarettes smoked per day multiplied by the number of years the person has smoked. It serves as a proxy for the cumulative burden of smoking on the lungs.[3]

Additionally, nicotine dependence, which can be assessed using standardized tools like the Fagerström Test for Nicotine Dependence (FTND), plays a key role in smoking behavior, the severity of addiction, and the difficulty in quitting.[4]

This study aims to compare PEFR among three defined groups—non-smokers, current smokers, and ex-smokers, and to examine the relationship of PEFR with smoking index and nicotine dependence.

Definitions[5]

- **Non-smokers:** Individuals who have never smoked tobacco in any form or have smoked less than 100 cigarettes in their lifetime and have not smoked in the past year.
- **Current smokers:** Individuals who are currently smoking cigarettes (daily or occasionally) and

have smoked at least 100 cigarettes in their lifetime.

- **Ex-smokers:** Individuals who previously smoked regularly (≥100 cigarettes in lifetime) but have quit smoking for at least the past 6 months.

Aims and Objectives

Aim:

To evaluate the effect of smoking index on Peak Expiratory Flow Rate (PEFR) among smokers, ex-smokers, and non-smokers and assess their level of nicotine dependence.

Objectives

- To measure and compare PEFR values among non-smokers, current smokers, and ex-smokers.
- To calculate the smoking index for current and ex-smokers.
- To assess nicotine dependence using the Fagerström Test for Nicotine Dependence (FTND) among current smokers.
- To determine the correlation between smoking index and PEFR.

MATERIALS AND METHODS

Study Design: This was an observational cross-sectional study.

Study Setting: The study was conducted at Shri B. M. Patil Medical College Hospital and Research Centre, Vijayapura, Karnataka.

Study Duration: The study was carried out over a period of 6 months.

Sample Size: With an anticipated proportion of PEFR among smokers of 84% and among non-smokers of 60%,6 the study required a sample size of 80 participants per group (i.e., a total of 240 participants, assuming equal group sizes) to achieve a power of 90% for detecting a difference in proportions between the three groups at a two-sided p-value of 0.05.

The formula used for sample size calculation was:

$$n = \frac{(z_{\alpha}+z_{\beta})^2 \, 2 \, p*q}{MD^2}$$

Where Z= Z statistic at a level of significance

MD= Anticipated difference between two proportions

P=Common Proportion

q= 100-p

Inclusion Criteria

- Age from 25 to 50 years
- Individuals willing to participate and provide informed consent
- Participants who could be clearly categorized into one of the three groups based on smoking history

Exclusion Criteria

- Known history of chronic pulmonary diseases (e.g., asthma, COPD, ILD)
- Active respiratory infection within the past 2 weeks
- History of significant occupational exposure (e.g., dust, asbestos)
- Individuals unable to perform PEFR reliably
- Passive smokers

Tools and Instruments

- Peak Flow Meter: Used to measure Peak Expiratory Flow Rate (PEFR)
- Fagerström Test for Nicotine Dependence (FTND): Used to assess nicotine addiction in current.
- Smoking Index Formula:

Smoking Index (SI)=Number of cigarettes smoked per day×Number of years smoked

Procedure

Participants were recruited from the general population and from hospital visitors. After obtaining informed consent, they were categorized into groups based on their smoking history.

Data Collection:

- Demographic details such as age, sex, height, and weight were recorded.
- Smoking history was documented for smokers and ex-smokers, including number of cigarettes smoked per day, years of smoking, and years since quitting (if applicable).
- Smoking Index was calculated for current and ex-smokers.
- The Fagerström Test for Nicotine Dependence (FTND) was administered only to current smokers to assess their present level of nicotine dependence. Ex-smokers were excluded from FTND scoring, as the test applies only to current smoking behavior.

PEFR Measurement: Peak Expiratory Flow Rate (PEFR) was measured using a standardized Mini-Wright Peak Flow Meter in all participants. Each subject was instructed to take a deep breath and exhale as forcefully as possible into the device while in a standing position. Three readings were recorded, and the highest value was taken as the final PEFR for analysis.

The obtained PEFR values were then compared with standard reference values adjusted for height, as shown in the following table,[6] to assess relative deviation from expected pulmonary function. These normal reference values were derived from population-based standards and reflect the expected PEFR (in L/min) corresponding to different heights.[6]

Height (cm)	Expected PEFR (L/min)
120	215
130	160
140	300
150	350
160	400
170	450
180	500

The mean expected PEFR value across all height categories was approximately 380 ± 100 L/min, consistent with previously published reference standards.6 These values were used to interpret the participants' PEFR as normal or reduced based on their height-adjusted expected levels.

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Data Analysis: Data were entered into a Microsoft Excel sheet and analyzed using the Statistical Package for the Social Sciences (SPSS) software (Version 20). Descriptive statistics such as mean and standard deviation were calculated, and results were presented as Mean ± SD, counts, percentages, and graphical diagrams. For continuous variables following a normal distribution, comparisons between the three groups were made using one-way ANOVA. For non-normally distributed variables, the Kruskal–Wallis test was applied. Categorical variables were compared using the Chi-square test. Pearson correlation was used to assess the relationship between Smoking Index and PEFR, and between FTND scores and PEFR. A p-value < 0.05 was considered statistically significant, and all tests were two-tailed.

RESULTS

The study included 240 participants, equally divided into three groups: non-smokers, current smokers, and ex-smokers (n = 80 each). The age distribution was comparable across groups, suggesting minimal age-related confounding in PEFR comparisons as shown in [Table 1]. The mean age of participants was comparable across groups, with non-smokers having a mean age of 37.91 ± 7.19 years, current smokers 38.76 ± 7.09 years, and ex-smokers 38.50 ± 7.15 years. Peak Expiratory Flow Rate (PEFR) values were highest among non-smokers (366.06 ± 60.00 L/min), followed by ex-smokers (346.43 ± 57.10 L/min), and lowest in current smokers (315.43 ± 50.15 L/min). The mean Smoking Index was 396.08 ± 164.41 among current smokers and 263.31 ± 104.21 among ex-smokers, reflecting higher cumulative tobacco exposure in current smokers. Nicotine dependence, assessed using the Fagerström Test for Nicotine Dependence (FTND), was 5.86 ± 1.62 in current smokers; FTND was not applicable to ex-smokers and non-smokers. The group wise descriptive statistics are depicted in [Table 2].

Table 1: Age distribution by Group

Age band (years)	Non-smokers	Current Smokers	Ex-smokers
25–29	12	10	11
30–34	15	14	14
35–39	17	16	16
40–44	18	19	19
45–50	18	21	20
Total	80	80	80

Table 2: Descriptive Statistics by Group

Variable	Non-smokers (n = 80)	Current Smokers (n = 80)	Ex-smokers (n = 80)
Age (years), mean ± SD	37.91 ± 7.19	38.76 ± 7.09	38.50 ± 7.15
PEFR (L/min), mean ± SD	366.06 ± 60.00	315.43 ± 50.15	346.43 ± 57.10
Smoking Index, mean ± SD	-	396.08 ± 164.41	263.31 ± 104.21
FTND score, mean ± SD	-	5.86 1.62	-

Table 3: PEFR Comparison Among Groups (One way ANOVA)

Group	PEFR (L/min), mean ± SD	F	P
Non-smokers	366.06 ± 60.00	16.678	<0.001
Current Smokers	315.43 ± 50.15		
Ex-smokers	346.43 57.10		

Table 4: Smoking Index Comparison Among Groups (Independent t-test)

Group	PEFR (L/min), mean ± SD	P
Current Smokers	396.08 ± 164.41	<0.0001
Ex-smokers	263.31 ± 104.21	

Table 5: Correlation Analysis

Parameter Pair	Pearson r	p-value	Interpretation
Smoking Index vs PEFR	-0.175	0.0269	Weak negative correlation, statistically significant
FTND Score vs PEFR	–0.234	0.0029	Weak-to-moderate negative correlation, statistically significant

Comparison of PEFR across the three groups using one-way ANOVA revealed a significant difference (F = 16.678, p < 0.001) [Table 3]. Non-smokers had the highest mean PEFR (366.06 ± 60.00 L/min), ex-smokers had intermediate values (346.43 ± 57.10 L/min), and current smokers had the lowest PEFR (315.43 ± 50.15 L/min). Post-hoc analysis indicated that PEFR was significantly reduced in current smokers compared to both ex-smokers and non-smokers, while ex-smokers also had significantly lower PEFR than non-smokers. This suggests that smoking is associated with measurable impairment in large airway function, with partial improvement after cessation.

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Current smokers exhibited a significantly higher cumulative smoking exposure than ex-smokers, with a mean Smoking Index of 396.08 ± 164.41 compared to 263.31 ± 104.21 in ex-smokers ($p < 0.0001$, independent t-test), as depicted in [Table 4]. This indicates that participants who continued smoking had a greater lifetime tobacco burden, whereas ex-smokers had reduced exposure due to cessation.
Pearson correlation analyses were performed among smokers and ex-smokers ($n = 160$) to explore relationships between smoking intensity, nicotine dependence, and lung function [Table 5]. There was a weak but statistically significant negative correlation between Smoking Index and PEFR ($r = –0.175$, $p = 0.0269$), indicating that higher cumulative smoking exposure was associated with reduced pulmonary function. Among current smokers, FTND scores also showed a weak-to-moderate negative correlation with PEFR ($r = –0.234$, $p = 0.0029$), suggesting that greater nicotine dependence is associated with lower peak expiratory flow.

DISCUSSION

Our findings revealed a clear gradient in PEFR: non-smokers had the highest values, ex-smokers were intermediate, and current smokers had the lowest, with highly significant differences ($p < 0.0001$). This aligns with previous evidence, including Gregg and Nunn's study of elderly smokers and ex-smokers, which demonstrated significant PEF reductions in current smokers—up to 73.3 L/min in heavy smokers—while ex-smokers of fewer than 20 cigarettes a day showed minimal deficits.[7] Similarly, Tambi Medabala et al. reported lower PEFR in cigarette and cigar smokers compared to nonsmokers, with greater declines noted in heavier users.[8] These parallels affirm the robustness of our results and underscore how smoking consistently impairs expiratory flow.
Our smoking index—quantifying current and ex-smoker exposure—showed significantly higher values in current smokers than ex-smokers. This mirrors literature such as the Indonesian study using the Brinkman Index, which demonstrated a strong negative correlation ($r = –0.721$; $p < 0.001$) between greater cumulative exposure and reduced PEFR.[9] Given the high statistical significance in both our data and theirs, it's clear that cumulative smoking burden remains a pivotal factor in lung function impairment.
Our ex-smokers exhibited intermediate PEFR values—higher than current smokers but lower than non-smokers—indicating partial functional recovery post cessation. Gregg and Nunn observed that ex-smokers who smoked fewer than 20 cigarettes daily showed no significant PEF reduction, while heavy ex-smokers still had deficits.[7] This supports our inference that while some reversal is possible, the extent of prior exposure dictates recovery. It suggests a spectrum where cessation benefits lung function, but residual damage lingers in heavier users.
We found a weak but statistically significant negative correlation between Smoking Index and PEFR ($r = –0.175$, $p = 0.0269$). This indicates that individuals with higher cumulative tobacco exposure tend to have lower PEFR, reflecting impaired lung function. Comparable findings have been reported in other studies, including those by Rubait et al. and Sawant et al,[6,10] where heavier and longer-duration smokers had reduced expiratory flow rates. The weak correlation suggests that factors such as genetics, environmental exposures, and intermittent smoking patterns may also influence PEFR, in addition to the Smoking Index.
Nicotine dependence, assessed using FTND, was moderately high in current smokers (5.86 ± 1.62). Our study showed a negative correlation between FTND scores and PEFR ($r = –0.234$, $p = 0.0029$), indicating that higher nicotine dependence is associated with poorer lung function. Although direct lung function correlations with FTND are rare in literature, the COPDGene study noted that in current smokers, those with high nicotine dependence had lower FEV_1 even when still in normal ranges.[11] This reflects our conceptual finding: greater dependence correlates with sustained smoking behaviors that likely contribute to poorer lung health.

Clinical Implications and Limitations

The study reinforces that PEFR is a simple yet effective measure to detect early lung impairment in smokers. The negative associations between Smoking Index and PEFR, as well as FTND and PEFR, underscore the importance of smoking cessation and interventions targeting nicotine dependence. Limitations include the cross-sectional design, which precludes causal inference, and the potential influence of unmeasured environmental or occupational exposures. Future longitudinal studies should evaluate changes in PEFR over time with smoking cessation and reductions in nicotine dependence.

CONCLUSION

The study demonstrates that smoking significantly reduces Peak Expiratory Flow Rate (PEFR) compared to non-smokers. Current smokers exhibited the lowest PEFR, while ex-smokers showed partial recovery after cessation. Higher cumulative smoking exposure, as measured by the Smoking Index, was associated with lower PEFR. Nicotine dependence, assessed using FTND, also correlated negatively with PEFR in current smokers. These findings highlight the detrimental effects of both smoking intensity and addiction on lung function. Early detection of reduced PEFR can help identify at-risk individuals for targeted interventions. Smoking cessation and reduction of nicotine dependence are crucial to preserve respiratory health. Overall, the study underscores the need for public health strategies to reduce smoking prevalence and its respiratory consequences.

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