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Evaluation of Pulmonary Function Changes in Smokers versus Non-Smokers Using Spirometry

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ABSTRACT

Background: Cigarette smoking is a major preventable cause of morbidity and mortality worldwide, contributing significantly to chronic respiratory diseases. Pulmonary function testing using spirometry provides an objective means of assessing smoking-related airway impairment and detecting early subclinical changes.

Objective: This study aimed to evaluate pulmonary function changes among smokers compared to non-smokers using spirometry in a tertiary care setting in Punjab, Pakistan.

Methods: A Cross-sectional comparison study was conducted at two tertiary care facilities between March 2023 and March 2024. Using purposive sampling, 90 individuals between the ages of 20 and 60 were enrolled, 45 of them were smokers and the remaining 45 were non-smokers. Using a systematic questionnaire, demographic and clinical data, including smoking history, were collected. The American Thoracic Society (ATS) recommendations were followed while doing the spirometry, and the findings were assessed for peak expiratory flow rate (PEFR), forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and FEV1/FVC ratio. The Statistical Package for Social Sciences (SPSS) software version 26 was used to analyze the data. Pearson's correlation test was used to determine the relationship between smoking exposure and spirometric indices, and independent t tests were used for group comparisons.

Results: Smokers demonstrated significantly reduced mean FEV1 (2.29 ± 0.61 L vs. 3.01 ± 0.55 L, $p < 0.001$), lower FEV1/FVC ratios (68.5% ± 7.2 vs. 81.1% ± 6.5, $p < 0.001$), and decreased PEFR (314.6 ± 72.8 L/min vs. 386.2 ± 68.9 L/min, $p < 0.001$) compared to non-smokers. Obstructive patterns were observed in 42.2% of smokers versus 8.9% of non-smokers. Pack-year analysis showed a significant inverse correlation with both FEV1 ($r = –0.41$, $p = 0.004$) and FEV1/FVC ratio ($r = –0.38$, $p = 0.006$).

Conclusion: Smoking is strongly associated with impaired pulmonary function, particularly obstructive airway changes. Spirometry is a valuable tool for early detection, highlighting the need for routine screening and targeted smoking cessation interventions to prevent progressive lung disease.

Keywords: pulmonary function, spirometry, smokers, non-smokers, FEV1, FEV1/FVC

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INTRODUCTION

Smoking is one of the leading causes of preventable death and illness worldwide, with over 1.3 billion people now consuming some form of tobacco [1]. According to the World Health Organization (WHO), smoking cigarettes kills more than 8 million people each year, including more than 1.3 million nonsmokers who are exposed to smokers' second-hand smoke. The prevalence of smoking is rising, particularly among the younger population in low- and middle-income countries such as Pakistan, adding to the burden of cardiovascular and respiratory disorders [2,3].

The lungs are one of the key organs damaged by smoke from cigarettes. Tar, nicotine, carbon monoxide, and reactive oxygen species (ROS) are only a few of the hundreds of chemical compounds found in inhaled tobacco smoke that cause airway inflammation, oxidative stress, and gradual tissue damage to the lung structure [4]. Long-term exposure to these toxins causes airway constriction, increased mucus formation, inadequate mucus clearance by cilia, and loss of elastic rebound of the lungs. These pathological alterations are the underlying cause of smoking-related lung illnesses such as emphysema, chronic bronchitis, and chronic obstructive pulmonary disease. Crucially, this loss in lung function may occur years before the disease is clinically noticeable, therefore early identification is critical [5,6].

Spirometry is the most widely used and standardized pulmonary function test, having been authorized by the European Respiratory Society (ERS) and the American Thoracic Society. It provides quantitative evaluations of lung volumes and airflow, particularly in the form of peak expiratory flow rate (PEFR), forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and FEV1/FVC ratio [7]. Such indicators are critical for detecting airflow limitation, distinguishing between restrictive and obstructive pulmonary patterns, and monitoring the disease's progression. Because spirometry may detect early limitation of airflow in asymptomatic individuals, it is particularly valuable in examining the impact of smoking on function [8,9].

Numerous studies have shown that smokers have early onset obstructive airway changes, as seen by considerably lower FEV1 and FEV1/FVC values than nonsmokers. The years of smoking (pack-years) and the intensity of smoking (the average number of cigarettes smoked per day) are frequently associated with the degree of impairment [10]. Non-smokers on the other hand tend to have normal lung function unless confounded with environmental exposures or pre-existing disorders. Despite a high prevalence of tobacco use and increased incidence of respiratory disease due to smoking, there are a significant number of data lacking in the Pakistani population directly comparing change in pulmonary function among smokers and non-smokers using spirometry [11].

The aim of this study was to use spirometry to compare and analyze the change in the lung functioning of smokers and nonsmokers. The study objective is to present the extent of functional impairment at early stages of exposure to tobacco by quantifying impairment and assessed the relationship between smoking-history and spirometric indices. These results will add to the local evidence base [12] which highlights the usefulness of spirometry as a screening tool for the early diagnosis of smoking-induced pulmonary damage.

MATERIALS AND METHODS

The purpose of this cross-sectional comparative study was to calculate the change in pulmonary function in smoker and nonsmoker by spirometry. It was carried out from March 2023 to March 2024 in 2 tertiary care centers in the province of Punjab, Pakistan. Non-probability purposive sampling technique was used and 90 participants were collected and divided equally into two groups (45 smokers and 45 non-smokers). All participants were adults aged 20 through 60 years of age.

Participants that had smoked for at least five years were included. Smoking exposure of the smokers was determined in pack-years. Nonsmokers were individuals who had never smoked in the past, and were exposed to the minimum amount of secondhand smoke. Subjects were excluded if they had a history of respiratory disease including tuberculosis, pulmonary fibrosis, asthma or chronic obstructive pulmonary disease. In addition, history of respiratory tract infections within four weeks, occupational exposure to dust or chemicals and cardiovascular and neuromuscular problems which may adversely affect performance during spirometry testing were also excluded.

Both participating centers' Institutional Review Boards (IRBs) authorized the trial, and each participant gave their written informed permission before being included in the study. A standard questionnaire was used to collect clinical and demographic data, such as age, gender, height, weight, and body mass index (BMI), as well as smoking history (duration, intensity, and pack years).

A computerized spirometer was used to evaluate pulmonary function, and it was calibrated every day in accordance with the manufacturer's recommendations. The American Thoracic Society (ATS) and European Respiratory Society (ERS) recommendations were followed throughout the surgery. For at least two hours before to the test, subjects were instructed not to smoke, engage in vigorous activity, or consume any food. In order to prevent air leaks during spirometry, the individuals were seated and had their nares taped. Each participant completed at least three moves that were adequate and reproducible, and the best outcomes were utilized for analysis. Peak expiratory flow rate (PEFR), forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and the FEV1/FVC ratio were among the measures evaluated. An obstructive ventilatory pattern was defined as having a FEV1/FVC ratio below 70%, while a restrictive pattern was defined as having an FVC below 80% of what would be expected with a normal or high FEV1/FVC ratio.

IBM Statistical Package and Data Analysis Language (SPSS) version 26 was used to analyze the data. While categorical factors like gender distribution and the prevalence of obstructive or restrictive patterns were given as percentages, continuous variables like age, BMI, and spirometry indices were reported as mean + standard deviation. The independent samples t-test was used to compare the mean spirometric values of smokers and nonsmokers, whereas the chi-square method was used for categorical comparisons. The association between pulmonary function measurements and smoking exposure (pack-years) was assessed using Pearson's correlation coefficient. Statistical significance was defined as P-values below 0.05.

RESULTS

This study involved 90 participants, 45 of whom smoked and 45 of whom did not smoke. The study population had a mean age of 41.3 ± 9.7 years, with no statistically significant difference between the two groups' age distributions (p = 0.34). However, there were significant gender disparities; smokers were more likely to be males (84.4%) than non-smokers (53.3%), whereas women were more likely to be non-smokers (46.7%) than smokers (15.6%). Non-smokers had a slightly higher mean BMI (25.2 ± 3.0 kg/m²) than smokers (24.6 ± 2.8 kg/m²), although the difference was not statistically significant (p = 0.28). Table 1 summarizes these demographic features.

Spirometric parameter analysis revealed a dramatic and statistically significant reduction in lung function in smokers vs nonsmokers. Smokers showed a considerably lower mean FEV1 of 2.29 ± 0.61 L compared to non-smokers at 3.01 ± 0.55 L (p < 0.001). Smokers showed a significantly lower FEV1/FVC ratio (68.5% ± 7.2) compared to non-smokers (81.1% ± 6.5), indicating a higher prevalence of obstructive ventilatory changes in the smoking group (p-value < 0.001). Smokers had a lower average FVC (3.28 ± 0.71 L) than non-smokers (3.47 ± 0.69 L), although the difference was not statistically significant (p = 0.09). Smokers exhibited considerably lower Peak Expiratory Flow Rate (PEFR) (314.6 ± 72.8 L/min) compared to non-smokers (386.2 ± 68.9 L/min, p < 0.001). Table 2 offers details on these findings.

When spirometry patterns were identified, obstructive alterations were seen in 42.2% of smokers against only 8.9% of nonsmokers, while restrictive patterns were found in 11.1% of smokers and 6.7% of nonsmokers. A normal spirometric pattern was maintained in 46.7% of smokers compared to 84.4% of non-smokers, indicating a significant difference in pulmonary function status between the groups. This distribution is seen in Table 3.

Table-1: Demographic characteristics of study participants

Variable	Smokers (n = 45)	Non-Smokers (n = 45)	p-value
Mean age (years)	42.1 ± 9.4	40.5 ± 9.9	0.34
Male, n (%)	38 (84.4%)	24 (53.3%)	0.002
Female, n (%)	7 (15.6%)	21 (46.7%)	0.002
Mean BMI (kg/m²)	24.6 ± 2.8	25.2 ± 3.0	0.28

Table 2. Comparison of spirometric parameters between smokers and non-smokers

Parameter	Smokers (n = 45)	Non-Smokers (n = 45)	p-value
FEV1 (L)	2.29 ± 0.61	3.01 ± 0.55	<0.001
FVC (L)	3.28 ± 0.71	3.47 ± 0.69	0.09
FEV1/FVC (%)	68.5 ± 7.2	81.1 ± 6.5	<0.001
PEFR (L/min)	314.6 ± 72.8	386.2 ± 68.9	<0.001

Table 3. Distribution of spirometric patterns among smokers and non-smokers

Spirometry Pattern	Smokers (n = 45)	Non-Smokers (n = 45)	p-value
Normal	21 (46.7%)	38 (84.4%)	<0.001
Obstructive	19 (42.2%)	4 (8.9%)	<0.001
Restrictive	5 (11.1%)	3 (6.7%)	0.46

Furthermore, correlation analysis revealed a strong association between smokers' lung impairment and their level of exposure to smoking. There were inverse associations between pack-years and forced expiratory volume (FEV1) (r = -0.41, p = 0.004) and forced vital capacity (FVC) (r = -0.38, p = 0.006), indicating that lung function declined more in individuals with higher cumulative smoking exposure. These findings indicate a strong dose-response association between the intensity of smoking and loss of lung function.As seen in Tables 2 and 3, smokers had considerably lower lung function than nonsmokers, with the most notable decreases in FEV1, FEV1/FVC ratio, and PEFR. Smoking has a deleterious impact on the respiratory system, as shown by an increase in the incidence of obstructive patterns and an inverse relationship between smoking intensity and pulmonary function indices.

DISCUSSION

The results of this investigation support the previously documented relationship between tobacco intake and respiratory impairment by indicating a clear and statistically significant worsening of pulmonary function in smokers compared to non-smokers [11]. In our study, smokers had lower mean FEV1, FEV1/FVC ratios, and peak expiratory flow rates than nonsmokers. Additionally, smokers were much more likely to have obstructive spirometric patterns. These findings are consistent with worldwide study, which repeatedly shows that smoking is the leading risk factor for the development of COPD with concomitant airway obstruction [12].

Because FEV1 is a strong predictor of morbidity and death from chronic lung disease, smokers' low FEV1 is especially concerning [13]. " According to our findings, the mean FEV1 loss was more than 0.7 liters in both smokers and nonsmokers, which is clinically significant. The average drop in FEV1/FVC ratio for smokers is 68.5%, compared to 81.1% for nonsmokers, emphasizing the obstructive alterations that are hallmark of smoking-induced lung disease. Importantly, obstructive patterns were recorded in more than 40% of smoker's vs fewer than 10% of nonsmokers, confirming spirometry's diagnostic significance in identifying early smoking-induced alterations [14].

The study's finding of a negative connection between spirometric indices and smoking intensity (pack-years) supports the dose-response concept. Consistent with prior findings, heavy smokers reported larger reductions in FEV1 and FEV1/FVC ratios, indicating that continued exposure to cigarette smoke accelerates the deterioration in lung function. This connection highlights the significance of early smoking cessation and population-based programs aimed at preventing smoking uptake, particularly among young individuals [15,16].

It is noteworthy to note that a small proportion of smokers and non-smokers had limited inclinations, although the difference was not statistically significant [17]. This might be due to a variety of underlying reasons that affect lung volumes independent of smoking, including obesity, musculoskeletal limitations, and undiscovered subclinical disorders. However, the specific pathogenic impact of smoking in the airway is blockage rather than restriction, since the majority of smokers exhibit obstructive patterns, while non-smokers prefer to report normal outcomes [18].

Because tobacco use is still common in Pakistan and there is little understanding about the health risks of smoking, the implications of these results are significant [19]. Furthermore, many smokers in our cohort with some degree of changed spirometry did not exhibit any substantial respiratory illness symptoms, suggesting that subclinical airway blockage exists long before capillary disease manifests. This is what underpins early diagnosis using spirometry screening, allowing for early intervention and smoking cessation counsel before irreversible alterations occur [20].

It is vital to mention that this study has a few flaws. The sample size was drawn from two tertiary care institutions and may not be generalizable to the general population, but it was likely sufficient to identify significant differences [21]. Also, measures of exposures that use pack-years could have attenuated recall bias, which may be tolerable when using history smoking as a measure of exposures. This study did not consider other factors that influence respiratory function such as air pollution. Despite these limitations, our findings point to the need for more general use of spirometry in general clinical practice, and present strong evidence that smoking is an important risk factor for impaired pulmonary function in this population [22].

CONCLUSION

This study showed that cigarette smoking is significantly associated with a decreased pulmonary function (lower FEV1, lower FEV1/FVC ratio and higher prevalence of obstructive pattern in smokers compared with nonsmokers). The level of impairment was dose-related and proportional to the amount of smoking. These results demonstrated that spirometry is a useful tool to detect subclinical changes early, and thus to be a candidate for routine screening and preventive medicine. The detection and treatment of tobacco use are important, in order to prevent long-term respiratory problems and reduce the overall burden of smoking-related pulmonary disease, particularly through smoking cessation programs.

Conflict of Interest: The authors report no conflicts of interest.

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Authors' contributions: RA: Conceptualization, drafting. AR: Data collection, editing. WA: Analysis, revision.

Data Availability Statement: The data used in this study are available upon reasonable request from the corresponding author, subject to ethical and institutional guidelines.

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