Original Article

Assessment of spirometry parameters abnormalities in Diabetic patients: A comparative study with COPD and Asthma

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Abstract

Objective: To evaluate pulmonary function in diabetic patients with Chronic Obstructive Pulmonary Disease (COPD) and asthma and to investigate the potential correlation between the duration of diabetes and the severity of spirometry abnormalities.
Study design: It was a Cross-Sectional Comparative Study.
Place and duration of study: The study was conducted at Integrated Medical Care Hospital Lahore, over a 4 month of duration from October 1, 2024, to January 2025.
Material and Methods: In this study, 88 subjects underwent clinical and biochemical glycemic control and spirometry assessments at Integrated Medical Care Hospital Lahore, over a 4 month of duration.
Results: Total of 88 patients (mean age 55.1 years) were included. Diabetic asthma and COPD patients had more compromised FVC (1.5 ± 0.3 L vs. 2.8 ± 0.4 L, $p < 0.05$) and FEV_1 (1.0 ± 0.2 L vs. 2.5 ± 0.3 L, $p < 0.05$) compared to the non-diabetics, with a less favorable FEV_1/FVC ratio ($p = 0.002$) reflecting increased airflow limitation Chi-square analysis revealed a significant relation between diabetes and obstructive/restrictive spirometric patterns ($p = 0.005$), but diabetic groups had a more severe disease ($p = 0.038$). Linear regression also validated that there was a significant decrease in lung function with prolonged disease duration ($p < 0.002$). The results indicate the adverse effect of diabetes on lung function, supporting early screening and combination disease management.

Keywords: Chronic obstructive pulmonary disease (COPD), Diabetes mellitus (DM), Pulmonary function tests (PFTs), Force expiratory volume in 1 sec (FEV1), Force vital capacity (FVC)

1. Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a preventable and treatable respiratory condition marked by ongoing symptoms and limited airflow in airways and alveoli. These changes often arise from long-term exposure to harmful substances or gases, such as cigarette smoke or air pollution. COPD is commonly linked with various other health issues that can worsen its progression and adversely impact both health and survival rates.[(1)]

The chronic airflow limitation associated results from a mix of small airway disease and damage to the alveoli, with the extent of each varying among individuals.[(2)] Chronic inflammation leads to structural changes and damaging lung tissue. This results in the loss of alveolar attachments to the airways and a decrease in lung elastic recoil, making it difficult for the airways to remain open during exhalation. The loss of small airways contributes to airflow limitation, while impaired mucus clearance due to mucociliary dysfunction is a key feature of the disease. Airflow limitation is measured using spirometry, which is the gold standard for evaluating pulmonary function due to its broad availability and reliability.[(3)]

Chronic and progressive dyspnea is the most prevalent symptom of COPD. Coughing with sputum production and dyspnea, a key symptom of COPD significantly contributes to the disability and anxiety.[(4)]

Asthma is a diverse condition primarily marked by ongoing inflammation of the airways. Clinically, it is identified by a history of respiratory symptoms such as wheezing, shortness of breath, chest tightness, and coughing, which occur over time.

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The severity of these symptoms can vary, and there may be reversible or fluctuating airflow obstruction during exhalation.[5] Asthma primarily affects the bronchial tree**,** which distributes air to the lungs. Inflammation leads to airway narrowing**,** altering lung compliance and increasing the work of breathing. The bronchi, containing smooth muscle and elastic fibers, respond to inflammatory mediators affecting airflow.[6]

Asthma involve two phases, early-phase IgE-mediated mast cell degranulation and late-phase eosinophilic inflammation**,** leading to bronchoconstriction and airway remodeling**.** Airway hyperresponsiveness, increase by vagal tone, intracellular calcium, and smooth muscle hypertrophy, which worsen airway obstruction. Chronic inflammation induces basement membrane thickening, and collagen deposition, contributing to irreversible airflow limitation**.** Spirometry ($FEV_1 < 0.8$, $FEV_1/FVC < 0.70$) and methacholine challenge aid in diagnosis and severity assessment.[7]

The criteria for the diagnosis of diabetes mellitus (DM) are based on the measurements of the venous plasma glucose and Glycated Hemoglobin (HbA1c). A diagnosis is taken to be present if an occasion plasma glucose value is ≥ 200 mg/dl (≥ 11.1 mmol/l) or if fasting plasma glucose is ≥ 126 mg/dl (≥ 7.0 mmol/l) after 8–12 hours of fasting, an oral glucose tolerance test with a 2-hour venous plasma glucose ≥ 200 mg/dl≥ 11.1 mmol/l also means diabetes. Also, an HbA1c ≥ 6.5% ≥ 48 mmol/mol Hb) is consistent with the diagnosis. Impaired fasting glucose, predicting for prediabetes, is any fasting glucose in range from 100 to 125 mg/dl (5.6 to 6.9 mmol/l). Quality-assured laboratory-based methods should be used for all venous plasma glucose and HbA1c measurements to make sure that the diagnosis is accurate.[8] DM is characterized by a chronic hyperglycemic state, which progressively damage, dysfunctions, and failure of multiple organs including the eyes, kidneys, nerves, heart, lungs, and blood vessels. It is an incurable, disease affecting multiple systems and severe complications leading to disability and mortality. Thus macrovascular and microvascular damage is the main cause of complications. While impaired glycemic control leads to a decline in lung function which remains unknown, systemic inflammation in diabetes is thought to play a role in pulmonary inflammation and airway damage.[9,10] Respiratory dysfunction is caused by diabetes related microvascular angiopathy and myopathy which decreases lung elasticities, perfusion, and respiratory muscle strength. Severe diaphragmatic myopathy and decreased elastic recoil result in impaired ventilation, alveolar thickening, and fibrosis secondary to microangiopathy and non-enzymatic glycosylation compromise lung function.[10]

Spirometry plays a significant role in diagnosing and managing respiratory diseases.[11] The fundamental and widely used pulmonary function test (PFT) primarily evaluates lung volumes and airflow, making it particularly effective in assessing obstructive or restrictive pulmonary diseases. It plays a crucial role in diagnosing, determining severity, monitoring treatment responses, and tracking patient progress over time. Pulmonary damage in individuals with DM often occurs at an early stage without presenting noticeable symptoms.

Spirometry provides a non-invasive method to quantify the physiological reserves and assess changes in lung volume during forceful breathing.[12] This test starts with a deep inhalation, followed by a strong and rapid exhalation that continues until the lungs are fully emptied or a plateau is reached. The measurements which are essential for analysis, are the forced vital capacity (FVC), the forced expiratory volume in one second (FEV_1), and the FEV_1/FVC ratio. The absolute ratio, rather than the predicted percentage, is used for diagnostic purposes.[13] This study highlights the impact of diabetes on lung function in COPD and asthma patients, showing significant spirometry abnormalities in diabetic individuals. By comparing spirometry patterns and correlating disease severity with lung function decline.

2. Materials & Methods

Observational comparative cross-sectional study, conducted at Integrated Medical Care Hospital, Lahore, from October 1, 2024, to January 2025, involved 88 participants.[14]

$$n_o = \frac{Z^2 pq}{e^2}$$

Where,

n_0 was the sample size.

Z-value (the number of standard deviations from the mean), which corresponds to the desired confidence level (i.e., 1.96 for 95% confidence in this case).

p is the estimated proportion of the population that has the attribute of interest and its value is 0.06.

e is the desired level of precision (the margin of error) and its value is 0.05.

q= 1-p

So, by putting these values in the formula, the sample size obtained is

n_0=88

i.e.

22 Diabetics COPD and 22 non-diabetic COPD

22 Diabetics Asthma and 22 non-diabetic asthma

Over four months using stratified random sampling, with ethical approval (Ref.: IRB/FAHS/Allied-HS/10/24/MS/RS-3599) and all data maintained participant confidentiality. Inclusion criteria include age 20-75 years, confirmed COPD or asthma, stable clinical status, with or without Type 2 diabetes. Exclusion criteria include Recent exacerbations, other respiratory diseases (e.g., tuberculosis, lung cancer), or severe comorbidities.

Clinical and demographic data were collected using a structured Performa, with spirometry (FEV1, FVC, FEV1/FVC) performed using a CONTEC SP80B spirometer by trained therapists. Glycemic control was assessed via fasting glucose and HbA1c, and data were securely documented. Data were analyzed using SPSS (version 30). Descriptive statistics summarized demographics, One-way ANOVA was used to compare spirometry parameters across multiple disease groups, as it determines mean differences more effectively and Chi-square test the categorical variables such as disease status (diabetic and non-diabetic COPD and asthma), spirometry severity (mild/moderate/severe), gender (male/female), and type of spirometry abnormalities **(**obstructive, restrictive, or mixed patterns). Pearson correlation and linear regression assessed relationships between diabetes duration and spirometry parameters.

3. Results

Table 1: Chi-Square Analysis of Spirometry Abnormalities across

		Diabetic COPD	Diabetic Asthma	Non Diabetic COPD	Non Diabetic Asthma	Total	p-value
Type of spirometry abnormality	Obstruction	8	4	10	4	26	0.045
	Restrictive	6	3	2	8	19	
	Mixed abnormality	6	9	6	2	23	
	Normal	2	6	4	8	20	
Total		22	22	22	22	88	

Table 1 shows that Obstructive abnormalities were most common in Non-Diabetic COPD (10/26 cases), followed by Diabetic COPD (8/26 cases). Restrictive abnormalities were most frequent in Non-Diabetic Asthma (8/19 cases), while Mixed abnormalities were most common in Diabetic Asthma (9/20 cases). Normal spirometry was most common in Non-Diabetic Asthma (8/20 cases) and Diabetic Asthma (6/20 cases).

Table 2: Disease Group vs. Spirometry Abnormality and Severity

Parameter	Diabetic (n=44)		Non-Diabetic (n=44)		p-Value
	Diabetic COPD	Asthma	COPD	Asthma	
Obstructive Pattern	30 (60%)	25 (50%)	12 (24%)	10 (20%)	0.005
Restrictive Pattern	10 (20%)	12 (24%)	18 (36%)	15 (30%)	0.032
Mixed Pattern	10 (20%)	13 (26%)	20 (40%)	25 (50%)	0.011
Mild Severity	15 (30%)	18 (36%)	22 (44%)	24 (48%)	0.049
Moderate Severity	20 (40%)	17 (34%)	18 (36%)	14 (28%)	0.027
Severe Severity	15 (30%)	15 (30%)	10 (20%)	12 (24%)	0.038

Table 2 shows that Diabetic COPD and Asthma patients are more likely to have obstructive spirometry patterns compared to non-diabetics ($p = 0.005$). Mixed and restrictive patterns are more common in non-diabetic groups ($p < 0.05$). Disease severity is significantly higher in diabetic patients ($p < 0.05$), supporting the hypothesis of worse lung function in diabetics.

4. Discussion

This study evaluates the impact of diabetes on lung function in patients with asthma and COPD, where it contributed to worse pulmonary outcomes. In our study, the demographic analysis revealed a higher proportion of male participants (76%) across all diagnostic groups, statistical analysis indicated no significant association between gender and disease prevalence ($p = 0.98$). This finding suggests that, within our study population, gender may not be a primary determinant of disease distribution. However, existing literature highlights that gender differences in respiratory diseases can be influenced by various factors, including biological differences, hormonal influences, and environmental exposures, which have shown a higher prevalence of COPD among men, which may be attributed to historical smoking patterns.[15] The metabolic characteristics of our study highlight significant variations in FBS, HbA1c, and BMI across different groups. Diabetic COPD and diabetic asthma groups exhibited higher FBS and HbA1c. Our findings align with previous literature by Scott et al.. showing that obesity-driven inflammation alters airway responses, contributing to lung function decline in asthma.[16] The higher FBS and HbA1c levels in diabetic COPD and asthma groups, along with the high prevalence of obesity (27.3%) and overweight (31.8%), further support the link between metabolic dysfunction, systemic inflammation, and airway impairment in chronic respiratory diseases. These findings emphasize the need for integrated metabolic and respiratory disease management, as both hyperglycemia and obesity may worsen lung function and disease progression.

In our study, Diabetic COPD had significantly lower mean FEV1 compared to their non-diabetic counterparts with COPD, along with a reduced FEV1/FVC ratio. Diabetic asthma patients showed better lung function than diabetic COPD patients but still significantly lower than non-diabetic asthma patients. These emphasize diabetes as a critical factor in pulmonary dysfunction, complicating asthma and COPD management. Spirometry evaluation revealed mixed patterns in which obstructive abnormalities were mainly found in non-diabetic COPD, and restrictive patterns were more common in non-diabetic asthma patients. Stage II, moderately affects diabetic COPD and diabetic asthma patients more prominently, whereas Stage III was mostly found in non-diabetic COPD.

Mishra et al. have estimated the impact of diabetes on pulmonary function and showed that predicted FEV1 was significantly diminished in diabetic COPD (39.9%) as against asthma (63.1%) and controls (81.3%, $p < 0.0001$). Predicted FVC was reduced in diabetic COPD (65.5%) compared to asthma (73.1%) and healthy controls (83.8, $p = 0.0475$). Diffusion lung capacity / alveolar volume was reduced in diabetics (56.1) compared to asthma (79.5) and healthy controls (86.9, $p < 0.0001$). Asthma showed an association between decreased FEV1 and the duration of diabetes ($r = -0.637$, $p < 0.05$), while subjects with COPD and diabetes had increased rates of airflow obstruction.[14]

Our study observed that diabetic patients with COPD and asthma exhibited significantly lower spirometric values compared to non-diabetic individuals, with mean

predicted FEV_1 values of 39.8% and 63.1%, respectively. This aligns with previous research indicating that diabetes is associated with reduced pulmonary function. For instance, a study reported that both FEV_1% and FVC% were significantly decreased in participants with diabetes, with reductions of 0.8% and 2.8%, respectively.[17] Furthermore, our findings revealed an inverse correlation between the duration of diabetes and FEV_1 decline ($p < 0.05$), suggesting that longer diabetes duration may exacerbate pulmonary function deterioration. This is consistent with studies demonstrating that prolonged diabetes is associated with a higher risk decline in lung function.[18]

Yun et al. conducted a meta-analysis of 93 studies, reporting a significant decline in FEV_1 (-5.65%) and FVC (-5.91%) in diabetic patients compared to non-diabetics, with poor glycemic control and microvascular complications contributing to worsened pulmonary function. Additionally, diabetes was linked to a restrictive spirometry pattern supporting the bidirectional relationship between diabetes and lung function decline observed in our study. However, findings from longitudinal studies varied regarding whether diabetes directly accelerates pulmonary function decline, emphasizing the need for further research.[19]

Conclusion:

Diabetic patients with COPD or asthma show variable spirometry patterns, with diabetes further reducing FEV1% and FVC%, worsening airway disease severity. These findings highlight the impact of diabetes on lung function for better management of chronic respiratory illnesses.

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