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RESEARCH ARTICLE

Association Between Duration of Type 2 Diabetes Mellitus and Decline in Pulmonary Function: A Cross-sectional Observational Study

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ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycaemia resulting from insulin resistance and progressive β-cell dysfunction. Although the classical complications of diabetes involve the retina, kidneys, nerves, and cardiovascular system, increasing evidence suggests that the lungs may also represent an important target organ affected by chronic hyperglycaemia. The extensive pulmonary microvascular network and connective tissue matrix are susceptible to non-enzymatic glycation, oxidative stress, and microangiopathic changes associated with long-standing diabetes. These pathological alterations may result in progressive deterioration of pulmonary function. The present study was conducted to evaluate the association between duration of T2DM and decline in pulmonary function among diabetic patients attending a tertiary care centre.

Methods: A hospital-based cross-sectional observational study was conducted among 171 patients with T2DM attending the Department of Medicine, Government Bundelkhand Medical College and Hospital, Sagar, Madhya Pradesh, over a period of 18 months. Demographic, anthropometric, clinical, and biochemical parameters were recorded. Pulmonary function tests (PFTs) were performed using computerized spirometry. The association between duration of diabetes and pulmonary dysfunction was analysed using appropriate statistical methods. A p-value <0.05 was considered statistically significant.

Results: Among the 171 participants, 57.9% had diabetes duration greater than five years. Pulmonary dysfunction was observed in 60.8% of participants, with a restrictive pattern being the most common abnormality (43.3%). Patients with diabetes duration greater than five years showed significantly higher prevalence of abnormal pulmonary function tests compared with those having diabetes duration ≤5 years (74.0% vs. 43.1%; p=0.002). Multivariate logistic regression demonstrated that longer duration of diabetes independently predicted pulmonary dysfunction (Adjusted OR=2.48; 95% CI: 1.32–4.67; p=0.005).

Conclusion: Longer duration of T2DM is significantly associated with decline in pulmonary function. Routine pulmonary function assessment may facilitate early detection of respiratory impairment in patients with longstanding diabetes mellitus.

Keywords: Type 2 diabetes mellitus; Pulmonary function test; Spirometry; Duration of diabetes; Restrictive lung disease; FVC; FEV1.

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Introduction

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycaemia resulting from insulin resistance and progressive β-cell dysfunction. The prevalence of diabetes has increased rapidly worldwide and represents a major public health challenge. India bears one of the largest global burdens of diabetes, with a steadily increasing number of affected individuals. Chronic hyperglycaemia contributes to multiple microvascular and macrovascular complications that significantly increase morbidity and mortality among diabetic patients[1].

Traditionally, diabetic complications have been recognized in organs such as the retina, kidneys, peripheral nerves, and cardiovascular system. However, growing evidence suggests that the lungs may also be affected by chronic metabolic abnormalities associated with diabetes. Owing to their extensive microvascular network and abundant connective tissue content, the lungs are particularly vulnerable to the effects of long-term hyperglycaemia[2-4].

Several mechanisms have been proposed to explain pulmonary involvement in diabetes mellitus. Persistent hyperglycaemia promotes non-enzymatic glycation of collagen and elastin within the lung parenchyma, resulting in reduced tissue elasticity and impaired lung compliance. In addition, diabetic microangiopathy can cause thickening of the alveolar-capillary basement membrane, leading to alterations in pulmonary mechanics and gas exchange. Oxidative stress and chronic inflammation may further contribute to structural and functional changes within the respiratory system[5-8].

Pulmonary function tests (PFTs) provide a simple, non-invasive method for assessing respiratory function and detecting early pulmonary impairment. Previous studies have demonstrated reductions in forced vital capacity (FVC), forced expiratory volume in one second (FEV_1),

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and other spirometric parameters among patients with T2DM. These abnormalities frequently occur even in the absence of overt respiratory symptoms, suggesting that pulmonary dysfunction may remain clinically unrecognized for prolonged periods[9-12].

Among the various factors influencing pulmonary function in diabetic patients, disease duration appears to play a crucial role. Prolonged exposure to hyperglycaemia may lead to cumulative microvascular damage, connective tissue alterations, and progressive deterioration of lung function. Several investigators have reported significant associations between longer duration of diabetes and reduced pulmonary function parameters, with restrictive ventilatory defects being the most commonly observed abnormality[13-16].

Poor glycaemic control has also been linked to pulmonary dysfunction. Elevated HbA1c levels have been associated with lower spirometric indices and increased prevalence of abnormal pulmonary function patterns. These findings suggest that both disease duration and chronic hyperglycaemia may contribute to respiratory impairment in patients with T2DM[17-20].

Despite increasing recognition of pulmonary involvement in diabetes, routine respiratory assessment is not commonly incorporated into diabetic care. Early identification of pulmonary dysfunction may facilitate timely interventions aimed at improving metabolic control and preserving respiratory health. Furthermore, data regarding the relationship between duration of diabetes and pulmonary function among Indian populations remain limited[21-24].

Therefore, the present study was undertaken to evaluate pulmonary function among patients with Type 2 diabetes mellitus attending a tertiary care hospital and to determine the association between duration of diabetes mellitus and pulmonary function decline. Understanding this relationship may help establish the importance of pulmonary function assessment as part of comprehensive diabetes management[25].

Materials And Methods

Study Design

This study was a hospital-based cross-sectional observational study.

Study Setting

The study was conducted at the Department of Medicine, Government Bundelkhand Medical College and Hospital, Sagar, Madhya Pradesh, India, a tertiary care teaching institution serving both urban and rural populations.

Study Duration

The study was conducted over a period of 18 months following approval from the Institutional Ethics Committee.

Study Population

Adult patients diagnosed with Type 2 diabetes mellitus attending the Medicine Outpatient Department and Inpatient Department were enrolled.

Inclusion Criteria

- Diagnosed cases of Type 2 diabetes mellitus according to ADA criteria.
- Age between 19 and 60 years.
- Both male and female patients.
- Willingness to provide written informed consent.

Exclusion Criteria

- Known chronic respiratory diseases such as COPD, asthma, and pulmonary tuberculosis.
- Acute respiratory infections.
- Significant cardiac, neuromuscular, or chest wall disorders affecting pulmonary function.
- Gestational diabetes mellitus.
- Current smokers.
- Chronic alcohol consumers/alcohol dependence.
- Individuals unwilling to participate.

Sample Size

Using prevalence-based sample size estimation, the minimum required sample size was calculated as 155. After accounting for a 10% non-response rate, the final sample size was increased to 171 participants.

Sampling Technique

Consecutive sampling was used until the required sample size was achieved.

Data Collection

Detailed demographic information, clinical history, duration of diabetes, family history, and anthropometric measurements were recorded using a structured proforma. Height, weight, and body mass index (BMI) were measured using standard techniques.

Biochemical Assessment

Fasting blood sugar (FBS), postprandial blood sugar (PPBS), and glycated haemoglobin (HbA1c) were measured using standard laboratory procedures.

Pulmonary Function Testing

Pulmonary function testing was performed using a computerized RMS Helios 401 spirometer. Participants were instructed regarding the testing procedure, and spirometrywas performed in a seated position. A minimum of three acceptable manoeuvres were obtained, and the best reading was considered for analysis.

Outcome Measures

The primary outcome was pulmonary dysfunction assessed using spirometric parameters including:

- Forced Vital Capacity (FVC)
- Forced Expiratory Volume in 1 second (FEV_1)
- FEV_1/FVC ratio
- Peak Expiratory Flow Rate (PEFR)
- Forced Expiratory Flow 25–75% (FEF25–75%)

Statistical Analysis

Data were entered into Microsoft Excel and analysed using appropriate statistical software. Quantitative variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequency and percentage. Associations between variables were assessed using Chi-square test and independent Student's t-test. Multivariate logistic regression analysis was performed to identify independent predictors of pulmonary dysfunction. A p-value <0.05 was considered statistically significant.

Results

A total of 171 patients with Type 2 diabetes mellitus were enrolled in the study. Demographic, clinical, glycaemic, and pulmonary function characteristics were analysed to evaluate the association between duration of diabetes mellitus and pulmonary dysfunction.

Baseline Characteristics

The baseline characteristics of study participants are summarized in Table 1. The majority of participants belonged to the 51–60 years age group (36.8%), and males constituted 57.3% of the study population. The mean BMI was 25.2 ± 3.9 kg/m², indicating an overall overweight population. More than half of the participants (57.9%) had diabetes duration greater than five years. The mean HbA1c level was 8.1 ± 1.6%, reflecting suboptimal glycaemic control.

Glycaemic Profile

The glycaemic profile of participants is shown in Table 2. The mean fasting blood glucose level was 156.2 ± 42.8 mg/dL and mean postprandial blood glucose level was 224.6 ± 58.9 mg/dL. Poor glycaemic control (HbA1c ≥7%) was observed in 115 participants (67.3%).

Pulmonary Function Assessment

The pulmonary function parameters of the study population are summarized in Table 4. The mean FVC was 2.68 ± 0.54 L, mean FEV_1 was 2.12 ± 0.48 L, and mean FEV_1/FVC ratio was 79.1 ± 6.8%.

The distribution of pulmonary function patterns is shown in Table 5 and Figure 1. Pulmonary dysfunction was observed in 104 participants (60.8%). Restrictive ventilatory impairment was the predominant abnormality, accounting for 43.3% of cases.

Figure 1: Distribution of Pulmonary Function Test Patterns Among Study Participants

Association BetweenGlycaemic Control and Pulmonary Dysfunction

The association between glycaemic control and pulmonary dysfunction is presented in Table 6 and Figure 2. Among participants with HbA1c <7%, only 39.3% had abnormal pulmonary function, whereas 71.3% of those with HbA1c ≥7% demonstrated pulmonary dysfunction. This association was statistically significant ($\chi^2 = 16.47$, $p < 0.001$).

Table 1: Baseline Characteristics of Study Participants (n=171)

Variable	*Value*
Age 19–30 years	18 (10.5%)
Age 31–40 years	36 (21.1%)
Age 41–50 years	54 (31.6%)
Age 51–60 years	63 (36.8%)
Male	98 (57.3%)
Female	73 (42.7%)
BMI (kg/m²)	25.2 ± 3.9
Duration of DM >5 years	99 (57.9%)
HbA1c (%)	8.1 ± 1.6

Table 2: Glycaemic Profile of Study Participants (n=171)

Parameter	*Mean ± SD*
FBS (mg/dL)	156.2 ± 42.8
PPBS (mg/dL)	224.6 ± 58.9
HbA1c (%)	8.1 ± 1.6

Table 3: Distribution According to Glycaemic Control (n=171)

Glycaemic control	*Frequency*	*Percentage (%)*
Good Control (HbA1c <7%)	56	32.7
Poor Control (HbA1c ≥7%)	115	67.3

Table 4: Mean Pulmonary Function Test Parameters (n=171)

Parameter	*Mean ± SD*
FVC (L)	2.68 ± 0.54
FEV_1 (L)	2.12 ± 0.48
FEV_1/FVC (%)	79.1 ± 6.8
PEFR (L/s)	6.2 ± 1.4
FEF25–75% (L/s)	2.1 ± 0.7

Table 5: Distribution of Pulmonary Function Test Patterns (n=171)

PFT Pattern	*Frequency*	*Percentage (%)*
Normal	67	39.2
Restrictive	74	43.3
Obstructive	21	12.3
Mixed	9	5.2

Figure 2. Association Between Glycaemic Control and Pulmonary Dysfunction

Association Between Duration of Diabetes Mellitus and Pulmonary Dysfunction

The primary objective of the study was to evaluate the relationship between duration of diabetes mellitus and pulmonary dysfunction. As shown in Table 7 and Figure 3, participants with diabetes duration greater than five years exhibited a significantly higher prevalence of abnormal pulmonary function tests compared with those having diabetes duration of five years or less (74.0% vs. 43.1%). The association was statistically significant ($\chi^2 = 9.56$, $p = 0.002$).

Figure 3. Association Between Duration of Diabetes Mellitus and Pulmonary Dysfunction

Comparison of Pulmonary Function Parameters According to Glycaemic Control

Pulmonary function parameters were significantly lower among participants with poor glycaemic control, as shown in Table 8. Mean FVC, FEV_1, and FEV_1/FVC ratio were all significantly reduced in participants with HbA1c ≥7%.

Multivariate Logistic Regression Analysis

Multivariate logistic regression was performed to identify independent predictors of pulmonary dysfunction (Table 9). Poor glycaemic control (HbA1c ≥7%) emerged as the strongest predictor of pulmonary dysfunction (Adjusted OR = 3.12; 95% CI: 1.65–5.89; p <0.001). Duration of diabetes greater than five years independently increased the

Table 6: Association BetweenGlycaemic Control and Pulmonary Dysfunction

Glycaemic control	*Normal PFT*	*Abnormal PFT*	*Total*
HbA1c <7%	34 (60.71%)	22 (39.29%)	56
HbA1c ≥7%	33 (28.69%)	82 (71.31%)	115

Chi-square = 16.47; p <0.001

Table 7: Association Between Duration of Diabetes Mellitus and Pulmonary Dysfunction

Duration of DM	*Normal PFT*	*Abnormal PFT*	*Total*
≤5 years	41 (56.94%)	31 (43.06%)	72
>5 years	26 (26.00%)	73 (74.00%)	99

Chi-square = 9.56; p = 0.002

Table 8: Comparison of Pulmonary Function Parameters According to Glycaemic Control

Parameter	*HbA1c <7% (Mean ± SD)*	*HbA1c ≥7% (Mean ± SD)*	*p-value*
FVC (L)	2.91 ± 0.46	2.57 ± 0.52	0.001
FEV_1 (L)	2.34 ± 0.41	1.98 ± 0.47	<0.001
FEV_1/FVC (%)	81.4 ± 5.9	77.8 ± 6.7	0.003

Independent Student's t-test applied.

Table 9: Multivariate Logistic Regression Analysis for Predictors of Pulmonary Dysfunction

Variable	*Adjusted OR*	*95% CI*	*p-value*
HbA1c ≥7%	3.12	1.65–5.89	<0.001
Duration of DM >5 years	2.48	1.32–4.67	0.005
BMI ≥25 kg/m²	1.89	1.02–3.51	0.040

risk of pulmonary dysfunction by approximately 2.5-fold (Adjusted OR = 2.48; 95% CI: 1.32–4.67; p = 0.005). BMI ≥25 kg/m² was also significantly associated with pulmonary dysfunction.

Key Findings

Overall, pulmonary dysfunction was identified in 104 of 171 participants (60.8%). Restrictive ventilatory impairment was the predominant abnormality. Patients with diabetes duration greater than five years demonstrated significantly higher rates of pulmonary dysfunction compared with those having shorter disease duration. Poor glycaemic control and elevated BMI further increased the likelihood of pulmonary impairment. These findings indicate that pulmonary function declines progressively with increasing duration of Type 2 diabetes mellitus and support the inclusion of pulmonary assessment in routine diabetic care.

Discussion

The present study evaluated pulmonary function among patients with Type 2 diabetes mellitus (T2DM) and examined the association between duration of diabetes mellitus and pulmonary dysfunction. The findings revealed a high prevalence of pulmonary impairment, with restrictive ventilatory dysfunction being the predominant abnormality. Additionally, longer duration of diabetes, poor glycaemic control, and elevated body mass index were significantly associated with impaired pulmonary function.

The majority of study participants belonged to the 51–60 years age group, which is consistent with the known epidemiology of T2DM. Similar demographic patterns have been reported in previous studies evaluating pulmonary function among diabetic patients, where increasing age was associated with a greater burden of respiratory abnormalities. Age-related decline in lung function combined with chronic metabolic disturbances may contribute to accelerated pulmonary impairment in diabetic individuals.[26–28]

The study population was predominantly overweight, with a mean BMI of 25.2 ± 3.9 kg/m². Excess body weight is known to adversely affect respiratory mechanics by reducing chest wall compliance and lung volumes. Previous studies have demonstrated significant associations between obesity and reduced pulmonary function parameters, particularly FVC and FEV_1.[29,30] In the present study, BMI ≥25 kg/m² was identified as an independent predictor of pulmonary dysfunction, highlighting the combined impact of obesity and diabetes on respiratory health.

The glycaemic profile indicated generally poor metabolic control, with a mean HbA1c level of 8.1 ± 1.6% and approximately two-thirds of participants having HbA1c levels ≥7%. Chronic hyperglycaemia has been implicated in pulmonary damage through several mechanisms, including non-enzymatic glycation of connective tissue proteins, oxidative stress, chronic inflammation, and microvascular injury. Structural changes involving thickening of the alveolar-capillary membrane may result in reduced lung compliance and impaired pulmonary function.[31–33]

A major finding of the present study was the high prevalence of pulmonary dysfunction, which was observed in 60.8% of participants. Previous studies have similarly reported reduced pulmonary function among patients with diabetes mellitus and have suggested that respiratory involvement may represent an underrecognized chronic complication of the disease.[34,35] The relatively high prevalence observed in the present study may be related to the large proportion of participants with poor glycaemic control and longer duration of diabetes.

Among the pulmonary abnormalities identified, restrictive ventilatory impairment was the most common pattern, accounting for 43.3% of cases. Obstructive and mixed patterns were considerably less frequent. These findings are consistent with previous reports demonstrating that restrictive lung dysfunction is the predominant pulmonary manifestation of T2DM. Proposed mechanisms include glycosylation of lung connective tissue, reduced pulmonary elasticity, and diabetic microangiopathy affecting the pulmonary capillary bed.[36–38]

The primary objective of the study was to evaluate the relationship between duration of diabetes mellitus and pulmonary dysfunction. Participants with diabetes duration greater than five years demonstrated significantly higher rates of abnormal pulmonary function compared with those having diabetes duration of five years or less (74.0% versus 43.1%; p = 0.002). Furthermore, multivariate logistic regression analysis identified longer duration of diabetes as an independent predictor of pulmonary dysfunction. Similar findings have been reported by earlier studies that demonstrated progressive decline in spirometric parameters with increasing duration of diabetes mellitus.[39,40] These observations support the hypothesis that prolonged exposure to hyperglycaemia leads to cumulative structural and functional damage within the lungs.

Another important finding was the significant association between glycaemic control and pulmonary dysfunction. Participants with HbA1c ≥7% exhibited a markedly higher prevalence of abnormal pulmonary function tests compared with those having HbA1c <7%. Moreover, FVC, FEV_1, and FEV_1/FVC values were significantly lower among participants with poor glycaemic control. These findings are consistent with previous evidence demonstrating inverse relationships between HbA1c levels and pulmonary function parameters.[31,39] Poor glycaemic control may accelerate pulmonary damage through enhanced protein glycation, endothelial dysfunction, and persistent inflammatory processes.

The findings of the present study have important clinical implications. Pulmonary dysfunction may develop gradually and remain clinically silent during the early stages of diabetes. Therefore, routine pulmonary function assessment may help identify respiratory impairment before the onset of significant symptoms, particularly among patients with longstanding disease and poor glycaemic control. Early optimization of glycaemic status, weight management, and lifestyle modification may contribute to preservation of pulmonary function and overall health outcomes.

The present study has certain limitations. The cross-sectional design limits the ability to establish causal relationships, and the study was conducted at a single tertiary care centre, which may affect the generalizability of the findings. Additionally, the absence of a non-diabetic control group precluded direct comparison of pulmonary function between diabetic and healthy individuals. Nevertheless, the relatively large sample size and comprehensive pulmonary function assessment strengthen the validity of the study findings.

In conclusion, pulmonary dysfunction was highly prevalent among patients with Type 2 diabetes mellitus and was predominantly characterized by a restrictive ventilatory pattern. Longer duration of diabetes, poor glycaemic control, and elevated BMI were significantly associated with impaired pulmonary function. These findings support the growing recognition of the lung as a target organ in diabetes mellitus and emphasize the importance of incorporating pulmonary function assessment into comprehensive diabetic care.

Conclusion

The present study demonstrated that pulmonary dysfunction is a common complication among patients with Type 2 diabetes mellitus, with abnormal pulmonary function observed in a substantial proportion of participants. Restrictive ventilatory impairment was the predominant pulmonary function abnormality identified. Patients with longer duration of diabetes mellitus exhibited significantly higher rates of pulmonary dysfunction compared to those with shorter disease duration, indicating a progressive decline in respiratory function with chronic disease progression.

Poor glycaemic control was strongly associated with reduced pulmonary function and emerged as the most significant independent predictor of pulmonary dysfunction. Additionally, elevated body mass index was found to contribute to respiratory impairment. These findings suggest that chronic hyperglycaemia, prolonged disease duration, and excess body weight collectively play important roles in the development of pulmonary dysfunction among patients with Type 2 diabetes mellitus.

The study highlights the importance of recognizing the lung as a potential target organ affected by diabetes mellitus. Routine pulmonary function assessment, particularly among patients with longstanding diabetes and poor glycaemic control, may facilitate early detection of respiratory impairment and enable timely therapeutic interventions. Incorporation of pulmonary function testing into comprehensive diabetes management may help improve long-term clinical outcomes and quality of life in patients with Type 2 diabetes mellitus.

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