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Effect of Duration of Type 2 Diabetes Mellitus on Impairment of Lung Functions: A Cross-Sectional Study

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ABSTRACT

Background: Pulmonary complications in patients with type 2 diabetes mellitus (T2DM) are frequently underrecognized. This study aimed to assess the relationship between the duration of T2DM and pulmonary function impairment using spirometry.
Methodology: A cross-sectional study was conducted at King George's Medical University, Lucknow, including 129 diabetic patients and 129 age- and sex-matched non-diabetic controls. Pulmonary function was assessed using standard spirometry measuring FEV_1, FVC, and FEV_1/FVC ratio. Diabetic subjects were categorized into three groups based on disease duration: <3 years, 3-5 years, and >5 years. Comparisons were analyzed using unpaired t-tests, ANOVA, and Pearson's correlation.
Results: FEV_1 and FVC values were significantly lower in T2DM patients compared to controls (FEV_1: 2.55 ± 0.42 vs. 2.79 ± 0.43 L; FVC: 3.18 ± 0.51 vs. 3.47 ± 0.59 L; $p<0.001$). FEV_1 and FVC showed a progressive decline with increasing duration of diabetes. However, the FEV_1/FVC ratio did not differ significantly. A significant negative correlation was found between the duration of diabetes and FEV_1 ($r = -0.39$) and FVC ($r = -0.35$).
Conclusion: Type 2 Diabetes Mellitus is associated with a statistically significant decline in pulmonary function, particularly in those with longer disease duration. These findings suggest a restrictive ventilatory pattern and highlight the need for routine lung function monitoring in diabetic care.

Keywords: FVC, FEV_1, Spirometry, Type 2 Diabetes Mellitus

INTRODUCTION

Type II diabetes mellitus (Type II DM) is a metabolic disease marked by high blood sugar levels due to insulin resistance and a relative lack of insulin. In 2021, diabetes affected about 537 million adults worldwide between the ages of 20 and 79 years. Most people with diabetes in developing countries fall within the 45–64-year age group. The total number of people living with diabetes is expected to rise to 643 million by 2030 and further to 783 million by 2045, with nearly three out of four individuals living in low- and middle-income countries [1–3].

The burden of diabetes is particularly high in Asian countries such as India, China, and Pakistan. Along with the rising number of diabetes cases, there is also a worrying increase in associated health conditions in Asian populations [4]. Type II DM is a major cause of illness and death due to complications such as blindness, kidney

failure, non-traumatic limb amputations, and heart disease. These complications mainly arise from damage to large and small blood vessels [5].

Long-standing high blood sugar leads to the formation of advanced glycation end products, which cause inflammation and thickening of the basement membrane of blood vessels. This results in microvascular damage, most commonly affecting the eyes, kidneys, and nerves[6]. Because of this, routine investigations in diabetic patients mainly focus on monitoring these organs.

The lungs are a vital organ with a rich blood supply and an extensive network of small blood vessels, but their involvement in diabetes has not been well studied. Lung damage in diabetes can contribute to heart and respiratory problems and may go unnoticed in the early stages due to the lack of obvious symptoms [7]. Early detection, however, could help preserve lung function and delay disease progression.

Studies examining lung function in patients with Type II DM have reported mixed and inconsistent findings [8]. In older adults, diabetes and respiratory diseases often occur together. Around 20% of patients with chronic bronchitis or chronic obstructive pulmonary disease (COPD) also have diabetes, and nearly half of these individuals have metabolic syndrome as well [9]. Diabetes has been linked to COPD, although the reverse relationship has also been reported. Both conditions share a background of long-term, low-grade inflammation and are sometimes grouped under chronic systemic inflammatory syndrome. Abnormal glucose metabolism has also been observed in patients with asthma[10].

Despite this, pulmonary complications of diabetes remain poorly understood and are not routinely screened for in clinical practice. Given the extensive microvascular circulation of the lungs, their involvement in diabetes is likely. Therefore, this study aims to evaluate changes in pulmonary function in patients with Type II DM compared to individuals without diabetes and to examine the relationship between lung function, duration of diabetes, glycemic control, and demographic factors.

MATERIALS & METHODS

This study was conducted in the Department of Physiology at King George's Medical University, Lucknow, India, over one year (2023-2024). Ethical approval was taken from the institutional ethical committee (Ref. no: XXII-PGTSC-IIA/P52). 258 participants were enrolled, consisting of 129 patients with T2DM and 129 healthy age and sex matched non-diabetic controls. Diabetic patients were recruited from the Medicine department OPD. Written informed consent was taken from all participants.

Participants included in the study were diagnosed cases of Type 2 Diabetes Mellitus (T2DM), aged between 30 and 60 years. Both male and female individuals were eligible for inclusion. Only non-smokers were considered for participation to eliminate the confounding effects of smoking on pulmonary function. Individuals with a history of smoking were excluded from the study to avoid potential confounding effects on pulmonary function. Participants with a history of respiratory diseases such as asthma or chronic obstructive pulmonary disease (COPD) were also excluded to ensure that observed pulmonary impairments could be attributed primarily to Type 2 Diabetes Mellitus. Additionally, individuals diagnosed with connective tissue disorders were excluded due to their potential impact on lung compliance and function. Participants who had undergone recent thoracic or abdominal surgery were not included, as postoperative changes could temporarily alter pulmonary parameters.

Participants with type II DM who were between the ages of 30 and 60 were randomly selected. The sample size was 258, comprising 129 cases (previously diagnosed with type II DM) and 129 controls (non-diabetics). Written informed consent was taken from both cases and control, history was taken and a general examination was undertaken.

Age (in years) was recorded, sex, and duration of disease in both groups, the height was measured using a wall-mounted measuring tape. Weight was measured in kilograms using an electronic weighing machine.

Grouping was done Based on Diabetes Duration. T2DM patients were categorized into three groups: Group A (Duration<3), Group B (Duration 3-5), Group C (Duration >5)

Pulmonary Function Testing

Spirometry was performed using a calibrated desktop spirometer following ATS/ERS guidelines. Each subject performed three forced expiratory maneuvers at 15-minute intervals, and the best reading was recorded. The parameters measured were Forced Expiratory Volume in 1 second (FEV_1), Forced Vital Capacity (FVC), FEV1/FVC ration.

Statistical Analysis

Data was analyzed using SPSS software. Between-group comparisons were made using unpaired t-tests. Analysis of variance (ANOVA) was used for comparisons diabetic subgroups. Pearson's correlation was applied to examine the relationship between spirometric parameters and diabetes duration. A p-value <0.05 was considered statistically significant.

RESULT

Demographics

The study included 129 patients with T2DM and 129 non-diabetic controls, matched for age and sex. Among the cases, 79 were males and 50 females, while the control group included 80 males and 49 females (Table 1).

Table 1: Gender wise patient distribution

	Cases (129)	Controls (129)
Males	79 (61.2%)	80 (62%)
Females	50 (38.8%)	49 (38%)

Comparison of Pulmonary Function Between Groups

Table 2 compares pulmonary function parameters between cases and controls. The mean FEV_1 was significantly lower in cases (2.55 ± 0.418 L) compared to controls (2.79 ± 0.43 L), with a highly significant difference (p = 0.00001). Similarly, mean FVC was significantly reduced in cases (3.18 ± 0.51 L) relative to controls (3.47 ± 0.59 L) (p = 0.00012). In contrast, the FEV_1/FVC ratio did not differ significantly between the two groups, with mean values of 0.804 ± 6.6 in cases and 0.809 ± 6.33 in controls (p = 0.2521).

Table 2: Comparison of FEV1, FVC, FEV1/FVC among case and controls

	CASE		CONTROL		
	MEAN	S.D(±)	MEAN	S.D(±)	P Value
FEV1	2.55	0.418	2.79	0.43	0.00001
FVC	3.18	0.51	3.47	0.59	0.00012
FEV1/FVC	0.804	6.6	0.809	6.33	0.2521

Pulmonary Function and Duration of Diabetes

Table 3 shows the comparison of pulmonary function parameters across different durations of diabetes mellitus (<3 years, 3–5 years, and >5 years). A progressive decline in mean FEV_1 was observed with increasing duration of diabetes, from 2.7 ± 0.48 L in patients with <3 years duration to 2.53 ± 0.33 L in those with 3–5 years and 2.37 ± 0.34 L in those with >5 years duration; this difference was statistically significant (p = 0.0008). Similarly, mean FVC decreased significantly with longer duration of diabetes, from 3.35 ± 0.6 L in the <3 years group to 3.17 ± 0.4 L and 2.98 ± 0.46 L in the 3–5 years and >5 years groups, respectively (p = 0.004). In contrast, the FEV_1/FVC ratio showed no significant difference across the three groups (p = 0.6017).

Table 3: Comparison of FEV1, FVC, FEV1/FVC among different groups of Diabetes Mellitus

	< 3 years		3 - 5 years		> 5 years		
	MEAN	**S.D (±)**	**MEAN**	**S.D(±)**	**MEAN**	**S.D(±)**	**P value**
FEV1	2.7	0.48	2.53	0.33	2.37	0.34	0.0008
FVC	3.35	0.6	3.17	0.4	2.98	0.46	0.004
FEV1/FVC	0.81	7.4	0.8	5.62	0.79	5.41	0.6017

Correlation Analysis

Figure 1 shows correlation between diabetes duration and FEV_1 in cases. Pearson correlation shows slight negative correlation (r = -0.39).

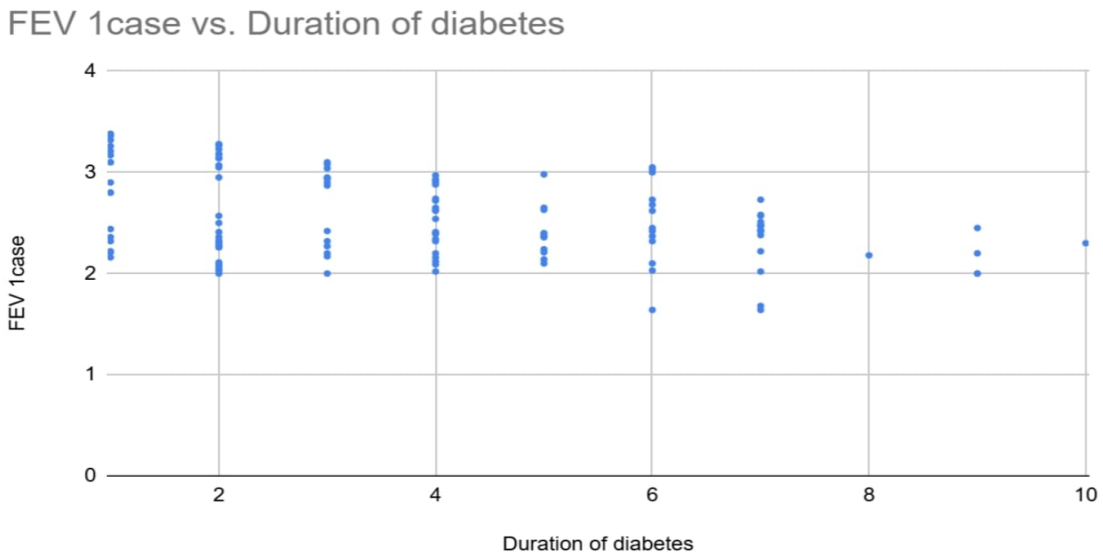

Figure 1: Scatter plot showing correlation between FEV1 and Duration of Diabetes

Figure 2 shows correlation between diabetes duration and FVC in cases. Pearson correlation shows slight negative correlation (r = -0.35).

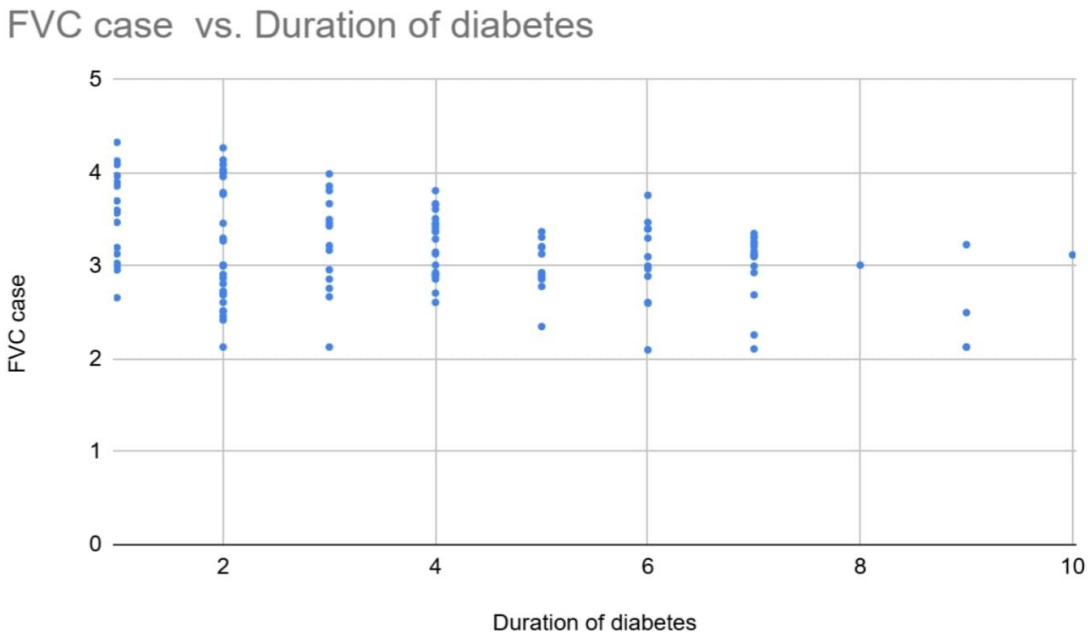

Figure 2: Scatter plot showing correlation FVC and Duration of Diabetes

Figure 3 shows correlation between diabetes duration and FEV_1/FVC ratio. Pearson correlation shows weak correlation but not statistically significant (r = -0.16).

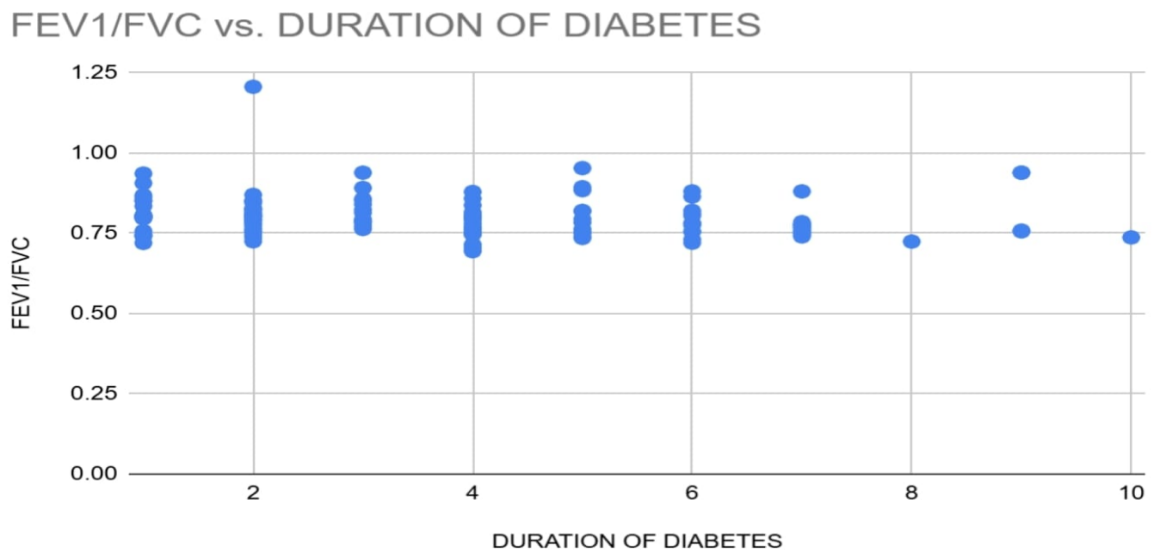

Figure 3: Scatter plot showing correlation between FEV1/FVC and Duration of Diabetes

DISCUSSION

In the present study, we observed that lung function parameters (FVC and FEV_1) were significantly reduced in patients with diabetes mellitus type 2(T2DM) as compared to non-diabetic controls, while the FEV_1/FVC ratio remained largely preserved. Furthermore, a progressive decline in FEV_1 and FVC was noted with increasing duration of diabetes. These findings indicate that the duration of T2DM is an important determinant of pulmonary impairment. Several previous studies have reported similar results, showing a restrictive pattern of lung dysfunction in T2DM.

The association between longer disease duration and greater impairment has been highlighted by Maan et al., who observed that patients with diabetes for >10 years had significantly lower FVC, FEV_1 and mid-expiratory flows than those with shorter duration [11].

As per study by Meo SA et al., FVC and FEV_1 significantly reduced in diabetic patients; FEV_1/FVC ratio lower but non-significant, similar to this study [12].

Similarly, in the study by Kumar P et al., there is also significant reduction in FEV_1 and FVC in diabetics; PFT decreases with increasing HbA1c and duration of diabetes [13].

Rajput S et al., did a comparative cross-sectional PFT analysis in type II diabetes mellitus and found that all pulmonary function parameters, especially FEV_1 and FVC, were lower in diabetics vs controls; restrictive parameters reduced with longer duration, similar to our study [14].

Dennis R J et al. also found that FEV_1 and FVC were significantly lower in poorly controlled diabetics; supports reduced lung volumes in diabetes [15].

The mechanisms underlying these changes are multifactorial. Chronic hyperglycemia leads to glycation of proteins and accumulation of advanced glycated end product (AGEs), leading to increased collagen cross-linking, thickening of alveolar-capillary basement membrane, and reduced lung elastic recoil [16,17]. Microangiopathy similar to that occurring in the kidney and retina has been demonstrated in pulmonary tissue of diabetic patients, suggesting an effect on alveolar microcirculation [18]. Oxidative stress and chronic low-grade inflammation further contribute to parenchymal injury and decline in lung compliance [19]. Respiratory muscle

weakness due to metabolic and neuropathic changes may also play a role [20].

Our findings have important clinical implications. As pulmonary involvement in diabetes is often subclinical, routine screening with spirometry, particularly in patients with longer duration of disease or poor glycemic control, may help in early detection and management. Optimization of glycemic control and measures aimed at reducing oxidative stress may delay or prevent lung function decline.

This study has several strengths, including the use of standardized spirometry techniques and stratification by duration of diabetes. However, its cross-sectional design limits causal inference, and potential confounding factors such as environmental exposures and physical activity could not be completely excluded. Future prospective studies are warranted to assess the longitudinal impact of disease duration and glycemic status on pulmonary function and to explore interventions for preserving lung health in T2DM.

Limitations of the Study

Our study provides insights into the impact of type 2 diabetes on pulmonary function, but it has some limitations. Firstly, the cross-sectional design limits our ability to establish a causal relationship between diabetes and reduced lung function-our findings reflect associations rather than direct cause-and-effect. Secondly, although we controlled for age and smoking status, important variables such as body mass index (BMI), and glycemic control (e.g., HbA1c) were not accounted for. These factors could independently influence lung function and may have influenced our results. Additionally, we did not assess respiratory symptoms or perform diffusion capacity measurements, which could have provided a more comprehensive evaluation of lung involvement. Finally, the study was conducted on a small sample size, so the findings cannot be generalized to broader populations.

CONCLUSION

This study highlights the significant impact of type 2 diabetes mellitus on pulmonary function. The observed reductions in both FEV_1 and FVC among diabetic patients, as compared to non-diabetic controls, were statistically significant, while the FEV_1/FVC ratio showed a non-significant decline. These findings indicate a predominantly restrictive ventilatory pattern in individuals with type 2 diabetes. Moreover, the decline in pulmonary function was found to be more pronounced with increasing duration of diabetes, suggesting a progressive nature of lung involvement as a chronic complication of the disease. The results underscore the importance of recognizing the lungs as a target organ in the long-term management of type 2 diabetes. Given the subclinical nature of early pulmonary changes, routine screening with spirometry could be beneficial, especially in patients with longstanding diabetes. Incorporating pulmonary function assessment into diabetic care protocols may aid in early identification of respiratory complications and facilitate timely intervention to preserve lung function. Future longitudinal and interventional studies are recommended to explore the effects of glycemic control, duration of disease, and comorbid conditions on lung function, and to evaluate the potential benefits of preventive and therapeutic strategies. In conclusion, pulmonary dysfunction in type 2 diabetes is a significant but often under-recognized complication. Regular monitoring, along with optimized glycemic control, may play a crucial role in preventing or mitigating its progression and improving the overall quality of life in diabetic patients.

Declaration by Authors
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