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Assessment of Pulmonary Function Using Spirometry in Patients with Diabetes Mellitus: A Cross-Sectional Comparative Study

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Submission Date : 07 Jan 2026
Accepted Date : 19 Feb 2026
Published Date : 30 March 2026
DOI: https://doi.org/10.3329/jrpmc.v11i1.89952

Abstract

Background:
Diabetes mellitus (DM) is a long-term metabolic disease that is becoming more common around the world. Its systemic complications affect more than just the usual target organs. However, pulmonary involvement in diabetes is still not well understood in everyday clinical practice.

Objective:
To evaluate pulmonary function via spirometry in patients with diabetes mellitus and to investigate the correlation between lung function deterioration and disease duration.

Methods:
A cross-sectional comparative study was performed from June to November 2013 at Rajshahi Medical College Hospital and Rajshahi Diabetic Association General Hospital in Bangladesh. There were 88 participants who did not smoke and were not obese. They had type 1 DM, type 2 DM, or were matched with non-diabetic controls. Spirometry was used to measure pulmonary function (FVC, FEV_1, FEV_1/FVC), and SPSS version 16.0 was used to look at the data.

Results:
Both type 1 and type 2 diabetic patients showed a significant drop in FVC and FEV_1 (measured and % predicted) when compared to controls ($p<0.01$). The FEV_1/FVC ratio stayed the same or went up, which means that the breathing pattern was mostly restrictive. Every person with type 1 diabetes and about 78–79% of people with type 2 diabetes had FVC values that were less than 80% of what was expected. A longer duration of diabetes (>10 years) was significantly correlated with greater decreases in FVC and FEV_1 ($r=-0.48$, $p=0.002$).

Conclusion:
Diabetes mellitus, especially of extended duration, is linked to considerable restrictive pulmonary dysfunction, underscoring the lungs as a critical target organ in diabetes.

Keywords: Type-1 DM, Type-2 DM, Pulmonary function, Spirometry, FVC, FEV

Citation: Rashid MB,Shahida SA,Mahmud RH,Ahmed KM,Haque MA.Assessment of Pulmonary Function Using Spirometry in Patients with Diabetes Mellitus: A Cross-Sectional Comparative Study.J Rang Med Col.2026 Mar;11(1):51-56.doi: https://doi.org/10.3329/jrpmc.v11i1.89952

Introduction:

Diabetes mellitus is a long-term metabolic disease that causes high blood sugar levels because of problems with insulin secretion, insulin action, or both.[1] The International Diabetes Federation (IDF) says that the number of people with diabetes around the world went from 415 million in 2015 to 537 million in 2021. By 2030, it is expected to reach 643 million, and by 2045, it is expected to reach 783 million.[2] Bangladesh is one of the fastest-growing countries, and this disease is spreading quickly there. There were about 13.1 million adults in Bangladesh with diabetes in 2021. This number is expected to grow to more

than 22 million by 2045.[3] The growing burden is caused by a number of things, including rapid urbanisation, an ageing population, obesity, sedentary lifestyles, and unhealthy eating habits. This is especially true in low- and middle-income countries.[4]

Diabetes is widely acknowledged as a multisystemic disorder. In the past, its complications affected the kidneys, heart, eyes, and peripheral nerves. Nonetheless, growing evidence indicates that the respiratory system is also a major target organ.[5] Chronic hyperglycemia causes oxidative stress, systemic inflammation, and microangiopathy, which change the structure and function of lung tissues.[6] Too many reactive oxygen species (ROS) hurt the alveolar epithelium, pulmonary microvasculature, and respiratory muscles. This causes endothelial dysfunction and a slow loss of lung elasticity.[7]

A major mechanism underlying pulmonary impairment is the non-enzymatic glycation of structural proteins, particularly collagen and elastin, within the lung parenchyma, bronchial tree, and chest wall. The accumulation of advanced glycation end products (AGEs) increases lung stiffness, reduces compliance, and produces a restrictive ventilatory defect.[8] Additionally, glycosylation of basement membranes and plasma protein binding lead to thickening of the alveolar–capillary basal lamina, impairing pulmonary diffusion capacity and gas exchange.[9] Diabetes-induced pulmonary microangiopathy resembles pathological changes seen in diabetic nephropathy and retinopathy.[10] Since normal lung mechanics and gas exchange depend on intact connective tissue and microvasculature, these alterations result in measurable abnormalities on pulmonary function tests.[11]

Recent studies and meta-analyses (2015–2025) consistently demonstrate substantial decreases in forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1), whereas the FEV_1/FVC ratio remains normal or slightly elevated, suggesting a primarily restrictive pattern of dysfunction.[12] The severity of impairment is associated with prolonged disease duration, inadequate glycaemic control, and microvascular complications.[13] Consequently, this study sought to assess the influence of diabetes mellitus, specifically its duration, on pulmonary function within the present study population.

Methods:

This cross-sectional comparative study was conducted at Rajshahi Medical College Hospital and Rajshahi Diabetic Association General Hospital, Bangladesh, from June to November 2013. A total of 88 participants were enrolled, including patients with diabetes mellitus of at least five years' duration and age-, sex-, and BMI-matched non-diabetic healthy controls. All participants were non-smokers, non-obese (BMI <25 kg/m), and free from known cardiovascular or respiratory diseases. After obtaining informed consent, clinical evaluation and pulmonary function testing were performed using a digital spirometer (Spirolab III). Forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and FEV_1/FVC ratio were measured, with three acceptable manoeuvres recorded and the best value selected for analysis. Relevant laboratory investigations, including fasting and post-prandial blood glucose and HbA1c, were reviewed. Data were analyzed using SPSS version 16.0, and group comparisons were performed using Student's t-test, with $p<0.05$ considered statistically significant.

Results:

Table-I showed that out of 88 people, most of them (84.1%, n=74) had type 2 diabetes, and 15.9% (n=14) had type 1 diabetes. There were more females (n=48) than males (n=40) overall, especially in type 2 diabetes.

Table-I: Distribution of study participants by diabetes status and sex

Diabetes Status	Male (n)	Female (n)	Total no. (%)
Type-1 DM	7	7	14(15.9)
Type-2 DM	33	41	74(84.1)
Total	40	48	88(100)

Table-II showed that both male and female type-1 diabetic participants (n=7 each) had FVC and FEV1 percentages that were much lower than those of the controls. This suggests that they had restrictive pulmonary impairment. The FEV1/FVC ratios were slightly higher in diabetics.

Table-II: Spirometric results of type-1 diabetes mellitus and control groups

Variable	Diabetic (n=7) Mean±SD	Non-Diabetic (n=7) Mean±SD	p-value
Male			
FVC measured value	2.48±0.517	3.27±0.507	0.013
FVC% predicted	58.14±10.38	89.57±3.50	0.001
FEV_1 measured value	2.25±0.479	2.68±0.518	0.127
FEV_1% predicted	61.00±10.89	84.85±5.42	0.001
FEV_1/FVC %	90.95±8.36	81.60±5.13	0.027
Female			
FVC measured value	2.00±0.566	2.87±0.295	0.004
FVC% predicted	62.71±13.18	93.71±3.45	0.000
FEV_1 measured value	1.80±0.497	2.41±0.242	0.013
FEV_1% predicted	64.57±12.17	89.57±3.59	0.001
FEV_1/FVC %	90.80±7.55	84.77±4.17	0.049

Table-III: Spirometric results of type-2 diabetes mellitus and control groups

Variable	Diabetic (n=33) Mean±SD	Non-Diabetic (n=33) Mean±SD	p-value
Male			
FVC measured value	2.53±0.573	3.37±0.556	0.002
FVC% predicted	69.30±11.27	89.00±6.77	0.001
FEV_1 measured value	2.34±0.507	2.82±0.511	0.003
FEV_1% predicted	81.03±11.54	91.70±9.50	0.001
FEV_1/FVC %	93.65±6.42	83.57±5.21	0.001
Female			
FVC measured value	1.77±0.350	2.20±0.377	0.003
FVC% predicted	68.78±11.41	84.87±3.18	0.001
FEV_1 measured value	1.65±0.338	1.91±0.304	0.004
FEV_1% predicted	75.90±13.96	86.70±5.67	0.001
FEV_1/FVC %	93.09±7.15	86.88±4.67	0.002

Table IV: Univariate analysis of factors associated with FVC % predicted

Variable	Mean±SD/r	p-value
Diabetes status	69.2±11.8 vs 88.9±6.8	<0.001
Duration of DM	r=−0.48	0.002
Age	r=−0.21	0.087
Sex	73.5±12.1 vs 71.2±11.9	0.412
BMI	r=−0.19	0.104

Table-III demonstrated that type-2 diabetic participants (n=33 for each sex) exhibited significantly diminished FVC and FEV1 values in comparison to controls, alongside elevated FEV1/FVC ratios, signifying a predominantly restrictive ventilatory pattern.

Table-IV showed that diabetes status and a longer duration of diabetes were both strongly linked to a lower FVC % predicted ($p<0.01$). Age, sex, and BMI, on the other hand, did not have a strong link to FVC.

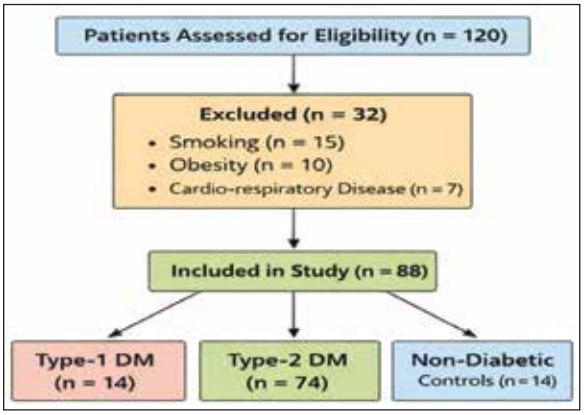

Figure 1: Flow diagram showing selection and distribution of study participants

Figure-1 illustrated the participant recruitment process. Out of 120 initially assessed individuals, 32 were excluded due to smoking, obesity, or cardio-respiratory disease, resulting in 88 enrolled participants: 14 with type-1 diabetes, 74 with type-2 diabetes, and 14 non-diabetic controls.

Figure-2: Measurement of pulmonary function using spirometry (Spirolab III)

This Figure demonstrated pulmonary function measurement using the digital Spirolab III spirometer. Standardized techniques were applied to assess forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and the FEV_1/FVC ratio, ensuring accuracy and reproducibility across all diabetic and non-diabetic participants.

This Figure presented a representative flow–volume loop from a diabetic participant, showing a restrictive ventilatory pattern. The curve highlighted reduced lung volumes while airflow is preserved, reflected by a normal or increased FEV_1/FVC ratio, confirming restrictive impairment rather than obstruction.

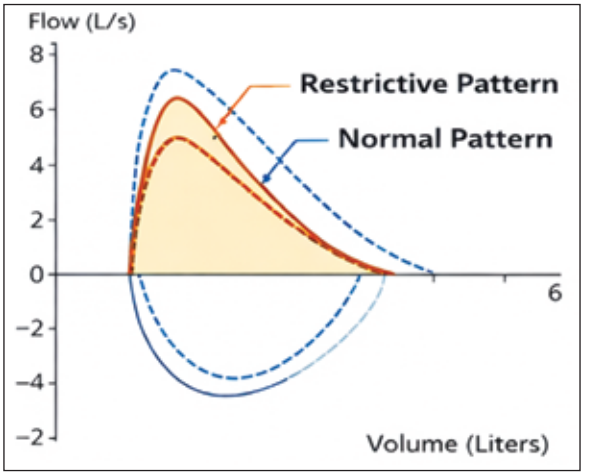

Figure-3: Representative spirometric flow–volume curve showing restrictive ventilatory pattern

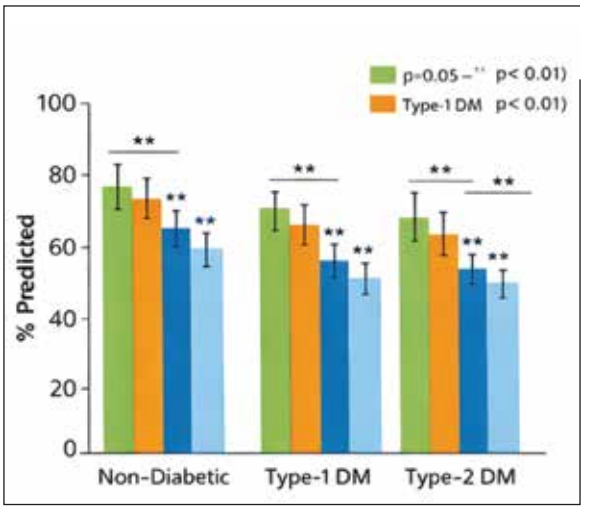

Figure-4: Comparison of mean FVC and FEV_1 (% predicted) between diabetic and non-diabetic groups

In This Figure compared mean percentage predicted FVC and FEV_1 values across groups. Both type-1 and type-2 diabetic patients exhibit significantly lower values than non-diabetic controls ($p<0.01$), indicating a predominant restrictive pulmonary pattern associated with diabetes mellitus.

Table-V showed that both type-1 and type-2 diabetes were linked to lower FVC and FEV_1, normal or higher FEV_1/FVC ratios, and mostly restrictive lung impairment that got worse the longer you have diabetes, with no big differences between men and women.

Table-V: Pulmonary function findings in diabetes mellitus

Parameter	Non-Diabetic Controls	Type-1 Diabetes Mellitus	Type-2 Diabetes Mellitus	Key Interpretation
FVC (% predicted)	Normal (80%)	Markedly reduced (<80%)	Reduced in majority (<80%)	Indicates restrictive lung impairment in diabetics
FEV_1 (% predicted)	Normal	Significantly reduced	Significantly reduced	Decline proportional to diabetes presence
FEV_1/FVC ratio	Normal	Normal or increased	Normal or increased	Suggests restrictive (not obstructive) pattern
Sex difference	-	Similar in males & females	Similar in males & females	No significant sex-based variation
Duration effect	-	Greater reduction with >10 years	Greater reduction with >10 years	Longer duration worsens lung function
Prevalence of restrictive pattern	Absent	100%	~78–79%	Restrictive defect predominant in diabetes

Discussion:

The current study shows that patients with either type 1 or type 2 diabetes mellitus have much worse pulmonary function than people who don't have diabetes. This is mostly due to a restrictive ventilatory pattern. This study found that all type 1 diabetic patients and about 78–79% of type 2 diabetic patients had restrictive impairment. These results align with the findings of Davis et al (2004), which indicated an 8–10% decrease in FVC and FEV_1 in diabetic individuals relative to controls.[14] Van den Borst et al (2010) conducted a meta-analysis that revealed significantly reduced FVC (−5.8%) and FEV_1 (−6.3%) in diabetic patients, while maintaining a stable FEV_1/FVC ratio, indicating a restrictive defect.[14] In India, Shah et al (2013) found restrictive abnormalities in 72% of type 2 diabetic patients, which is very close to the 78–79% prevalence found in this study.[15]

The significant negative correlation between diabetes duration and FVC% predicted ($r=-0.48$, $p=0.002$) further supports the progressive nature of pulmonary involvement. Walter et al (2003) demonstrated that longer diabetes duration was associated with gradual declines in FVC and FEV_1.[16] Similarly, Sayeed et al (2007) in Bangladesh reported significantly lower lung function among patients with disease duration exceeding 10 years.[17] These findings are comparable with the greater reduction in pulmonary parameters observed in participants with longer-standing diabetes in this study. Unlike some previous studies that suggested minor sex-related differences in lung function decline, no significant sex-based variation was identified in the current analysis.

Limitations of the Study:

The study's type-1 diabetic cohort was small (n=14), constraining generalisability and statistical power. Its cross-sectional design precludes the determination of causality between diabetes duration and the decline in pulmonary function.

Conclusion:

Individuals with type-1 and type-2 diabetes demonstrated markedly diminished FVC and FEV_1, accompanied by normal or elevated FEV_1/FVC ratios, signifying a predominance of restrictive pulmonary dysfunction. Longer diabetes duration, especially exceeding 10 years, correlated with a more significant decline in lung function, underscoring systemic pulmonary effects.

Healthcare professionals should acknowledge the lungs as a possible location for diabetic organ damage. It is recommended that diabetic patients undergo periodic spirometric testing to identify early pulmonary impairment and enhance management, thereby decreasing associated morbidity and mortality.

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