Quest Journals
Journal of Medical and Dental Science Research
Volume 13~ Issue 4 (April 2026) pp: 04-09
ISSN(Online): 2394-076X ISSN (Print):2394-0751
www.questjournals.org

Research Paper

Spirometric Findings in Patients with Type Two Diabetes Mellitus: A Comparative Study

ABSTRACT
Background: *Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder with well-recognized microvascular and macrovascular complications. Emerging evidence suggests that the lungs may serve as an additional target organ adversely affected by chronic hyperglycemia, yet this aspect of diabetes-related pathology remains underexplored in clinical practice. Spirometry provides an objective, non-invasive means of assessing pulmonary function and detecting subclinical impairment. This study assessed and compared the spirometric indices of adults with T2DM and age- and sex-matched non-diabetic controls.*
Methods: *A comparative cross-sectional study was conducted among 295 adults comprising 147 T2DM patients recruited from an endocrinology clinic and 148 apparently healthy controls. Sociodemographic and clinical data were obtained using structured questionnaires and medical records. Pulmonary function tests were performed using a standardized digital spirometer in accordance with American Thoracic Society/\European Respiratory Society guidelines. Spirometric indices measured included forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), FEV_1/FVC ratio, forced expiratory flow between 25–75% of the FVC ($FEF_{25–75}$%), and peak expiratory flow (PEF). Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 25. Categorical variables were summarized using frequencies and percentages, and continuous variables as mean ± standard deviation (SD). Group differences were assessed using chi-square and independent t-tests, with $p < 0.05$ considered statistically significant.*
Results: *Participants with T2DM had a mean age comparable to controls and were similar in sex, marital status, education, and ethnicity, though they had significantly higher rates of self-employment and unemployment ($p < 0.001$). Among the T2DM group, 42.9% had lived with diabetes for <5 years, and 91.7% had good glycaemic control. Across all measured parameters, mean spirometric values were significantly lower in T2DM participants compared with controls: FEV_1 (2.05 ± 0.74 vs 2.54 ± 0.74 L; $p < 0.001$), FVC (2.66 ± 1.06 vs 3.13 ± 0.86 L; $p < 0.001$), FEV_1/FVC (78.00 ± 11.76% vs 80.52 ± 7.47%; $p = 0.029$), $FEF_{25–75}$% (2.14 ± 0.94 vs 2.92 ± 1.23 L/s; $p < 0.001$), and PEF (4.30 ± 2.01 vs 5.76 ± 2.14 L/s; $p < 0.001$).*
Conclusion: *This study demonstrates that adults with T2DM have significantly lower spirometric indices than non-diabetic controls, indicating early and clinically relevant pulmonary function impairment. The findings underscore the need to incorporate routine spirometric assessment into comprehensive diabetes care for early detection and management of respiratory complications.*
Keywords: *Type 2 diabetes mellitus; Spirometry; Pulmonary function; FEV_1; FVC; Nigeria*

*Received 28 Mar., 2026; **R**evised 06 Apr., 2026; **A**ccepted 08 Apr., 2026 © The author(s) 2026.*
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I. INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) has emerged as one of the most formidable public health challenges of the 21st century, with its global prevalence rising steadily across both high- and low-income regions. It is a chronic metabolic disorder characterized by insulin resistance, progressive β-cell dysfunction, and sustained hyperglycemia, resulting in multisystemic complications that impair life expectancy and quality of life. According to the World Health Organization, over 422 million adults are living with diabetes globally, with the prevalence disproportionately increasing in sub-Saharan Africa, including Nigeria (1). The insidious onset and chronic nature of T2DM predispose affected individuals to both microvascular complications such as nephropathy, neuropathy, and retinopathy and macrovascular complications, including coronary artery disease and cerebrovascular disease. While these complications are well recognized and actively screened for, an emerging body of evidence identifies the lungs as an additional, yet underappreciated, target organ affected by chronic hyperglycemia.

The respiratory system is highly vascularized and composed of abundant connective tissue, which makes it susceptible to the deleterious effects of long-standing hyperglycemia. Non-enzymatic glycation of collagen and elastin within the lung parenchyma increases tissue stiffness, while thickening of alveolar capillary basement

membranes impairs pulmonary microcirculation and gas exchange (2). Chronic low-grade systemic inflammation, oxidative stress, and autonomic neuropathy frequent in T2DM further contribute to pulmonary dysfunction (3). These pathophysiological alterations may precede clinical symptoms and silently progress over time, yet routine diabetes care rarely includes pulmonary assessment. This gap contrasts with the standard practice of regular screening for nephropathy, retinopathy, and cardiovascular complications, and underscores the need for greater clinical attention to respiratory sequelae in diabetes.

Spirometry remains the gold standard for detecting subclinical pulmonary impairment. Numerous studies have shown a consistent decline in key spirometric indices including forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and the FEV_1/FVC ratio among patients with T2DM compared with age- and sex-matched non-diabetic controls (4). These reductions typically reflect a restrictive ventilatory pattern, though obstructive changes have also been reported, particularly in individuals with coexisting risk factors such as obesity or smoking. The degree of impairment correlates with diabetes duration, poor glycemic control (HbA1c > 7%), and the presence of microvascular complications, suggesting that pulmonary dysfunction is not merely coincidental but may represent an integral component of the diabetic complication spectrum.

Clinically, reduced pulmonary function in T2DM has important implications. It predisposes affected individuals to increased risk of respiratory infections, perioperative pulmonary complications, and diminished exercise tolerance, thereby compounding their cardiometabolic risk burden. Despite this, respiratory evaluation is seldom incorporated into routine diabetes management, especially in resource-constrained settings such as Nigeria where healthcare systems face dual burdens of communicable and non-communicable diseases. Against this backdrop, the present study aims to systematically evaluate spirometric parameters in patients with T2DM, delineating the pattern and magnitude of pulmonary function impairment in this population. Generating local data will not only enhance clinical recognition of diabetes-associated pulmonary dysfunction but also support integrating spirometric screening into holistic diabetes care.

II. METHODS

Study Population

This study employed a comparative cross-sectional design involving 295 adult participants, comprising 147 patients with Type 2 Diabetes Mellitus (T2DM) and 148 non-diabetic controls. The participants with T2DM were consecutively recruited from the Endocrinology and Medical Outpatient Clinics of a tertiary hospital in Nigeria, while the controls were age- and sex-matched apparently healthy individuals selected from the general population during community health outreach programmes. Eligibility for inclusion required participants to be aged 30 years or older, to have no history of chronic pulmonary disease, and, for the diabetic group, to have a confirmed diagnosis of T2DM made at least six months prior to recruitment. Individuals with Asthma, Chronic Obstructive Pulmonary Disease, prior thoracic surgery, acute respiratory infections within the preceding four weeks, or current smoking history were excluded to eliminate confounding respiratory influences.

Data Collection

Data collection was conducted using a structured interviewer-administered questionnaire designed to capture participants' sociodemographic details, medical history, and clinical characteristics. Information collected included age, sex, marital status, educational attainment, occupation, and ethnic group. For the diabetic cohort, additional variables such as duration of diabetes, type and duration of treatment, and level of glycaemic control were documented from participants' medical records and validated by self-report. Anthropometric measurements were obtained using standard procedures, and clinical parameters were recorded on the day of spirometric assessment to ensure contemporaneous data.

Assessment of Spirometry Indices

Pulmonary function was evaluated using a standardized portable digital spirometer following the American Thoracic Society (ATS) and European Respiratory Society (ERS) guidelines for spirometry testing. All assessments were performed by trained respiratory physiologists in the sitting position, using a nose clip to prevent air leakage. Each participant performed at least three acceptable forced expiratory maneuvers, and the highest reproducible values were recorded. The spirometric indices measured included forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), the FEV_1/FVC ratio, forced expiratory flow between 25% and 75% of the FVC maneuver ($FEF_{25–75}$%), and peak expiratory flow (PEF). Predicted values were referenced against population-adjusted normal ranges, and results were expressed in absolute values (litres or litres per second) and percentages of predicted values. The tests were conducted in the morning to minimize diurnal variability, and all equipment was calibrated daily according to manufacturer specifications.

Ethical Considerations

Ethical approval for this study was obtained from the institutional Health Research Ethics Committee of the tertiary hospital where the study was conducted. Written informed consent was obtained from all participants prior to enrolment, and participation was entirely voluntary. Confidentiality of participants' information was strictly maintained, and all data were anonymized prior to analysis. The study adhered to the ethical principles outlined in the Declaration of Helsinki for research involving human subjects.

Data Analysis

Data were entered into a password-protected database and analyzed using Statistical Package for the Social Sciences (SPSS) version 25 (IBM Corp., Armonk, NY, USA). Categorical variables such as sex, marital status, educational level, occupation, and ethnic group were summarized using frequencies and percentages, and group differences were assessed using the chi-square (χ^2) test. Continuous variables, including spirometric indices, were expressed as means ± standard deviations (SD) and compared between groups using the independent samples t-test. Statistical significance was set at $p < 0.05$.

III. RESULTS

A total of 295 participants were enrolled in the study, comprising 147 individuals with Type 2 Diabetes Mellitus (T2DM) and 148 non-diabetic controls. Among these, 110 (37.3%) were male, with a comparable distribution between the T2DM group (54 males, 36.7%) and the control group (56 males, 37.8%), while females constituted 185 (62.7%) of the study population and were slightly more frequent among participants with T2DM (63.3%) compared to the controls (62.2%). Statistical analysis revealed no significant association between sex and diabetic status ($\chi^2 = 0.038$, $p = 0.894$).

Marital status analysis showed that the majority of participants were married (254, 86.1%), comprising 122 (83.0%) in the T2DM group and 132 (89.2%) in the control group, while 23 (7.8%) were single, 12 (4.1%) were widowed, 4 (1.4%) were divorced, and 2 (0.7%) were separated. Although married individuals were slightly more represented among controls, this variation did not reach statistical significance ($\chi^2 = 7.313$, $p = 0.086$). Educational attainment also varied across the groups, with most participants having tertiary education (249, 85.3%), including 117 (81.3%) of the T2DM group and 132 (89.2%) of the control group, followed by secondary education (37, 12.7%), primary education (5, 1.7%), and no formal education (1, 0.3%). These differences were not statistically significant ($\chi^2 = 5.290$, $p = 0.119$).

In terms of occupation, a statistically significant difference was observed between the groups ($\chi^2 = 26.616$, $p < 0.001$). While the majority of participants were employed (210, 71.2%), this was markedly higher in the control group (125, 84.5%) compared to the T2DM group (85, 57.8%). Conversely, self-employment was more common among participants with T2DM (44, 29.9%) than among controls (17, 11.5%), and unemployment was also higher in the T2DM group (7.5% versus 1.4% in controls). A small proportion (3.7%) reported other occupational categories. Ethnic distribution showed that participants were predominantly Yoruba (83, 28.2%), followed by Ibo (53, 18.0%) and Hausa (11, 3.7%), with no significant difference between groups ($\chi^2 = 2.667$, $p = 0.447$).

Table 1: Sociodemographic characteristics of study participants

	T2DM (n = 147)	Control (n = 148)	Total (n = 295)	Statistical Test	*p-value*
Variable	**n (%)**	**n** (%)	**n (%)**		
Sex (n = 295)					
Male	54 (36.7)	56 (37.8)	110 (37.3)	0.038[a]	*0.894*
Female	93 (63.3)	92 (62.2)	185 (62.7)		
Marital Status (n = 295)					
Single	11(7.5)	12 (8.1)	23 (7.8)		
Married	122 (83.0)	132 (89.2)	254 (86.1)	7.313[b]	*0.086*
Separated	1 (0.7)	1 (0.7)	2 (0.7)		
Divorced	4 (2.7)	0 (0.0)	4 (1.4)		
Widowed	9 (6.1)	3 (2.0)	12 (4.1)		
Level of Education (n = 292)					
None	1 (0.7)	0 (0.0)	1 (0.3)		
Primary	2 (.4)	3 (2.0)	5 (1.7)	5.290[b]	*0.119*
Secondary	24 (16.7)	13 (8.8)	37 (12.7)		
Tertiary	117 (81.3)	132 (89.2)	249 (85.3)		
Occupation (n = 295)					

Unemployed	11 (7.5)	2 (1.4)	13 (4.4)		
Self-employed	44 (29.9)	17 (11.5)	61 (20.7)	26.616[a]	*0.000**
Employed	85 (57.8)	125 (84.5)	210 (71.2)		
Others	7 (4.8)	4 (2.7)	11 (3.7)		
Tribe (n = 294)					
Hausa	30 (20.5)	39 (26.4)	69 (23.5)		
Ibo	30 (20.5)	23 (15.5)	53 (18.0)	2.667[a]	*0.447*
Yoruba	39 (26.7)	44 (29.7)	83 (28.2)		

Among the 147 participants with Type 2 Diabetes Mellitus, the duration of diabetes varied considerably, with 63 (42.9%) having lived with the condition for less than five years, 46 (31.3%) for five to ten years, and 38 (25.9%) for more than ten years. All participants were on treatment for diabetes at the time of the study, reflecting full therapeutic engagement within this cohort. The duration on treatment mirrored the duration of illness, with 67 (45.6%) having received therapy for less than five years, 47 (32.0%) for five to ten years, and 33 (22.4%) for more than ten years, suggesting early and sustained initiation of therapy following diagnosis.

Regarding treatment modalities, the majority of participants (106, 72.1%) were managed with oral hypoglycaemic agents (OHA), while 6 (4.1%) were on insulin therapy alone, and 31 (21.1%) were on combination therapy with both OHA and insulin. A small subset (4, 2.7%) reported managing their diabetes with diet and exercise alone, indicating that most participants required pharmacological intervention for glycaemic control.

Assessment of glycaemic control, available for 144 participants, revealed that 132 (91.7%) had good control, while only 12 (8.3%) exhibited poor control. This high rate of good glycaemic control suggests effective therapeutic adherence and possibly consistent follow-up care among the study participants.

Table 2: Clinical profile of T2DM participants

	T2DM (n = 147)	
Parameters	**Responses**	**n (%)**
Duration of DM?	<5 years 5 – 10 years >10 years	63 (42.9) 46 (31.3) 38 (25.9)
Treatment for DM?	Yes No	147 (100) 0 (0.0)
Duration on treatment?	<5 years 5 – 10 years >10 years	67 (45.6) 47 (32.0) 33 (22.4)
Type of treatment	OHA Insulin OHA and insulin Diet and Exercise only	106 (72.1) 6 (4.1) 31 (21.1) 4 (2.7)
DM control (n = 144)	Good Poor	132 (91.7) 12 (8.3)

T2DM – type 2 diabetes mellitus; DM – Diabetes mellitus: OHA – Oral hypoglycaemic agents

The mean spirometric values of participants with Type 2 Diabetes Mellitus were significantly lower than those of the non-diabetic control group across all measured indices. The mean forced expiratory volume in one second (FEV_1) was 2.05 ± 0.74 L in the T2DM group compared with 2.54 ± 0.74 L in the controls, and this difference was highly significant ($t = –5.758$, $p < 0.001$). Similarly, the mean forced vital capacity (FVC) was significantly reduced among T2DM participants (2.66 ± 1.06 L) compared with controls (3.13 ± 0.86 L) ($t = –4.265$, $p < 0.001$). The FEV_1/FVC ratio, which reflects airflow limitation, was also significantly lower in the T2DM group (78.00 ± 11.76%) than in the control group (80.52 ± 7.47%) ($t = –2.197$, $p = 0.029$). Moreover, the mean forced expiratory flow between 25% and 75% of the FVC maneuver ($FEF_{25–75}$%) was markedly reduced among participants with T2DM (2.14 ± 0.94 L/sec) compared with controls (2.92 ± 1.23 L/sec) ($t = –6.130$, $p < 0.001$).

In addition, the peak expiratory flow (PEF) was significantly lower in the diabetic group (4.30 ± 2.01 L/sec) compared with their non-diabetic counterparts (5.76 ± 2.14 L/sec) ($t = –6.042$, $p < 0.001$). Collectively, these findings demonstrate that individuals with T2DM exhibit a consistent pattern of reduced pulmonary function across both large and small airway indices, indicating a generalized impairment in ventilatory performance relative to non-diabetic controls.

Table 3: Comparison of mean spirometric indices of T2DM participants with those of controls

	T2DM (n = 147)	Control (n = 148)	t-Test	*p-value*
Spirometric Indices	**Mean ± SD**	**Mean ± SD**		
FEV_1(L)	2.05 ± 0.74	2.54 ± 0.74	-5.758	*0.000**
FVC (L)	2.66 ± 1.06	3.13 ± 0.86	-4.265	*0.000**
FEV_1/FVC (%)	78.00 ± 11.76	80.52 ± 7.47	-2.197	*0.029**
$FEF_{25-75\%}$ (L/Sec)	2.14 ± 0.94	2.92 ±1.23	-6.130	*0.000**
PEF (L/Sec)	4.30 ± 2.01	5.76 ± 2.14	-6.042	*0.000**

*Statistically significant; T2DM-type 2 diabetes mellitus; CI-Confidence interval; SD-Standard deviation; FEV1Forced expiratory volume in the first second of the FVC maneuver; FVC-Forced expiratory volume; FEF25-75%-Forced expiratory flow in the 25-75% of the FVC maneuver; PEF-Peak expiratory flow ; T2DM – Type 2 diabetes mellitus

IV. DISCUSSION

This study demonstrated a consistent and clinically meaningful reduction in spirometric performance among adults with Type 2 Diabetes Mellitus (T2DM) compared with non-diabetic controls. Participants with T2DM exhibited significantly lower mean FEV_1, FVC, FEV_1/FVC ratio, $FEF_{25–75}$%, and PEF values, indicating a generalized impairment in ventilatory performance. This pattern suggests a restrictive-leaning physiology with superimposed small-airway dysfunction, which aligns closely with previously published findings. Recent meta-analytic evidence confirmed that adults with T2DM have significantly reduced FEV_1, FVC, and $FEF_{25–75}$% compared with controls, while showing minimal or inconsistent reductions in the FEV_1/FVC ratio (1). Similarly, cross-sectional studies conducted in South Asia and East Africa reported lower FVC, FEV_1, and mid-flows among diabetic cohorts compared to age- and sex-matched controls (2,3). An Egyptian study also observed significant reductions in FEV_1 and FVC among T2DM patients, though it reported no significant differences in $FEF_{25–75}$% or PEF (4). These collective findings corroborate the broad pattern of spirometric depression demonstrated in our study.

Several pathophysiological mechanisms have been proposed to explain the pulmonary impairment seen in diabetes. Chronic hyperglycemia promotes non-enzymatic glycation of collagen and elastin in the lung parenchyma, leading to tissue stiffening and reduced elastic recoil. Microangiopathic changes, including thickening of the alveolar–capillary basement membrane, compromise pulmonary microcirculation and gas exchange, while chronic low-grade systemic inflammation and oxidative stress further exacerbate lung injury (5,6). These mechanisms explain the predominant reduction in FVC and FEV_1 with only mild change in the FEV_1/FVC ratio, as seen both in our findings and in other contemporary studies (7,8).

Evidence also suggests that glycaemic burden and control influence pulmonary function. Several studies have reported inverse correlations between HbA1c levels and key spirometric indices, with poorer glycaemic control associated with lower FEV_1 and FVC (9,10). Although most of our participants demonstrated good glycaemic control, the broader literature suggests that stricter glycaemic regulation may be protective for lung function. Future longitudinal studies could further explore this dose–response relationship in our population.

Clinically, reduced pulmonary function in T2DM is not merely a localized impairment but a marker of broader systemic risk. Prospective studies have shown that lower baseline FEV_1 and FVC are associated with higher risks of cardiovascular events and all-cause mortality in people with diabetes (11,12). Reduced spirometric values are also linked to diminished exercise tolerance and lower cardiorespiratory fitness (13). Early evidence suggests that respiratory muscle training and structured physical activity may improve lung function and overall functional status in diabetic individuals (14). These findings underscore the potential utility of incorporating routine spirometric screening into diabetes care, especially for patients with longer disease duration, central obesity, or poor glycaemic control.

Our findings are also consistent with emerging data from sub-Saharan Africa, where several studies, including Nigerian cohorts, have reported higher prevalence of restrictive ventilatory patterns among T2DM patients compared with non-diabetic controls (15,16). Although variations in reference equations and measurement protocols exist, the convergence of findings reinforces the global generalizability of this association.

Key strengths of our study include the use of an age- and sex-matched control group, standardized spirometric assessment protocols, and consistency of differences across multiple ventilatory indices. Nonetheless, the cross-sectional design precludes causal inference, and the absence of diffusion capacity and lung volume measurements limits our ability to distinguish between true restriction and reduced effort. Despite these limitations, the agreement between our results and findings from multiple international studies strengthens the validity of the observed associations.

In summary, our study confirms that adults with T2DM exhibit significantly lower spirometric values than non-diabetic controls, reflecting early pulmonary involvement in diabetes. The convergence of evidence from meta-analyses and regional studies supports the inclusion of pulmonary function assessment as part of routine comprehensive diabetes care. Future prospective studies should examine whether optimizing glycaemic control and introducing targeted respiratory interventions can preserve or improve pulmonary function and reduce cardiometabolic risk in this population.

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