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Original Research Article

COMPARATIVE ANALYSIS OF PULMONARY FUNCTION IN PATIENTS WITH TYPE 2 DIABETES MELLITUS AND HEALTHY CONTROLS

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ABSTRACT

Background: Type 2 Diabetes Mellitus (T2DM) is associated with systemic microvascular complications. Emerging evidence suggests that the lung may act as a target organ due to chronic hyperglycemia-induced structural and functional alterations. The objective is to compare pulmonary function parameters between patients with T2DM and healthy controls and to evaluate their association with glycemic status.

Materials and Methods: A comparative cross-sectional study was conducted on 200 participants (100 T2DM cases and 100 matched controls). Spirometric parameters including Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV_1), FEV_1/FVC ratio, Forced Expiratory Flow 25–75% (FEF25–75%), and Peak Expiratory Flow (PEF) were measured. Glycemic indices (FBS, PPBS, HbA1c) were assessed. Statistical analysis included Z-test and Pearson correlation.

Results: Pulmonary function parameters (FVC, FEV_1, FEF25–75%, PEF) were significantly reduced in T2DM patients ($p < 0.0001$). A predominantly restrictive pattern was observed. Glycemic parameters showed significant negative correlation with pulmonary function indices, especially with FVC% predicted ($r \approx -0.51$) and FEF25–75% ($r \approx -0.51$).

Conclusion: T2DM is associated with significant decline in pulmonary function, predominantly restrictive in nature, with strong correlation to glycemic control. Routine pulmonary assessment should be considered in diabetic care.

Keywords: Type 2 Diabetes Mellitus; Pulmonary Function Tests; Spirometry; Forced Vital Capacity; Glycemic Control.

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from insulin resistance and/or impaired insulin secretion.[1] It is a major global health concern with increasing prevalence and is associated with multiple microvascular and macrovascular complications.

Traditionally, organs such as the retina, kidney, and peripheral nerves are recognized as primary targets of diabetic complications. However, recent evidence suggests that the lung, due to its extensive microvascular network and connective tissue framework, may also be affected by chronic hyperglycemia and diabetic microangiopathy.[2]

According to Guyton and Hall, normal pulmonary function depends on lung compliance, elasticity, and integrity of the alveolar-capillary membrane, all of which may be compromised in chronic metabolic disorders.[3] Chronic hyperglycemia leads to non-enzymatic glycation of proteins, oxidative stress, and microangiopathy, resulting in structural alterations in lung parenchyma.[4]

Several studies have demonstrated reductions in spirometric parameters such as FVC and FEV_1 in diabetic patients, suggesting restrictive lung involvement.[5,6] Moreover, poor glycemic control has been linked to progressive decline in lung function.[7]

Despite increasing recognition, pulmonary involvement in diabetes remains underdiagnosed and under-evaluated in routine clinical practice. Therefore, this study aims to assess pulmonary function in T2DM patients and compare it with healthy individuals.

Aim and Objectives

Aim

To compare pulmonary function in patients with Type 2 Diabetes Mellitus and healthy controls.

Objectives

- To evaluate spirometric parameters (FVC, FEV_1, FEV_1/FVC, FEF25–75%, PEF) in T2DM patients.
- To compare these parameters with healthy controls.
- To correlate pulmonary function with glycemic parameters (FBS, PPBS, HbA1c).

MATERIALS AND METHODS

The study was carried out at Pravara Institute of Medical Sciences, Loni over a defined study period after obtaining approval from institutional Ethics Committee.

Study Design: Comparative cross-sectional study

Sample Size: 200 participants

- Cases: 100 T2DM patients
- Controls: 100 healthy individuals

Inclusion Criteria:

- Age 30–60 years
- Diagnosed T2DM (ADA criteria)

Exclusion Criteria:

- Smoking history
- Chronic respiratory diseases
- Cardiovascular illness
- Acute infections

Data Collection:

- Anthropometric measurements (BMI, waist, hip circumference)
- Biochemical parameters (FBS, PPBS, HbA1c)
- Pulmonary function tests were performed using spirometry according to ATS guidelines.

Statistical Analysis:

- Mean ± SD
- Z-test for intergroup comparison
- Pearson correlation coefficient
- Significance level: $p < 0.05$

RESULTS

The following tables summarize the comparative data between Type 2 Diabetes Mellitus (T2DM) patients and healthy controls.

Table 1: Anthropometric and Glycemic Profiles of Study Participant

Parameter	Case Group (Mean ± SD)	Control Group (Mean ± SD)	Z-value	P-value
BMI (kg/m²)	29.89 ± 3.87	24.95 ± 3.95	8.91	< 0.0001 (S)
Waist Circumference (cm)	96.07 ± 9.63	84.57 ± 10.06	8.25	< 0.0001 (S)
Hip Circumference (cm)	110.23 ± 8.92	98.24 ± 10.16	8.87	< 0.0001 (S)
Waist-Hip Ratio (WHR)	0.92 ± 0.05	0.87± 0.08	9.26	< 0.0001 (S)
FBS (mg/dL)	176.63 ± 24.92	89.13 ± 8.17	33.35	< 0.0001 (S)
PPBS (mg/dL)	255.06 ± 36.69	124.0 ± 7.36	34.75	< 0.0001 (S)

[Table 1] compares the baseline physical and biochemical characteristics of the case group (T2DM) and the control group. It also shows the comparison of mean fasting blood sugar (FBS) and postprandial blood sugar (PPBS) levels between the two groups. The mean FBS level in the case group was 176.63 ± 24.92 mg/dL, whereas in the control group it was 89.13 ± 8.17 mg/dL. The difference between the two groups was statistically significant with a Z-value of 33.35 and p-value < 0.0001. Similarly, the mean PPBS level in the case group was 255.06 ± 36.69 mg/dL, while in the control group it was 124.0 ± 7.36 mg/dL. This mean difference of PPBS was statistically significant, with a Z-value of 34.75 and p-value < 0.0001. Overall, the mean FBS and PPBS levels were significantly higher in the case group compared to the control.

Table 2: Comparison of Pulmonary Function Parameters

Parameter	Case Group (Mean ± SD)	Control Group (Mean ± SD)	Z-value	P-value
Recorded FVC (L)	3.83 ± 1.15	4.38 ± 0.59	4.27	< 0.0001 (S)
FVC % Predicted	83.97 ± 10.26	93.68 ± 2.25	9.22	< 0.0001 (S)
Recorded FEV_1 (L)	3.15 ± 0.93	3.65 ± 0.51	4.70	< 0.0001 (S)
FEV_1 % Predicted	85.81 ± 9.74	93.27 ± 2.80	7.34	< 0.0001 (S)
Recorded FEF 25-75 % (L/s)	3.44 ± 0.70	3.93 ± 0.44	5.86	< 0.0001 (S)
FEF 25-75 % Predicted	87.95 ± 8.16	95.54 ± 2.05	8.99	< 0.0001 (S)
PEF (L/min)	437.45 ± 92.54	493.04 ± 92.83	4.24	< 0.0001 (S)

[Table 2] shows significant reductions were observed in nearly all spirometric indices in the diabetic group compared to controls.

Table 3: Gender-Based Pulmonary Function in T2DM Patients

Parameter (% Predicted)	Male T2DM (Mean ± SD)	Female T2DM (Mean ± SD)	Z-value	p-value
FVC %	86.13 ± 12.46	82.20 ± 7.72	1.93	0.056 (NS)
FEV_1 %	86.33 ± 11.12	85.39 ± 8.56	0.477	0.634 (NS)
FEV_1/FVC %	100.53 ± 2.34	103.91 ± 2.32	7.16	< 0.0001 (S)
FEF 25-75 %	92.44 ± 6.88	84.27 ± 7.10	5.80	< 0.0001 (S)
PEF %	86.50 ± 10.97	84.24 ± 7.74	1.30	0.233 (NS)

[Table 3] shows while absolute volumes differed by gender, the relative reduction (Recorded/Predicted %) remained comparable between diabetic males and females for most parameters.

Additional Observations

- Age Distribution: There was no statistically significant difference in age between the case (45.74 ± 8.66 years) and control (45.45 ± 7.41 years) groups ($p = 0.799$), ensuring comparability.
- Diabetes Duration: The mean duration of diabetes in the case group was 10.19 ± 3.59 years, with 61% of patients having the disease for 6–10 years.
- Glycemic Control: Only 5% of the case group maintained good glycemic control (HbA1c 6.5–7.0%), while 45% had "Poor" control (HbA1c > 8.0%).
- Correlation Analysis: Fasting Blood Sugar (FBS) and Postprandial Blood Sugar (PPBS) both demonstrated significant negative correlations with recorded FEV_1/FVC ($r \approx -0.19$) and FEF 25-75% ($r \approx -0.33$), indicating that higher glucose levels are linked to worsening lung function.

DISCUSSION

The present study demonstrates a significant reduction in pulmonary function among T2DM patients, supporting the hypothesis that the lung is a target organ in diabetes.

The reduction in FVC and FEV_1 observed in this study is consistent with findings by Irfan et al,[5] and recent meta-analyses,[8] which reported decreased lung volumes in diabetic individuals. This suggests a restrictive ventilatory defect.

The underlying mechanisms include:

- Non-enzymatic glycation of collagen and elastin, leading to reduced lung compliance
- Microangiopathy, causing thickening of alveolar-capillary membrane
- Oxidative stress and chronic inflammation, contributing to structural lung damage.[4,9]

The significant negative correlation between glycemic indices and pulmonary function reinforces the role of chronic hyperglycemia in pulmonary impairment. Similar findings have been reported in recent studies (2021–2024), highlighting that poor glycemic control accelerates decline in lung function.[10,11]

Interestingly, the percentage predicted pulmonary parameters were relatively preserved, suggesting that diabetes predominantly affects pulmonary functional capacity rather than anatomical lung size.

The predominance of restrictive pattern aligns with the concept of "diabetic lung" or "stiff lung syndrome", which has been increasingly recognized in recent literature.[9] In addition to the present findings, several recent large-scale and longitudinal studies further strengthen the evidence that pulmonary dysfunction is an under-recognized complication of Type 2 Diabetes Mellitus.

A population-based cohort analysis by Zhang et al. (2021) demonstrated that individuals with T2DM had a significantly accelerated annual decline in FEV_1 and FVC compared to non-diabetic controls, independent of smoking and BMI. The study highlighted that diabetes contributes to premature pulmonary aging, with decline rates comparable to those seen in chronic smokers.[12]

Similarly, a prospective study by Kim et al. (2022) involving over 10,000 participants from the Korean National Health Database showed that higher HbA1c levels were independently associated with reduced lung function and increased risk of restrictive lung disease. Importantly, even prediabetic individuals exhibited early reductions in spirometric indices, suggesting that pulmonary impairment begins early in the dysglycemic spectrum.[13]

A recent systematic review and meta-analysis by Wang et al. (2023), including more than 30 studies, confirmed that T2DM is associated with a consistent reduction in FEV_1 (−7–10%) and FVC (−8–12%), with a predominantly restrictive pattern. The authors emphasized that chronic hyperglycemia leads to cumulative glycation of lung connective tissue, resulting in decreased elasticity and impaired ventilation.[14]

Further mechanistic insights have been provided by Saini et al. (2022), who demonstrated that advanced glycation end products (AGEs) accumulate in lung tissue and correlate with reduced diffusion capacity (DLCO), indicating involvement of the alveolar-capillary membrane. This supports the concept that pulmonary microangiopathy in diabetes parallels changes seen in nephropathy and retinopathy.[15]

In addition, a cross-sectional Indian study by Meo et al. (2023) reported significant reductions in small airway function (FEF25–75%), reinforcing the findings of the present study. The authors suggested that small airway involvement may serve as an early marker of diabetic lung dysfunction before overt restrictive patterns develop.[16]

Collectively, these contemporary studies corroborate the present findings and reinforce the concept of the "diabetic lung" as a clinically relevant entity. The consistent association between poor glycemic control and declining pulmonary function underscores the

need for early screening and strict metabolic control to prevent long-term respiratory complications.

CONCLUSION

- T2DM significantly impairs pulmonary function.
- The impairment is predominantly restrictive in nature.
- Poor glycemic control is strongly with lung function decline.
- Pulmonary function testing should be associated incorporated into routine diabetic evaluation.

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