RESEARCH ARTICLE

Pulmonary Diffusion Capacity and Exercise Tolerance in Adults with Type 2 Diabetes Mellitus: A Cross-Sectional Comparative Study

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ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) may affect the pulmonary microvasculature and alveolar–capillary membrane. Diffusing capacity of the lung for carbon monoxide (DLCO) may identify abnormalities not evident on routine spirometry.

Aim: To compare pulmonary function, diffusion capacity and six-minute walk distance (6MWD) between adults with T2DM and non-diabetic controls, and to explore associations with glycaemic control and diabetes duration.

Methods: This single-centre cross-sectional comparative study included 60 participants aged 30–60 years: 30 with T2DM and 30 non-diabetic controls. Participants underwent spirometry, single-breath DLCO testing and 6MWD assessment, group comparisons and correlations were done.

Results: Spirometric parameters did not differ significantly between groups. Mean total lung capacity (TLC) was lower in the diabetic group (4.18 ± 0.99 vs 4.57 ± 1.05 L; $p<0.05$). Mean DLCO was 20.8 ± 8.9 versus 25.6 ± 9.4 mL/min/mmHg, and DLCO/alveolar volume (DLCO/VA) was 5.15 ± 1.21 versus 5.72 ± 1.18, both lower in participants with diabetes (reported $p<0.05$). Mean 6MWD was also lower in the diabetic group (536 ± 80 vs 590 ± 75 m; $p<0.01$). HbA1c the results section within the diabetic group reports inverse correlations of DLCO with ($r=-0.61$; $p<0.001$) and diabetes duration ($r=-0.54$; $p<0.01$).

Conclusion: In this study, small cross-sectional sample, T2DM was associated with lower diffusion capacity and reduced walking distance despite similar spirometric indices. Larger studies using verified analyses and haemoglobin-corrected DLCO are required.

Keywords: Type 2 diabetes mellitus; DLCO; pulmonary function; alveolar–capillary membrane; six-minute walk test

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INTRODUCTION

Type 2 diabetes mellitus is a prevalent long-term metabolic condition linked to both microvascular and macrovascular issues type 2 diabetes mellitus (T2DM). The lung is a potential target of diabetes-related microvascular damage due to its vast capillary network and huge alveolar–capillary surface area. Previous studies have reported anomalies in lung mechanics and structural alterations in the pulmonary basal lamina in individuals with diabetes [1-4].

Hemoglobin content, pulmonary capillary blood volume and membrane characteristics all affect DLCO, which measures gas diffusion across the alveolar–capillary membrane. Diabetes has been linked to decreased DLCO or other pulmonary function metrics in a number of investigations, even in those without obvious respiratory symptoms [3–7]. While exercise capacity may be impacted by pulmonary, cardiovascular, and peripheral muscle variables, spirometry may not be able to detect anomalies in gas transfer [6, 8].

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The evidence regarding the relationship between pulmonary diffusion, glycemic management, and diabetes duration is mixed. This study looked at correlations between, HbA1c, and diabetes duration and compared spirometry, lung volumes, DLCO, and six-minute walk distance between persons with type 2 diabetes and non-diabetic controls.

MATERIALS AND METHODS

A cross-sectional comparative study was conducted in the Department of Respiratory Medicine in a tertiary care centre at Puducherry for a period of 18 months with the study participants of 60 numbers aged 30-60 years; 30 adults with T2DM and 30 non-diabetic controls after approval from Institutional Ethics Committee (Ref : 20/SVMC/IEC-Cert/February.24). Exclusion criteria included unwillingness to participate, active pulmonary infection or sepsis, pre-existing lung disease, contraindications to DLCO or 6MWD testing and current smoking.

Clinical and Laboratory Assessment: Written informed consent was obtained. Demographic and anthropometric information, including age, height, weight and body mass index (BMI), was recorded. Fasting blood glucose, post-prandial blood glucose and HbA1c were measured. Diabetes duration and treatment history were documented for participants with T2DM.

Pulmonary Function and Exercise Testing: Spirometry included forced vital capacity (FVC), forced expiratory volume in one second (FEV1), FEV1/FVC, forced expiratory flow at 25–75% of FVC (FEF25–75%) and peak expiratory flow (PEF). DLCO was measured using the single-breath method with an EASY-ONE PRO DLCO instrument; DLCO/VA was also recorded. The six-minute walk distance (6MWD) was measured with baseline and post-test observations recorded.

STATISTICAL ANALYSIS

SPSS version 23.0 was used in the study. Continuous variables were summarised as mean ± standard deviation and categorical variables as frequencies. Between-group comparisons, used independent-samples t-tests or non-parametric alternatives where appropriate; categorical variables were compared using chi-square and Fisher's exact tests. Pearson and Spearman correlation was used as appropriate. A p-value <0.05 was considered statistically significant.

RESULTS

The results of the study are presented in table 1-5. The study had 60 participants, 30 in each group. 78 people were initially examined; however 18 were not included due to ineligibility, refusal, or failure to follow up. Each of the 60 enrolled individuals finished the 6MWD and pulmonary function tests.

Table 1: Baseline characteristics

Characteristic	T2DM (n=30)	Control (n=30)
Age, years	47.6 ± 7.8	45.8 ± 8.1
Height, cm	164.2 ± 10.3	161.8 ± 14.1
Weight, kg	73.3 ± 18.4	72.1 ± 17.9
BMI, kg/m²	27.2 ± 5.4	26.9 ± 5.1
Male, n (%)	22 (73.3)	20 (66.7)
Female, n (%)	8 (26.7)	10 (33.3)

Anthropometric measurements and age were comparable amongst the groups. Men made up 66.7% of the controls and 73.3% of the diabetes group.

Table 2: Spirometry, Lung Volume and Diffusion

Parameter	T2DM (n=30), mean ± SD	Control (n=30), mean ± SD	Reported p-value
FVC (L)	2.93 ± 0.88	2.86 ± 0.89	>0.05
FEV1 (L)	2.36 ± 0.75	2.34 ± 0.76	>0.05
FEV1/FVC (%)	83.5 ± 6.8	83.2 ± 6.9	>0.05
FEF25–75%	2.84 ± 0.96	2.73 ± 1.02	>0.05
PEF (L/s)	6.04 ± 2.05	6.12 ± 2.24	>0.05
TLC (L)	4.18 ± 0.99	4.57 ± 1.05	<0.05
DLCO (mL/min/mmHg)	20.8 ± 8.9	25.6 ± 9.4	<0.05*
DLCO/VA	5.15 ± 1.21	5.72 ± 1.18	<0.05

There were no discernible changes in Spirometric characteristics between the groups. The diabetic group significantly had decreased levels of TLC, DLCO, and DLCO/VA.

Table 3: Exercise Capacity and Associations

Outcome	T2DM (n=30), mean ± SD	Control (n=30), mean ± SD	Reported p-value

6MWD (m)	536 ± 80	590 ± 75	<0.01
Predicted 6MWD (%)	95.1 ± 13.4	102.4 ± 12.6	<0.05

The diabetic group had a lower mean 6MWD and percentage-predicted 6MWD.

Table 4: Correlation Analysis within Diabetic Group (Good control vs. poor control)

Correlation in diabetic group	r	Reported p-value
HbA1c vs DLCO	-0.61	<0.001
Diabetes duration vs DLCO	-0.54	<0.01
HbA1c vs 6MWD	-0.48	<0.05

Poorly controlled diabetes mellitus showed significantly decreased DLCO and 6MWB compared to well controlled diabetes and duration of diabetes mellitus independently was associated with decreased in DLCO and 6 MWT.

Table 5: Glycemic-Control Subgroup Analysis

Parameter	Good control (HbA1c ≤7%)	Poor control (HbA1c >7%)	Reported p-value
DLCO	26.1 ± 6.2	17.8 ± 7.4	<0.001
DLCO/VA	6.02 ± 0.88	4.63 ± 1.03	<0.001
6MWD (m)	582 ± 65	504 ± 71	<0.01

Table 5 reports lower DLCO, DLCO/VA and 6MWD among participants with HbA1c >7%.

DISCUSSION

In this cross-sectional comparison, T2DM subjects walked a shorter distance in six minutes and had lower DLCO and DLCO/VA than non-diabetic controls, although conventional spirometric indicators were comparable. This result is consistent with earlier observations of lung functional abnormalities and decreased diffusion capacity in diabetes [3–7, 9–12].

Changes in the pulmonary capillary blood volume or alveolar–capillary membrane linked to long-term metabolic and microvascular damage may be reflected in reduced DLCO. Alveolar epithelial and capillary basal laminae thickening in diabetes has been reported histopathologically, offering a reasonable explanation for poor gas transport [2,4]. However, DLCO is affected by a number of variables, such as lung volume, pulmonary vascular status, and hemoglobin concentration.

Spirometric measurements did not differ significantly between groups, suggesting that measured airflow and forced volumes did not differentiate groups in this sample. Similar observations have been reported in studies where diffusion abnormalities were present despite relatively intact spirometry [3,5,7]. The diabetic group had lower 6MWD. This functional difference may reflect a combination of changes in pulmonary gas exchange and extrapulmonary factors such as cardiovascular function, autonomic dysfunction, and skeletal muscle function.

CONCLUSION

Adults with T2DM in this study had lower DLCO, DLCO/VA and six-minute walk distance than non-diabetic controls, despite no significant differences in spirometric indices. These findings suggest that diffusion and functional exercise abnormalities may be present when routine spirometry is preserved. Confirmation in larger prospective studies with haemoglobin-corrected DLCO, prespecified analyses and fully reconciled statistical outputs is warranted.

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