A Cross Sectional Study on Impact of Diabetes Mellitus on Lung function Parameters

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Chronic hyperglycemia in Type 2 Diabetes Mellitus (T2 DM) is associated with ongoing damage, dysfunction, and failure of many organs, particularly the eyes, kidneys, nerves, heart, lungs, blood vessels and the diabetic patients may have considerable reductions in lung functioning. Diabetes Mellitus, Peak Expiratory Flow, and Fasting Blood Sugar are some of the terms used in this study. One hundred T2 DM patients, ranging in age from 30-70 years old and of either gender, were submitted to spirometry, vital parameters were recorded, glycated hemoglobin (HbA1c) and fasting blood sugar (FBS) were evaluated, and healthy controls were a matched. Diabetics forced vital

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capacity (FVC) ranged from 1.51 to 4 (Liters) with a mean of 2.4 ±0.6SD, whereas controls' FVC ranged from 2.2 to 4.74 with a mean of 3.14 ±0.7SD and a significant P value. (P<0.001) diabetics peak expiratory flow rate (PEFR) ranged from 188 to 459 (liters per minute) with a mean of 288 ±70SD, whereas controls PEFR ranged from 243 to 571 with a mean of 373±74 and a significant P-value. When compared to male diabetics, the PEFR in female diabetics was 239 ±38SD with a significant P-value. Spirometric parameters in male diabetics were found to be insignificant when compared to healthy controls (P <0.001). In both sexes, HbA1c and FBS were shown to be extremely significant when compared to controls. Variable PEFR in healthy controls and in the lung function was found to be impaired in female diabetics, but male diabetics had a normal PEFR.

1. INTRODUCTION

Diabetes Mellitus (DM) affects more than 366 million people worldwide, with Pakistan ranking eighth [1]. Damage and dysfunction of multiple systems are caused by DM. The pulmonary consequences of diabetes mellitus are poorly understood. Pulmonary damage in most diabetic patients is asymptomatic at first and rarely manifests as symptoms [2]. The increased systemic inflammation linked to diabetes may induce pulmonary inflammation, which damages the airways [3]. In mice, diabetes exacerbated the inflammatory response and the resulting lung damage. Lung function is lost as a result of a decline in lung antioxidant activity and greater vulnerability to environmental oxidants [4]. Pulmonary difficulties in DM are caused by the thickening of alveolar, alveolar-capillary, and pulmonary arteriole walls, which results in pulmonary dysfunction [5]. Spirometry is a noninvasive method for determining the physiological reserves in a vast microvascular bed that is not impacted by diabetes clinically [6]. In diabetic patients, lung function may provide important indicators of the course of systemic microangiopathy [7]. FVC and FEV1were found to be significantly and inversely related to diabetes [8]. Due to diabetes-related systemic inflammation, which causes pulmonary inflammation and airway injury, hyperglycemia in DM may result in a loss in lung function [9]. Lung function may be harmed as a result of reduced antioxidant defense and immune function impairment. Due to alterations in collagen and elastin, as well as micro-angiopathy, DM can induce pulmonary problems.

In T2DM respiratory involvement causes breathlessness with exertion, orthopnea, and increased susceptibility to respiratory infections [10]. The altered chemotactic, phagocytic, and bactericidal activities of polymorphonuclear leukocytes, as well as reduced phagocytic function in diabetic patients, contribute to the increased vulnerability to pulmonary infection [11]. Inspiratory and expiratory capacity is reduced because of respiratory muscle weakness, lowering vital capacity [12]. As a result, measuring VC is an effective way to detect respiratory muscle weakening. Airflow blockage, as well as restriction, can lower FVC. According to an electron microscopic investigation, all sections of the lung are equally damaged in diabetic patients, and the thickness of the basal lamina in both the lungs and the kidneys is of the same degree [13]. Lung function in diabetic patients can be used to track the evolution of systemic microangiopathy, which is encouraged in T2 diabetics to keep their BMI within normal ranges and minimize the effects on lung function. We hypothesized that DM could be linked to a decline in lung functions. Exercise and good food habits should be prioritized.

2. MATERIALS AND METHODS

This study was conducted at Peoples University of Medical & Health Sciences Nawab shah Pakistan. From June 2020 to June 2021. The study enlisted the participation of 150 people. T2 Diabetes Mellitus affected one hundred people. They were compared to a group of 50 healthy people. The study excluded participants having a history of Asthma, Hypertension, Obesity, Smoking, COPD, Anemia, Cardiac Failure, or DM complications.

Spirometry was performed on all patients and controls, and vital values, as well as height and weight, were recorded. Biochemical analysis was performed on blood samples. Anthropometric measures, BMI, spirometric parameters (FVC, FEV1, FEV1/FVC, and PEF), and biochemical variables (HbA1c and FBS) were also taken into consideration.

2.1 Statistical Analysis

SPSS version 25.0 was used for the statistical analysis. Finding the means, calculating the standard deviation, and calculating the standard error of the mean were used to compare FVC, FEV1, PEFR, and Percentage ratio, FBS, and HbA1c. Spirometric evaluations, FBS, and HbA1cwere all subjected to the T-test.

3. RESULTS

In this study, the male-female ratio was 1: 1.03. In Table 1 Spirometric values, Forced Vital Capacity (FVC), Forced Expiratory Volume in 1st second (FEV1), Peak Expiratory Flow (PEF), and the ratio of FEV1 and FVC were compared between the T2 DM patients and healthy controls. The minimum value for FVC was 1.51 Liter per minute (L/min) and a maximum of 3.99L/min with a mean of 2.4± 0.6in patients. In control was between 2.2 and 4.74L/min with a mean of 3.14 ± 0.5. The minimum value for FEV1was 1.4 and the maximum was 3.50L/min with a mean of 2.0 ± 0.5 in patients. In control, FEV1was between 1.5 and 3.95 L/min with a mean of 2.5 ± 0.4. The minimum value for FEV1/ FVC was 69 L/min and a maximum of 98 L/min with a mean of 85 ± 7.99 in patients. In control, FEV1/FVC ratio was between 77 and 97 L/min with a mean of 86 ± 6.5. The minimum value for PEF was 188 L/min and a maximum of 459 L/min with a mean of 288 ± 70 in patients. In control, PEF was between 243 and 571 L/min with a mean of 373 ± 74. All cases and controls were analyzed for comparison of biochemical variables such as Fasting blood Sugar and Glycated Hemoglobin. The minimum FBS level in cases was 83 and the maximum 299 mg per dl withmean173 ± 57. In Controls minimum FBS level was 69 and the maximum was 104 mg per dl with a mean of 93 ± 8.0. The minimum HbA1c level in cases was 5.99 and maximum 12.7 % with a mean of 8.7± 1.16. In Controls minimum HbA1c level was 4.4 and the maximum was 5.94% with a mean of 5.1±0.2 (Table1).

In Table 2 the Spirometric values, Forced Vital Capacity (FVC), Forced Expiratory Volume in 1stsecond (FEV1), Peak Expiratory Flow (PEF), and the ratio of FEV1 and FVC were compared between the 49 diabetic female patients and 24 healthy control females. The minimum value for FVC was 1.51 L/min and a maximum of 2.89 L/min with a mean of 2.2 ± 0.2 in patients. In controls, FVC was between 2.9 and 3.82 L/min with a mean of 2.8 ± 0.3. The minimum value for FEV1 was 1.1 and a maximum of 2.84 L/min with a mean of 1.6 ± 0.1 in patients. In control, FEV1 was between 1.99 and 3.43L/min with a mean of 2.5 ± 0.2. The minimum value for FEV1/ FVC was 75 L/min and a maximum of 97L/min with a mean of 84 ± 9 in patients. In control, FEV1/ FVC ratio was between 77 and 97 L/min with a mean of 87 ± 6.2. The minimum value for PEFR was 188 L/min and a maximum of 321 L/min with a mean of 239 ± 38 in patients. In control, PEFR was between 243 and 441 L/min with a mean of 345 ±50. In the study group, all cases and controls were analyzed for comparison of biochemical variables, Fasting blood Sugar, and Glycated Hemoglobin. The minimum FBS level in female cases was 83 and the maximum 289 mg per dl with a mean of 156 ± 48. In Controls minimum FBS level was 78 and the maximum 102 mg per dl with a mean of 93 ± 5.8. The minimum HbA1c level in cases was 6.4 and maximum 10 % with a mean of 8.6 ± 0.8. In Controls minimum HbA1c level was 4.4 and the maximum 5.8 % with a mean of 5.1 ± 0.2 (Table 2).

Table 1. Comparison of Spirometric and Biochemical parameters between Patients and Controls

Variables	Patients Mean± SD	Range	Control Mean± SD	Range	P value
FVC (L/min)	2.4 ± 0.6	1.51 – 3.99	3.14 ± 0.5	2.2 – 4.74	< 0.05
FEV$_1$ (Litres)	2.0 ± 0.5	1.4 – 3.50	2.5 ± 0.4	1.5 – 3.95	> 0.05
Percentage ratio (%)	85 ± 7.99	69 – 98	86 ± 6.5	77 – 97	> 0.05
PEFR (litres/min)	288 ± 70	188 – 459	373 ±74	243 - 571	< 0.05
FBS (mg/dl)	173 ± 57	83 – 299	91 ± 8.0	69 – 104	< 0.001
HbA1c (%)	8.7 ± 1.16	5.99 – 12.7	5.1 ± 0.2	4.4- 5.94	< 0.001

Table 2. Comparison of Spirometric and Biochemical parameters between Female Patients and Controls

Variables	Patients Mean± SD	Range	Control Mean± SD	Range	P value
FVC (litres)	2.2 ± 0.2	1.51 – 2.87	2.7 ± 0.3	2.7 – 3.82	> 0.05
FEV_1(litres)	1.6 ± 0.1	1.1– 2.84	2.5 ± 0.2	1.99 – 3.43	> 0.05
Percentage ratio (%)	84 ± 9	74 – 97	87 ± 6.2	77 – 97	> 0.05
PEFR (litres/min)	239 ± 38	188 - 321	345 ± 50	243 – 441	< 0.001
FBS (mg/dl)	156 ± 48	83 - 289	93 ± 5.8	78 – 102	< 0.001
HbA1c (%)	8.6 ± 0.8	6.4 – 10	5.1 ± 0.2	4.4 – 5.8	< 0.001

Table 3. Comparison of Spirometric and Biochemical parameters between male Patients and Control

Variables	Patients Mean± SD	Range	Control Mean± SD	Range	P value
FVC (litres)	2.99 ± 0.6	1.85 – 3.99	3.1 ± 0.6	2.2 – 4.74	> 0.05
FEV_1(litres)	2.4 ± 0.6	1.18 – 3.90	2.6 ± 0.5	1.09-3.95	> 0.05
Percentage ratio (%)	86 ± 7.5	66-98	86 ± 8.3	81 - 95	> 0.05
PEFR (litres/min)	344 ± 75	221-563	354 ± 82	199 - 519	> 0.05
FBS (mg/dl)	190 ± 8.6	104 - 299	91 ± 9.2	69-104	< 0.001
HbA1c (%)	8.7 ± 1.34	5.99 -12.86	5.1 ± 0.2	4.74- 5.74	< 0.001

In Table 3 the Spirometric values, Forced Vital Capacity (FVC), Forced Expiratory Volume in 1st second (FEV1), Peak Expiratory Flow Rate (PEFR), and the ratio of FEV1 and FVC were compared between the male patients and controls. The minimum value for FVC was 1.86 L/min and a maximum of 3.99 L/min with a mean of 2.99 ± 0.6 in patients. In control, FVC was between 2.2 and 4.74with a mean of 3.1 ± 0.6 L/min. The minimum value for FEV1 was 1.18 L/min and a maximum of 3.90 with a mean of 2.4 ± 0.6 in patients. In control, FEV1 was between 1.09 and 3.95 L/min with mean2.6 ± 0.5. The minimum value for FEV1/ FVC was between 66 and 98 L/min with a mean of 86 ± 7.5in patients. In controls, the FEV1/ FVC ratio was between 81 and 95 L/min with a mean of 86 ± 8.3.

The minimum value for PEFR was 221 L/min and a maximum of 563 L/min with a mean of 344±75 in patients. In controls, the PEFR was between 199 and 519 L/min with a mean of 354 ± 82. In the study group, all cases and controls were analyzed for comparison of biochemical variables i.e. Fasting blood Sugar, and Glycated Hemoglobin combined for both sexes. The minimum FBS level in cases was 104 and a maximum of 299 mg per dl with a mean of 190 ± 8.6. In Controls minimum FBS level was 69 and the maximum 104 mg per dl with a mean of 91 ± 9.2. The minimum HbA1c level in cases was 5.99 and maximum 12.86 % with a mean of 8.7 ± 1.34. In Controls minimum HbA1c level was 4.75

and the maximum was 5.74% with a mean of 5.1 ± 0.2 (Table 3).

4. DISCUSSION

Hyperglycemia causes the development of glycation end products, which are then deposited in various tissues, resulting in diabetes retinopathy, neuropathy, kidney, and lung dysfunction. The mean FBS in our study was 173 ± 57 SD inpatients and 91 ± 8.0SD in controls, indicating a 58percent shift with a significant P-value (P 0.001). Patients had a mean HbA1c of 8.7 ± 1.16 SD, while controls had a mean HbA1c of 5.1 ± 0.2 SD, indicating a 61percent reduction with a significant P-value (P 0.001). Agarwal's [14] findings are in line with our observations. He discovered that T2 diabetics with impaired lung function had significantly higher mean fasting blood glucose, postprandial blood glucose, and HbA1c levels (P 0.001). McKeever [15] and colleagues discovered that an increase in mean HbA1c was linked to lower FVC and FEV1. However, Klein and Kabeya [16,17] found that the reduction in lung function over time was identical in nondiabetics and diabetics in the Normative Aging Study and that the results did not change after stratifying for smoking status. These findings were in contrast to our findings, which demonstrated that participants who acquired diabetes during the follow-up period had lower FEV1 and FVC before the disease

started than those who did not [18]. Spirometry is a simple, reliable, non-invasive diagnostic technique that can help diabetics and individuals who are not diabetic but have compromised lung functions take early preventive actions. The Spirometric values FVC, FEV1, Percentage ratio, and PEFR were statistically significant in this investigation. Diabetes patients exhibited significantly lower FVC and FEV1 than non-diabetic controls, according to Mohammad Irfan and colleagues [19]. They concluded that impaired lung function is a long-term consequence of diabetes. This could be related to biochemical changes in lung collagen and elastin constituents, as well as non-enzymatic glycosylation of proteins caused by persistent hyperglycemia, culminating in microangiopathy. Reduced lung function has also been linked to respiratory muscle weakness caused by autonomic and phrenic neuropathy [20]; however, the glycemic status of the two groups was not compared. Fasting blood sugar and glycated hemoglobin were used to examine the glycemic status of patients and controls in our investigation, which revealed a substantial drop in isoperimetric parameters. When compared to matched controls, Meo's study on Saudi diabetes patients revealed significant reductions in FVC, FEV1, and PEF. They also discovered a substantial link between a dose-effect response of disease duration and reduced pulmonary function impairment in diabetes individuals. However, Agarwal's study in India found no variations in the pulmonary function indices FVC, FEV1, PEF, and maximal static inspiratory and expiratory pressures. The study's biggest flaw was the minimal number of patients in each group. However, in our investigation, a sufficient number of participants were enlisted who had a substantial decrease in FVC and PEF. The difference in FEV1 between patients and controls was negligible. (P less than 0.05) Sanjeev found insignificant FEV1 in the female group who were not using oral medication, which was similar to our findings [21]. In non-smokers, Walter and Litonjua similarly showed negligible FEV1. Similarly, in two groups of patients with disproportionate changes in FEV1 and FVC with a heterogeneous pattern of lung impairment, FEV1 was somewhat lowered but not significantly. Reduced FVC and FEV1 were found to predict the development of diabetes later in life [22]. This supports our hypothesis that deteriorated lung function could be a potential predictor of developing diabetes mellitus. The FEV1/FVC (percentage ratio) in patients varied from 69 to 98, with a mean of 86.7SD, whereas

the control ranged from 77 to 97, with a mean of 87.5SD, indicating a negligible P value (P <0.05). This finding agrees with Sanjeev's discovery that the FEV1/FVC ratio was statistically insignificant. The restrictive but not obstructive dysfunction resulted in significant decreases in FVC, FEV1, and the percentage ratio (FEV1/FVC) [23]. The restrictive kind of pulmonary impairment produced by basal lamina thickness, fibrosis, and non-enzymatic glycosylation of chest wall and bronchial tree proteins could explain the non-significant percentage ratio in our investigation. Patients had PEFRs ranging from 188 to 459, with a mean of 288 ± 70 SD, while controls had PEFRs ranging from 243 to 571, with a mean of 373 ± 74SD. With a strong P value, there is a 76 percent change. (Note: P<0.05) Ozoh's [24] findings are consistent with our research. He discovered that diabetes patients' PEFR was considerably lower than healthy controls. Kanya Kumari's [25] study on Indian diabetics found that FVC, FEV1, FEV1/FVC, PEFR, and FEF were reduced by 24-74 percent when compared to expected values. T2 DM was also linked to a restrictive pattern of respiratory abnormalities, according to her findings. The restrictive character becomes more pronounced as the duration of diabetes grows. However, several investigations have found the contrary. Forced vital capacity, forced expiratory volume in the first second, and forced expiratory flow in the mid-expiratory phase were all within the predicted ranges, although the residual volume/total lung capacity ratio was somewhat higher. According to Sinha, pulmonary functions such as forced vital capacity, forced expiratory volume in the first second, peak expiratory flow rate, and maximal static inspiratory and expiratory pressures did not change across the three groups. In this study, we examined the FVC, FEV1, FEV1/FVC, and PEFR of male T2 diabetics to healthy adult males and found no statistically significant differences (P > 0.05). Our findings could be explained by the fact that our T2 Diabetic participants were soldiers who exercised and ate well. DM did not affect their BMI or lung function. A study by Dharwakder [26] found that lung functions in T2 diabetics were lowered due to respiratory muscle weakness and suggested that rigorous glycemic control and regular breathing exercises to strengthen the respiratory muscles could enhance pulmonary function tests in diabetics. When we compared FVC, FEV1, FEV1/FVC, and PEFR of female T2 Diabetics to healthy adult females, we discovered that FVC, FEV1, andFEV1/FVC were statistically significant (P 0.05), whereas PEFR was extremely significant

(P: 0.001). This finding is consistent with the findings of Ozoh's study, which found lower PEF in female T2 diabetic Nigerians with a restrictive lifestyle.

5. CONCLUSION

When both sexes' lung functions were combined, FVC and PEFR were found to be impaired in T2DM patients. Female diabetics have a lower PEFR than healthy controls, but male diabetics have a normal PEFR.

CONSENT

Participants gave their consent to participate in this study.

ETHICAL APPROVAL

The approval was taken from the university's ethical committee.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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