IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 15, Issue 10 Ver. V (October. 2016), PP 01-07
www.iosrjournals.org

A Study of Pulmonary Function Tests in Type 2 Diabetes Mellitus Original Research Article

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Abstract: Diabetes mellitus is associated with long term damage, dysfunction and failure of various organs and its complications are mostly due macro vascular and micro vascular damage.
Like other target organs lung is also affected in diabetes. The presence of an extensive micro vascular circulation and abundant connective tissue in the lungs, raises the possibility that lung tissue may be affected by microangiopathy process and non-enzymatic glycosylation of tissue proteins, included by chronic hyperglycemia, there by rendering the lung a "target organ" in diabetic patients.
Method: The study was conducted on 100 subjects aged 45 years and above.The selected subjects were categorised into two major groups: Group1 (control) consisted of randomly selected 50 healthy non-diabetic subjects. Group2 (Study Group) consisted of 50 subjects with type 2 Diabetes mellitus. Pulmonary function tests were performed using computerized spirometer, Spiro-Excel
Summary and Conclusion: According to our study, there was a predominant restrictive pattern of the disease in type 2 diabetes mellitus, with a significant reduction of FVC, FEV1 and PEFR and normal FEV1/FVC%. In conclusion, keeping in view, the observations of the study i.e statistically significant decrease of FVC, FEV1and PEFR parameters, our result suggests that type 2 diabetes mellitus adversely affect the lung function.

I. Introduction

Diabetes comprises of heterogenous group of diseases, characterised by a state of chronic hyperglycemia, resulting from a diversity of aetiologies, environmental and genetic, acting jointly. Diabetes mellitus is associated with long term damage, dysfunction and failure of various organs and its complications are mostly due macro vascular and micro vascular damage; include cardiovascular disease, nephropathy, diabetic retinopathy, neuropathy and lung damage.[1,2]. The microvascular complications appear early within 5 to 10 years and macrovascular complications appear within 15 to 20 years from the onset of diabetes.. Hyperglycemia causes thickening of basal lamina in pulmonary capillaries leading to decreased diffusion capacity. The alteration in scleroproteins in turn affects mechanical properties of lungs. In this chronic disease susceptibility and severity of systemic inflammation increases which may cause peripheral airway obstruction.[3,4].

Since normal lung mechanism and gas exchange are influenced by the integrity of the pulmonary connective tissue and microvasculature, abnormalities in either of these two structural components of the lung may lead to the development of measurable
abnormalities of pulmonary finction.[5].

Meo et al. also observed that some spirometric lung function parameters were decreased in type 2 Diabetes and decline was more in patients with long duration of Diabetes. There is significant reduction in mean FVC in all diabetic patients and the reduction is more pronounced with duration of diabetes.[3]. Recent studies conducted by Lange et al and Asanuma et al indicate that both IDDM and NIDDM patients are associated with slight reduction in FVC and it was because of impaired defense against environmental challenges such as smoking and airway infections in diabetes.[6,7]

II. Review Of Literature

Lange et al reported that both IDDM and NIDDM are associated with slight reduced values of FEV1 and FVC. The reduction in lung function was more pronounced in diabetic subjects treated with insulin than in diabetic subjects without insulin treatment. This suggests that severity of Diabetes Mellitus might influence the degree of lung function impairment. The authors also reported the highly significant association between the raised values of plasma glucose and impairment of lung function. Many confounding factors might lead to reduction of both FEV1 and FVC in diabetic subjects, two of them being obesity and cardiac failure. The authors ruled

out these confounding factors as they had included BMI and none of the patients had cardiac failure during examination especially in NIDDM so reduced values of FVC and FEV1 were related to the impairment of lung function and were more pronounced in diabetic subjects treated with insulin than in diabetic subjects treated with oral hypoglycaemia agents and/or diet.[8] Schuyler M R et al observed that decreased elastic recoil at low lung volumes in juvenile diabetes mellitus was similar to that found in aging and was consistent in functional integrity of elastin. The authors further reported that in diabetes, total lung capacity (TLC) was significantly smaller than that of normal control subjects which could be due to alteration of collagen matrix which renders it less distensible at high lung volumes, limits the expansion of lungs or causes difference in lung maturation.

The changes observed in pressure volume curve could be due to alteration of collagen and elastin. It was postulated that these changes were related to subtle abnormalities in lung scleroproteins. The authors also observed similar changes in other organs.[9] Vracko R et al reported that epithelial and capillary basal laminae (BL) of alveoli are significantly thicker in diabetes than they are in age mathched control subjects.[10] Sandler reported that major long-term complications of diabetes mellitus is currently thought to involve both microangiopathic process and non-enzymatic glycosylation (NEG) of tissue proteins. The most consistent abnormalities were reduced lung volumes in young (aged < 25 years) insulin dependent diabetic subjects, reduced pulmonary elastic recoil in both young and adult (aged > 25 years) diabetic subjects and impaired diffusion due to reduced pulmonary capillary blood volume in the adult age group. Non-enzymatic glycosylation induced alteration of lung connective tissue was the most likely pathogenic mechanism underlying mechanical pulmonary dysfunction in diabetic subjects while most tenable explanation for impaired diffusion in these patients was the presence of underlying pulmonary microangiopathy.[11]

Aims And Objectives

- To study the pulmonary function of individuals with Type 2 Diabetes mellitus.
- To compare the pulmonary function tests of subjects with Type 2Diabetes mellitus with that of healthy non-diabetic subjects.

III. Material And Methods

This study was conducted in the Department of physiology, Maharishi Markandeshwar Institute of Medical Sciences and Research, Mullana (Ambala) in collaboration with Department of Medicine. Subjects were selected from patients visiting O.P.D or admitted in the hospital of M.M.I.M.S.R. The study was conducted on 100 subjects aged 45 years and above which visited our institute during January 2014 to January 2015.

The selected subjects were categorised into two major groups:

Group1 (control) consisted of randomly selected 50 healthy non-diabetic subjects.
Group2 (Study Group) consisted of 50 subjects with type 2 Diabetes mellitus.

Inclusive Criteria:-

- Age 45 years and above.
- Patients suffering from Type 2 Diabetes mellitus and attending O.P.D or admitted in hospital of M.M.I.M.S.R.

Exclusive Criteria

- Subjects with gross abnormalities of the vertebral column or thoracic cage.
- Any past history of respiratory disease, chest wall injuries.
- With current or previous history of smoking.

A detailed history and clinical examination was conducted on subjects as per the proforma. The anthroprometric data i.e height, weight, Body Mass Index (BMI) were recorded and pulmonary function tests performed.

Technique:-

The equipment used was computerized spirometer, Spiro-Excel (Medicaid systems Chandigarh). It had a turbine flow meter and the range for flow measurement is 0.03 L/sec. Range for volume measurement is 0-10 L. The subject was made to sit comfortably. The subject was asked to breathe in and out to familiarize himself with the equipment. The subject was then asked to inhale to his maximum capacity and forcefully blow out into the sensor (nose clipped) as hard as possible for as long as possible. This procedure was repeated and the best of three readings was considered for analysis. Data was tabulated and statistically analysed.

The parameters recorded were:-

A) Physical Parameters

Height:-A vertical measuring rod was fixed to the wall and the subjects were asked to remove the shoes and stand on flat floor in front of measuring rod with feet parallel and heels, buttocks, shoulders and back of head touching upright side. The head was held comfortably erect with lower border of the orbit in the same horizontal plane as the external auditory meatus. The arms were kept hanging by the sides in natural manner. The horizontal bar of the measuring rod was lowered to touch the head. The height was recorded to the nearest centimetre (cm).

Weight:-The platform beam balance was used to record the weight. The subjects were asked to remove the shoes and wear minimum clothing‟s and stand on the center of the platform. The reading was recorded to the nearest kilogram (kg).

Body Mass Index:- Body mass index was calculated by:-

Quetelet's Index i.e Weight(kg)
Height(m2)

B) Pulmonary Function Parameters:-

Medspiror was used to calculate the following parameters:-

1. Forced Vital Capacity (FVC):- It is maximum volume of gas that can be expired when the patient exhales as forcefully and rapidly as possible after a maximal inspiration. FVC will be smaller in both obstructive and restrictive disorders and is not of a concern unless it is 75-85% of predicted volumes. FVC alone cannot give the diagnosis of obstructive or restrictive. FVC is measure in litres.

2. Forced Expiratory Volume in 1 second (FEV1):- FEV1 measures the volume of air expired forcefully over the first second of an FVC maneuver. FEV1 reported as a volume, although it measures flow over specific intervals. Healthy individuals are able to expel 75-80% of their vital capacity in 1 second of FVC test. Low FEV1 is highly suggestive of obstructive diseases.

3. FEV1/FVC ratio: - The most standardized index of airway obstructive disease, related to ability to work and function in life. FEV1/FVC ratio expressed as % is used to determine of the pattern is obstructive, restrictive or normal. A low FEV1/FVC ratio indicates an obstructive pattern where as if ratio is normal and FVC value is low, it indicates restrictive pattern and a normal FVC value indicate normal pattern.

4. Peak Expiratory Flow Rate:- It is the maximum rate of airflow observed during a sudden forced expiration, from the position of full inspiration. It is measured in litres per second.

Ethical Consideration:- An informed and written consent was taken from participants before conducting the study.

I. Comparative anaysis of the physical parameters, Pulmonary function parameters and biochemical Parameters of the subjects under group 1(control) and
Group 2 (diabetic)

A**) Physical Parameters**

Table 1: Showing overall comparison of physical parameters of the subjects belonging to different groups i.e. Group 1(control) and Group 2 (diabetic).

	Group	N	Mean	SD	T - Test	P value
Age	1	50	52.28	6.22	0.359	0.720
	2	50	51.86	5.44		
Height	1	50	163.68	6.40	0.538	0.592
	2	50	162.92	7.68		
Weight	1	50	65.98	13.56	0.785	0.434
	2	50	67.92	11.02		
BMI	1	50	24.62	4.83	1.308	0.101
	2	50	25.88	4.80		

Table shows mean age of Group 1 as (52.28± 6.22) and mean age of Group 2 as (51.86 ± 5.44) which is found to be statistically insignificant (p = 0.720).It also shows mean height of Group1 as (163.68±6.40) and mean height of Group 2 as (162.92± 7.68) which is also found to be statistically insignificant (p=0.592).Also depicting mean weight of Group 1 as (65.98± 13.56) and mean weight of Group 2 as (67.92±11.02) which was also statistically insignificant (p = 0.434).Mean B.M.I of Group 1 was found to be (24.62±4.83) and mean B.M.I of Group 2 was (25.88±4.80) which was statistically insignificant.

B. Pulmonary function parameters

Table 2: – Table showing overall comparison of Lung Volumes among Group1(control) and Group 2(Diabetic).

Parameter	Group	N	Mean	SD	T -Test	P value
FVC	1	50	2.89	0.39	7.605	0.0001
	2	50	2.29	0.40		
FEV1	1	50	2.53	0.36	6.322	0.0001
	2	50	1.97	0.51		
PEFR	1	50	6.62	1.51	3.964	0.0001
	2	50	5.42	1.51		
FEV1/FVC	1	50	87.84	6.68	1.184	0.239
	2	50	85.87	10.43		

Table shows mean FVC of Group 1 as (2.89± 0.39) and mean FVC of Group 2 as (2.29 ± 0.40) which is found to be statistically significant (p = 0.0001).It also shows mean FEV1 of Group1 as (2.53±0.36) and mean FEV1 of Group 2 as (1.97± 0.51) which is also found to be statistically significant (p=0.0001).Also depicting mean PEFR of Group 1 as (6.62± 1.51) and mean PEFR of Group 2 as (5.42±1.51) which was also statistically significant (p = 0.0001).Mean FEV1/FVC of Group 1 was found to be (87.94±6.68) and mean FEV1/FVC of Group 2 was (85.87±10.43) which was statistically insignificant.

C) Biochemical Parameters

The Biochemical parameters i.e Blood Glucose Fasting are presented in table 3. Table 3: Table showing overall comparison of mean BGF among Group 1(control) and Group 2(Diabetic).

	Group	N	Mean	SD	T -Test	P Value
BGF(mg%)	1	50	87.48	8.63	10.936	0.0001
	2	50	138.84	32.07		

The overall mean BGF ± S.D in Group 1 was 87.48 ± 8.63 mg% and in Group 2 was 138.84 ± 32.07 mg%. Intergroup comparison revealed that statistical significant difference existed between Group 1 vs Group 2 (p=0.0001).

IV. Discussion

The present study was conducted in the Department of physiology, Maharishi Markandeshwar Institute of Medical Sciences and Research, Mullana (Ambala) in collaboration with Department of Medicine to observe the alterations in lung functions in patients with Diabetes Mellitus. Various observations depending on duration of disease and pulmonary function impairment were analysed.

The aim of present study was

- To study the pulmonary function of individuals with type 2 Diabetes Mellitus.
- To compare the pulmonary function tests of Type 2 Diabetes mellitus with that of healthy non- diabetic subjects

Pulmonary functions i.e PEFR, FEV1, FVC, FEV1/FVC% were determined using computerized spirometer (spiro-excel) .

Total 100 subjects were taken. All subjects were males. 50 formed the normal healthy control and 50 formed the study group. Study groups were further divided into groups according to the duration of diabetes mellitus.

GROUP 1- Control Group- 50 healthy non-diabetic subjects.

GROUP 2- Study Group- 50 subjects with Type 2 Diabetes mellitus

Physical Parameters:-

The mean age is comparable in Group 1, Group 2. There is no significant difference between the mean age of Group 1 and Group 2 (p = 0.720).

There is no significant difference between the age of Group 1 and Group 2A (P = 0.752). There is also no significant difference between the age group of Group 1 and Group 2B (p = 0.801). The mean age of Group 2A vs Group 2B is also not significant (p = 0.939). Height is comparable in all the four groups. There was no significant difference in mean height of Group 1 when compared with mean height of Group 2 (p = 0.592). There is no significant difference between the mean height of Group 1 and Group 2A (p = 0.490).

There is also no significant difference between the mean height of Group 1 and Group 2B (p = 0.820) Weight is compared in the two groups. There is no significant difference in mean weight of Group 1 when compared with mean weight of Group 2 (p = 0.434).

There is no significant difference in mean weight of Group 1 when compared with Group 2A (p = 0.762).

B.M.I is compared in Group 1, Group 2. There is no significant difference between the B.M.I of Group 1 when compared with Group 2 (p = 0.167). There is no significant difference between the B.M.I of Group 1 and Group 2A (p = 0.440). There is also no significant difference between the B.M.I of Group 1 and Group 2B (p= 0.167).

The observations of present study are in agreement with observations made by Shravya Keerthi G et al[12] who reported that there is no significant difference in the anthropometric data such as age, height, weight and body mass index between the diabetic patients and non-diabetic subjects. Meo S A et al [13] reported that there was no statistically significant difference in the anthropometric profiles (age, weight, height) between male diabetic and control. Asauma et al [14] also observed that there was no significant difference in the anthroprometric Profiles (age, height, weight) between male diabetics and control. Our observations are quite in aggrement with the observations made by Ratnesh Namdeo Gajbhiye and Anil Shrihari Tambe [15] who reported that anthroprometric parameters (age, height, weight, B.M.I) were found to be non-significant in type 2 diabetes as compared to control. Pulmonary Function Parameters

Forced Vital Capacity:-

The forced vital capacity represents the largest amount of air that can be expired after a maximal inspiratory effort, is frequently measured as an index of pulmonary function. It gives useful information about the strength of the respiratory muscles and other aspects of pulmonary function.[16]

In the present study, the mean value of FVC were 2.89 litres, 2.29 litres in males of Group 1, Group 2 respectively.

Overall Group Result:-

Lung Function data for type 2 diabetes patients (Group 2) and their matched control (Group 1) are shown in table 2 with mean FVC in Group 2 (2.29 ± 0.40) and that of Group 1 (2.89 ± 0.39). Type 2 diabetic patients had statistically significant reduction in FVC (P =0.0001).

The results of our study are in agreement with Lange et al and Asanuma et al who reported that both IDDM and NIDDM patients are associated with slight reduction in FVC and it was because of impaired defence against environmental challenges such as smoking and airway infections in diabetes. There is increased cross- linkage formation between polypeptides of collagen in pulmonary connective tissue, which decreases FVC and hence is responsible for restrictive respiratory defects[14,17].

Similar observations were reported by Davis W.A et al who conducted a large Community based study in western Australia in type 2 diabetic patients and demonstrated that FVC were decreased in type 2 diabetic patients. They also suggested that the reduced lung volume and airflow limitation are likely to be chronic complication of type 2 diabetes.[19] Our observations are also in agreement with Nandhini R et al who reported that percentage predicted values of FEV1 were consistently lower in diabetes than in non- diabetes, with a significant p value of 0.01.[20] Hence decrease in FVC could be due to increase cross linkage of pulmonary collagen in progressive diabetes which resulted in increased elastic recoil or decreased chest wall compliance and could be responsible for restrictive respiratory defects.[21]

Forced Expiratory Volume In One Second (Fev1):-

The fraction of the vital capacity expired during the first second of a forced expiration is referred to as FEV1. In the present study, the mean value of FEV1 were 2.53 litres, 1.97 litres in males of Group 1, Group 2 respectively.

Overall Group Result:-

Lung Function data for type 2 diabetes patients (Group 2) and their matched control (Group 1) are shown in table 2 with mean FEV1 in Group 2 (1.97 ± 0.51) and that of Group 1 (2.53 ± 0.36). Type 2 diabetic patients had statistically significant reduction in FEV1 (P =0.0001).

Our observations are quite in agreement with Lange et al who reported that there was slight reduction on FEV1 in subjects of all age groups, enrolled in Copenhagen city heart study, having both IDDM and NIDDM.[17] Davis et al demonstrated that FEV1 were decreased in type 2 Diabetic patients and also suggested that the reduced lung volumes and airflow limitations are likely to be chronic complication of type 2 diabetes.[19] Meo et al in their studies on Saudi diabetic patients showed significant reduction in FEV1 as compared to their matched controls.[13] peak expiratory flow rate (pefr):- In the present study, the mean value of PEFR were 6.62 litres/sec, 5.42 litres/sec in males of Group 1, Group 2 respectively.

Overall Group Result:- Lung Function data for type 2 diabetes patients (Group 2) and their matched control (Group 1) are shown in table 2 with mean PEFR in Group 2 (5.42 ± 1.51) and that of Group 1 (6.62 ± 1.51). Type 2 diabetic patients had statistically significant reduction in PEFR (P =0.0001).

Our observations are quite in agreement with Davis et al who demonstrated that PEFR were decreased in type 2 diabetic patients.[19] Meo et al also in their studies on Saudi diabetic patients showed significant reduction in PEFR as compared to their matched control.[13] Shravya Keerthi G et al also reported that there was an absolute decrease in the mean values of PEFR when compared to predicted values which was statistically significant ($p < 0.001$). [22]

Fev1/Fvc Ratio:- FEV1/FVC% is the volume of air expired in the first second, expressed as percentage of FVC. It is more sensitive indicator of airway obstruction than FVC or FEV1. The alteration in collagen and elastic ratio is the main factor in the diabetic patient. The decrease in FEV1/FVC% in diabetic subjects may be related with the poor mechanical properties of the lung, like lung compliance and elastic recoil of lung. Loss of elastic recoil leads to dynamic collapse of small airways during expiration. In addition, myopathic or neuropathic changes affecting the respiratory muscles further impairs the endurance, efficiency of ventilator pump.[24] In the present study, the mean value of FVC/FEV1% were 87.94%, 85.87% in males of Group 1, Group 2 respectively.

Overall Group Result:- Lung Function data for type 2 diabetes patients (Group 2) and their matched control (Group 1) are shown in table 2 with mean FEV1/FVC% in Group 2 is 85.87% and that of Group 1 87.94%. Type 2 diabetic patients had reduction in FEV1/FVC% but it was not statistically significant (P =0.239).

Similar observations were reported by Meo et al who reported that there was no significant difference for FEV1/FVC% relative to control.[13] Muhammad Irfan et al also demonstrated that FEV1/FVC was less in diabetes and was statistically non-significant.[23] Our observations are quite in agreement with Nandhini R et al who reported there was a rough decrease in the values of FEV1/FVC in diabetes as compared to that in non diabetics, though it didn"t reach a statistical significance.[20]

Diabetes And Biochemical Parameters:-

Blood Glucose Fasting:- In the present study, the mean value of BGF were 87.48 mg%, 138.84 mg% in males of Group 1, Group 2 respectively.

Overall Group Result:- Lung Function data for type 2 diabetes patients (Group 2) and their matched control (Group 1) are shown in table 3 with mean BGF in Group 2 is 138.84 mg% and that of Group 1 is 87.48 mg%. Type 2 diabetic patients had statistically significant increase in BGF (P =0.0001).

Our findings are consistent with the observations made by Singh, Sircar and Singh who concluded the spirometric measurements on NIDDM patients with short history of presenting complaints and hyperglycemia. The results showed significant restrictive impairments in ventilation in the diabetic group. [24]

Lange et al also reported highly significant association between raised values of plasma glucose and impairement of lung function.[25] Our observations are in agreement with Mahmoud M.El-Habashya et al who reported that uncontrolled diabetes show a greater decrease in ventilator functions than controlled diabetes.[25]

Summary And Conclusion

According to our study, there was a predominant restrictive pattern of the disease in type 2 diabetes mellitus, with a significant reduction of FVC, FEV1 and PEFR and normal FEV1/FVC%. In conclusion, keeping in view, the observations of the study i.e statistically significant decrease of FVC, FEV1and PEFR parameters, our result suggests that type 2 diabetes mellitus adversely affect the lung function.

Hence, an early detection of the reduced pulmonary function and the respiratory myopathy through simple spirometry as a routine test is essential for preventing the respiratory complications outcome which is caused by diabetes mellitus.

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Sources of support – Nil
Conflict of interest—None declared

DR.ANUPAMA KAUR is no longer affiliated with M.M.I.M.S.R. However this work was done during her stay in the organization.