Can pulmonary function tests be used as a tool to determine lung age?

Sweety.L.M[1], Chandra Selvi.E[2], Saikumar.P[3]

[1, 2, 3] *Department of Physiology, Sree Balaji Medical College & Hospital, Bharath University, Chennai, India.*

Abstract: Back ground: *Diabetes mellitus, which is the chronic metabolic disorder, with increasing incidence, causes multiple organ damage, but lung as a target organ is seldom concentrated. Studies done earlier had proved that pulmonary complications occur in diabetes mellitus due to various causes. This study is focused to determine the lung age using pulmonary function tests, which indicate the quantity of morbidity of diabetes.**Aim & objective:*** *To determine the lung age in patients with type 2 diabetes mellitus using pulmonary function tests.* ***Materials and methods:*** *Around forty five type 2 diabetic patients attending Diabetology out patient department of Sree Balaji Medical College & Hospitals were recruited. Age and sex matched controls were also selected. Both the cases and controls were subjected to do pulmonary function tests. From the pulmonary function test parameters like FVC & FEV1 the lung age was calculated. The results were analyzed using paired student t test.* ***Result:*** *There was no statistical difference between the chronological age and estimated lung age in controls. Whereas in diabetic patients there was significant statistical increase in the estimated lung age when compared with the chronological age (p<0.001).**conclusion:*** *The estimated age of diabetic lung is well above the chronological age. We conclude that spirometric lung age can be used to estimate degree of impairment caused by diabetes in lungs. It can also be used as a tool to educate the patients to have good diabetic control.*
Key words: *Lung Age, Diabetes mellitus, chronological age*

I.   Introduction

The average life span of an Indian is around 63.7 yrs [1]. There are number of morbid conditions as cardiovascular diseases, infectious diseases, tumors, suicides, road traffic accidents and so on which contributes to the reduction in the life span of Indians. Diabetes mellitus is one of the chronic metabolic syndromes whose world wide prevalence has risen dramatically over the past two decades. India leads the world with largest number of diabetic subjects earning the dubious distinction of being termed the "diabetes capital of the world". With an increasing incidence diabetes mellitus will be the leading cause of morbidity and mortality in the foreseeable future[2].

The life threatening complication of diabetes mellitus occurs due to secondary pathophysiologic changes in multiple organ system as heart (coronary artery disease), brain (cerebrovascular disease), kidneys (nephropathy), lungs (microangiopathy), eyes (retinopathy), nervous system (neuropathy) [3]. Through its varying complication diabetes mellitus indirectly affect the life span of an individual.

Earlier research work done by Kanya Kumari et al.,[4] and Sanjeev Verma et al.,[5] had proved that type 2 diabetes mellitus is associated with restrictive pattern of respiratory abnormality. Whereas Sreeja et.al. [6] and Md Omar Ali et al observed obstructive type of lung function abnormality. Sultan Meo et al., [7] had evidenced that pulmonary function in patients with diabetes was impaired by decrease in FVC and FEV1 compared to matched controls. Similarly deterioration of pulmonary gas exchange occurs due to micro angiopathic complications of diabetes mellitus [8]. As a result of all these complications ventilation gets impaired in diabetic patients.

It is a known fact that pulmonary function tests are widely used to assess lung volumes, capacities and diffusion across the respiratory membrane. However this study is focused upon the usage of pulmonary function test in different aspect. In this study we assessed the degree of functional impairment in lungs by measuring the 'Lung Age'. Lung age was calculated from the spirometric results and compared with the individual's chronological age [9]. The calculated lung age quantifies the pulmonary impairment caused by the disease in the lungs. Hence this helps in the quantification of morbidity of illness.

II.   Materials And Methods

Study population

This study was carried out in the Department of Physiology, Sree Balaji Medical College and Hospital .In our study we recruited 45 type 2 diabetic patients who attended the Diabetology out patient department of Sree Balaji Medical College and Hospital as subjects. They all belong to 35- 55 years of age. Out of which 15 were males and 30 were females. Age and sex matched healthy volunteers were selected as controls.

The study was approved by the institutional ethical committee. Questionnaire was given to all the subjects and a well informed written consent was obtained from all those who participated.

Inclusion criteria
a) Type 2 Diabetic patients
b) Stable patients
c) Non smokers
d) Individuals not practicing yoga

Exclusion criteria
 The patients suffering from the following diseases were excluded from this study.
 a) Cardiac diseases
 b) Liver diseases
 c) Bronchial asthma
 d) COPD
 e) Smokers

Blood Parameters: Around 5ml of venous blood was collected in our Central Laboratory both from controls and diabetic patients to assess their fasting and post prandial blood sugar levels. Both patients and controls were subjected to do pulmonary function test in our Physiology Department Laboratory using Computerized Spirometer.

Pulmonary Function Test The patients were instructed to inspire air maximally and then breathe out to the maximum using the spirometer mouth piece. The data's were displayed on the computer monitor. Lung age was calculated using measured FVC and FEV1.

Statistical analysis The results were tabulated and the values were expressed in mean $\pm$ standard deviation. Paired Student t test was used to compare and find the association between predicted lung age and FVC and FEV1 estimated lung age in cases and control group. Pearson correlation analysis was used to find the correlation between fasting blood sugar and estimated lung age.

III.   Results
Table 1. Physical characteristics of Diabetic Patients & controls

Parameters	Cases	Controls
Age (yrs)	47.8 ± 6.4	47.8 ± 6.2
Sex	Males = 30 Females = 15	Males = 30 Females = 15
Weight(kg)	62.3 ± 9	60.6 ± 5
Height(cm)	156.64 ± 8.59	154.64 ± 5.89
BMI	25.4 ± 3.95	25.3 ± 1.22
FBS(mg/dl)	134.22 ± 40.34**	88.84 ± 13.3**
PPBS(mg/dl)	212 ± 52.54**	125.6 ± 23.04**

 ** - p < 0.001 highly significant
FBS - Fasting Blood Sugar; PPBS – Post Prandial Blood Sugar; BMI – Body Mass Index;
Table 1 shows the physical characteristic variables of both cases and controls. All the values have been expressed in mean ± standard deviation. The fasting and post prandial blood sugar levels of diabetic patients are elevated.

Table 2 Comparison between predicted and estimated lung age in diabetic patients and controls.

PARAMETERS	LUNG AGE (yrs)			
	CASES		CONTROLS	
	Predicted	Estimated	Predicted	Estimated
FVC	47.8 ± 6.4	116.84 ± 25.4**	47.8 ± 6.2	48.2 ± 5.5ns
FEV1	47.8 ± 6.4	87.37 ± 19.7**	47.8 ± 6.2	48.08 ± 5.62ns

** - p<0.001 highly significant. ns – Not significant (p >0.05)

Men

Lung Age[9] FVC = 5.920H – 40(observed FVC) - 169.640

FEV1= 2.870H – 31.25(observed FEV1) – 39.375

Women

Lung Age[9] FVC = 4.792H – 41.667 (observed FVC) – 118.883

FEV1 = 3.560H – 40 (observed FEV1) - 77.280

H = Height in inches

Table 2 displays the comparison between the predicted and estimated lung age of diabetic patients and controls. It is evident that there exists a highly significant association between the predicted and estimated lung age among diabetics; whereas in the case of controls there is no association between the predicted and estimated lung age.

Table 3. Comparison between percent predicted values of FVC and FEV1 in cases and controls.

Parameters	Cases	Controls
% FVC	55.05 ± 13.89*	83.5 ± 9.7*
% FEV1	56.11 ± 19.71*	92.63 ± 15.8*

* - $p < 0.05$ significant

Figure 1& 2. Estimated lung age (FVC & FEV1) in diabetic patients of varying duration

Figure 1   Figure 2
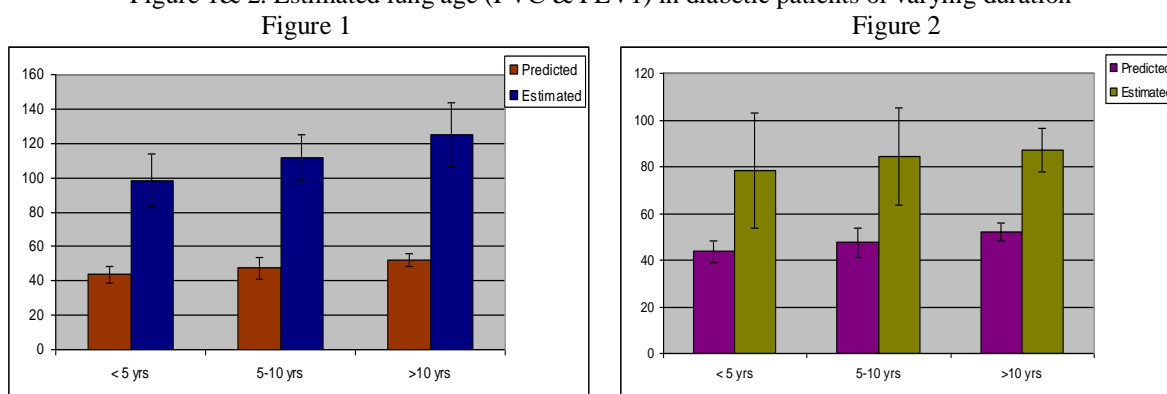

Figure 1 & 2 represents the bar diagram of estimated lung age by considering FVC & FEV1 of diabetic patients of varying duration. It can be clearly observed that as duration of disease progress the estimated lung age also increases.

Figure 3& 4. Correlation between fasting blood sugar & estimated Lung age (FVC) in controls & diabetic patients

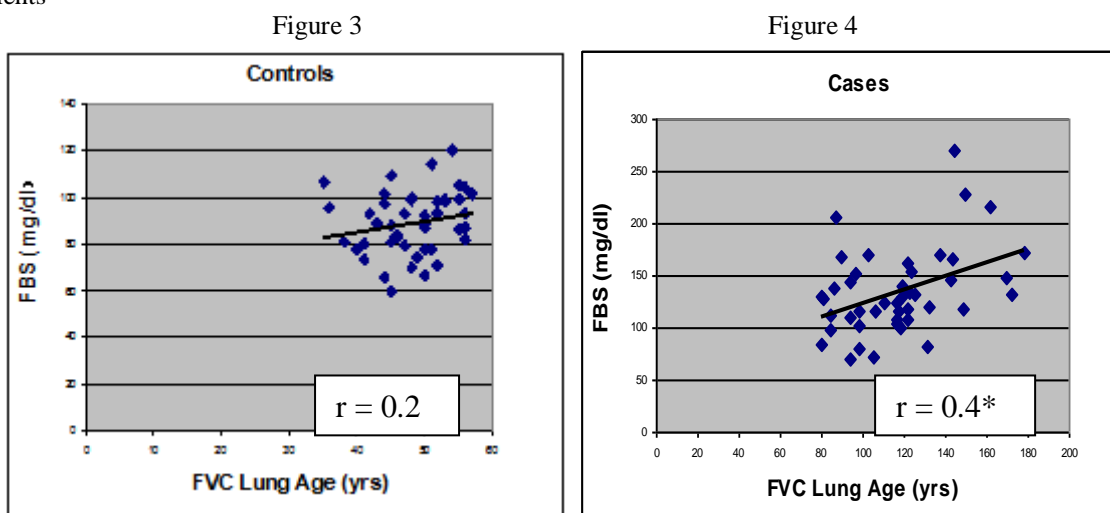Figure 3   Figure 4

Figure 3& 4 shows correlation between fasting blood sugar and lung age by calculating observed FVC both in diabetic patients and controls. There exist a positive correlation among both cases and controls; but the correlation was significant among diabetic patients.

Figure 5& 6. Correlation between fasting blood sugar & estimated Lung age (FEV1) in controls & diabetic patients.
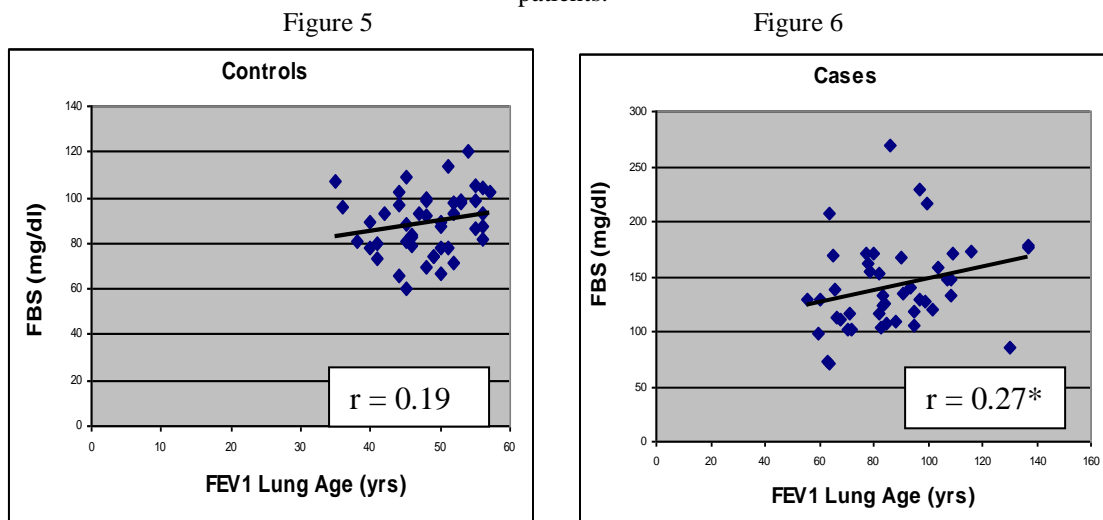
Figure 5

Figure 6

Figure 5 & 6shows correlation between fasting blood sugar and estimated lung age by calculating observed FEV1 both in diabetic patients and controls. There exist a positive correlation among both cases and controls; but the correlation was significant among diabetic patients.

IV.   Discussion

In our study the age, height, weight & sex were matched among diabetics and controls. The fasting and post prandial blood sugar levels of the diabetic patients were elevated compared with that of controls (table 1). Thus the elevated blood sugar levels leads to chronic hyperglycemia in patients. Hence they become more prone to develop complications.

The predicted and estimated lung age of diabetic patients by calculating FVC was 47.8 ± 6.4 and 116.84 ± 25.4years respectively (table 2). Whereas the predicted and estimated lung age in controls by calculating FVC was 47.8 ± 6.2 and 48.2 ± 5.5 years respectively. There was a statistically significant increase in the estimated lung age in diabetic patients in relation with FVC. This increased estimated lung age in diabetics may be associated with the functional impairment of the mechanics of breathing including abnormalities in the elastic recoil of the lung tissues, respiratory muscles, energy utilized for elevation and depression of thoracic cage.

In the bar diagram (figure 1&2) representing the estimated lung age of diabetic patients of varying duration showed increase in estimated lung age as duration of disease progressed. Moreover we observed significant positive correlation between fasting blood sugar values and estimated lung age by calculating FVC (figure 3&4) in diabetic patients. Whereas in control subjects though the correlation between fasting blood sugar values and lung age was positive it was not significant. Sanjeev Verma et al.,[5] suggested that insulin deficiency followed by chronic hyperglycemia in diabetic patients may increase cross-linkage formation between polypeptides of collagen fibers in pulmonary connective tissue thereby reducing FVC (table 3) and increasing estimated lung age.

The predicted and estimated lung age of diabetic patients by calculating FEV1 was 47.8 ± 6.4 and 87.37 ± 19.7 years respectively (table 2). Whereas the predicted and estimated lung age in controls by calculating FEV1 was 47.8 ± 6.2 and 48.08 ± 5.62 years respectively. In our results the reduction in FEV1 (table 3) reflects significant increase in the estimated lung age in diabetic patients. Various factors which reduce FEV1 might be the reason for the contribution towards the increase in the estimated lung age.

Moreover we observed significant positive correlation between fasting blood sugar values and estimated lung age by calculating FEV1 in diabetic patients (figure 5&6). Whereas in controls though the correlation between fasting blood sugar values and estimated lung age was positive it was not significant. The reason for reduction in FEV1 and increased estimated lung age in diabetics is due to hyperglycemia which causes NO dependent endothelial dysfunction and decreased production of NO which ultimately lead to bronchoconstriction[10].

Hence the discrepancy between the predicted and estimated lung age in diabetic individuals directly reflects the functional impairment and damage caused by the disease in lungs. This clearly proves that premature aging of the lung occurs due to obstructive and restrictive lung disease. This also helps us to quantitate the degree of damage caused by diabetes in the lung.

Diabetes mellitus causes multi system organ damage. But quantification of the degree of individual organ damage has not been proved earlier. Our study provides a method to estimate the lung age in diabetics by using spirometric results. Along with reduction in FVC and FEV1, estimation of lung age provides an additional incentive to the patients. But the estimated lung age should never be translated in the form of life span. The functional age or rate of aging of one organ such as the lung cannot be used to predict that of another organ system or the individual [9].

Thus spirometric lung age can be used as a tool to impress the patients regarding their degree of pulmonary impairment. It can also be used to educate the diabetic patients in order to have a good diabetic control to prevent further lung damage and to improve their lung functions. Thus we emphasize that the estimated lung age can be used as a psychological tool to confront the diabetics with the premature aging of lung.

V.   Conclusion

We conclude that spirometric lung age can be used to estimate degree of impairment caused by diabetes in lungs. It can also be used as a tool to educate the patients to have good diabetic control.

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