https://doi.org/10.48047/AFJBS.6.12.2024.372-380

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

A cross sectional study on effect of glycaemic status and duration of type II diabetes mellitus on the pulmonary function

AUTHOR DETAILS

First Author& Corresponding Author
1.M.Praveena,MD
Assistant Professor, Department of Physiology, Trichy SRMMCH&RC, Irungalur, Trichy – 621105.
Mail id: drpraveena2000@gmail.com
Mobile no. 9566371859
Second Author
2.K.ThamaraiSelvi,MD
Professor, Department of Physiology, SRMMCH&RC, SRM Institute of Science & Technology, Kattankulathur – 603203.
mail id: thamarak@srmist.edu.in
Third Author
3.Nachal Annamalai, MD
Retired Professor, Department of Physiology, Trichy SRMMCH&RC, Irungalur, Trichy – 621105.
mail id: nachal.a@gmail.com

Article History

Volume 6 Issue 12, 2024
Received: 25 May 2024
Accepted : 25 June 2024
doi:
10.48047/AFJBS.6.12.2024.372-380

ABSTRACT

Background: Diabetes mellitus is a metabolic disorder with multifactorial etiology. Type 2 diabetes (T2DM) occurs due to inadequate insulin secretion and resistance to insulin action. In India, the burden of diabetes expected to rise to over 134 million by 2045 in India. Pulmonary complications of diabetes mellitus have been poorly categorized. The duration of diabetes and glycaemic status has shown marked emphasis on functions of the lungs. The aim of our study was to determine the effect of glycaemic status and duration of diabetes on pulmonary function in spirometry among type 2 diabetes mellitus patients.

Materials and Methods: This is a cross-sectional study involving 140 type 2 diabetes mellitus patients. The study participants were subjected to cosmed computerized spirometer to assess pulmonary function tests. The data obtained was analysed using unpaired student't' test and to find the association, Pearson's correlation test was used.The pulmonary function tests were compared with duration of diabetes by ANOVA test. The p value < 0.05 was taken as level of statistical significance.

Results: The findings of our study revealed that there was a statistically significant reduction in mean values of FVC, FEV1, PEF, MIP, MEP and raised FEV1% among type 2 diabetic patients with poor glycaemic control and long duration of diabetes in comparison to subjects with good glycaemic control and relatively short duration of diabetes. Also, there was a statistically significant negative linear correlation between FVC, FEV1, PEF, MIP, and glycaemic status ($p<0.05$). The study findings suggest that there is a restrictive pattern of pulmonary impairment among the type 2

diabetes mellitus patients.
Conclusion: The development of pulmonary impairment among the type 2 diabetes mellitus patients is strongly associated with poor glycaemic control and long duration of diabetes. Therefore, periodic assessment of lung function by spirometry tests and intensive glycaemic control can avert or delay the hyperglycaemia induced progressive lung damage in diabetic individuals.
Keywords: Forced expiratory volume in 1 second(FEV1), FEV1%, Forced vital capacity, Glycaemic status, Peak Expiratory Flow, T2DM.

Introduction

Diabetes mellitus was identified as a disease entity in ancient Indian Ayurveda. Diabetes mellitus is a metabolic disorder characterized by hyperglycemia resulting from deficiency of insulin secretion, functions of insulin action or both[1]. Diabetes was characterized by polyuria can be traced to Egyptian papyrus dating back to around 1550 BC[2]. Diabetes mellitus has emerged as one of the largest global health emergencies of this century. It ranks among the ten leading causes of mortality along with cardiovascular disease, respiratory disease, and cancer[3].

The duration of diabetes and glycaemic control has varied impacts on pulmonary functions[4]. The abundance of connective tissue and extensive microcirculation of the lung has raised the possibility that the lung may also be a target organ, but its effect on the lungs is very poorly characterized[5,6].In diabetes, increased systemic inflammation may result in pulmonary inflammation leading to airway damage. Restriction of lung volume and alveolar gas transport will be caused by microangiopathy in the lungs. The other changes will be chronic low grade inflammation, reduced elastic recoil, decreased pulmonary capillary blood volume, decreased membrane diffusing capacity, diminished respiratory muscle performance and autonomic neuropathy involving respiratory muscles[7,8,9].Spirometry is one of the most commonly used pulmonary function test tool, to evaluate obstructive and restrictive lung pathology at an earlier stage. The present study emphasizes the significance of using spirometer as a routine screening tool, to improve the quality of life in the management of type 2 diabetic patients[10].

In India, few studies were done to evaluate the pulmonary functions and its relation with duration of diabetes and HbA1c values. In previous few studies, it was found that increase in mean HbA1c was significantly associated with a decrease in forced vital capacity and force expiratory volume in 1 second, but in other studies these effects were inconsistent [5, 6,7,11].The objective of our study was to enlighten the spirometric pulmonary function changes in relation to duration and glycaemic status in type 2 diabetes mellitus patients.

Aim

To determine the effects of type 2 diabetes mellitus on pulmonary function.

Objectives

To determine the association between pulmonary function tests in Type 2 Diabetes mellitus patient in relation to glycaemic status.

To determine the association between pulmonary function tests in Type 2 Diabetes mellitus patient in relation to duration of diabetes.

Material and methods

It was a cross sectional observational study involving 140 Type 2 Diabetes Mellitus diagnosed patients between 40 to 65 years attending the Medicine Department OPD during the period of September 2022 to February 2023.

Type 2 Diabetes mellitus patients aged between 40-65 years were included and age below 40 and above 65 years, history of smoking, alcohol, respiratory diseases, cardiovascular diseases, stroke, neuromuscular disease, chest wall disease, lung malignancy, previous lung/thoracic surgeries, vertebral column problems was excluded from the study.

Fasting and postprandial blood sugar levels estimated by glucohexokinase method.HbA1C estimated by cation-exchange high performance liquid chromatography(HPLC) method.The pulmonary function tests were assessed by Computerized Spirometer “COSMED Pony FX,Italy.”

The study was conducted in the Medicine department, TSRMMCH&RC, after getting clearance from the Institutional Human Ethics Committee (IHEC). Informed and written consent were obtained from all those who participated in the study. Based on inclusion and exclusion criteria, the study sample of 140 was recruited.Their detailed history was taken. Age, height, weight, BMI, respiratory rate were recorded, and detailed physical examination was done. According to American Diabetes Association guidelines 2023,FPG ≥126mg/dl and postprandial plasma glucose ≥ 200mg/dl, HbA1C ≥ 7% was taken as criteria for detecting Type 2 Diabetes patients**.** The pulmonary function tests of Type 2 Diabetes patients were assessed by using Computerized Spirometer "COSMED" in a quiet room in sitting position. The nose clip attached to nose and mouthpiece placed in mouth with lips closed around it. In an upright posture, maximal inhalation of atmospheric air done and then quickly expired forcefully followed by maximal inspiration. Repeat maneuvers done for a minimum of three times and the maximum values taken[12].The pulmonary parameters likeForced vital capacity(FVC), Forced expiratory volume in 1 second(FEV1), FEV1%, Peak expiratory flow(PEF).

Inspiratory muscle strength was recorded by emptying the lungs initially. Then maximum effort is applied to inspire forcefully through the machine. Recording of expiratory muscle strength was done by filling the lungs up to total lung capacity and then followed by maximum effort expiring forcefully through the machine. The highest value was recorded after three trials.Maximum inspiratory pressure (MIP) and Maximum expiratory pressure (MEP) were recorded by the machine.

Data thus collected was subjected to appropriate statistical analysis using an SPSS software version 24.0. For comparison of continuous variable, the unpaired student 't' test was used after testing for normality and to find the association Pearson's correlation test was used.The pulmonary function tests were compared with duration of diabetes by using one-way ANOVA test. The p value < 0.05 were taken as level of statistically significance.

Results

Table 1: Pulmonary function test parameters in relation to HbA1C values of Type 2 Diabetic patients. (n=140)

Pulmonary function tests	HbA1C	Mean	SD	p value
FVC	≤ 7 %	2.26	0.70	**0.008***
	>7 %	1.74	0.70	
FEV1	≤ 7 %	2.05	0.60	**<0.001***
	>7 %	1.37	0.61	
FEV1%	≤ 7 %	85.55	10.79	**0.023***
	%	92.07	5.84	
PEF	≤ 7 %	4.35	1.07	**0.035***
	%	3.38	1.71	
MIP	≤ 7 %	50.13	6.31	**0.031***
	%	40.76	16.67	
MEP	≤ 7 %	53.00	9.22	**0.020***
	%	42.08	17.60	

*****p value < 0.05 considered statistically significant

The mean values of FVC, FEV1, PEF, MIP, MEP mean values in type 2 diabetic patients with HbA1C >7 % was reduced with the p valuebeing statistically significant. In type 2 diabetic patients with HbA1C >7 % the mean value of FEV1% was higher with statistically significant p value**.**

Table 2: Pulmonary function test parameters in relation to Fasting plasma glucose levels (FPG) of Type 2 Diabetic patients. (n=140)

Pulmonary function Tests	FBS	Mean	SD	p value
FVC	<126 mg/dl	2.18	0.86	**0.009***
	≥126 mg/dl	1.77	0.72	
FEV1	<126 mg/dl	1.87	0.60	**<0.001***
	≥126 mg/dl	1.38	0.63	
FEV1%	<126 mg/dl	85.89	10.37	**0.007***
	≥126 mg/dl	91.47	7.40	
PEF	<126 mg/dl	4.18	1.68	**0.010***
	≥126 mg/dl	3.30	1.64	
	≥126 mg/dl	45.41	16.83	
MIP	<126 mg/dl	54.47	11.16	**<0.001***
	≥126 mg/dl	40.48	15.54	
MEP	<126 mg/dl	62.07	16.46	**<0.001***
	≥126 mg/dl	41.85	16.19	

*****p value < 0.05 considered statistically significant

The mean values of FVC, FEV1, PEF, MIP, MEP in type 2 diabetic patients withfasting blood sugar level ≥126 mg/dl was reduced with the p valuebeing statistically significant. In type 2 diabetic patients with fasting blood sugar level ≥126 mg/dl the mean value of FEV1% was higher with statistically significant p value**.**

Table 3: Pulmonary function test parameters in relation to Post prandial blood sugar (PPBS) levels of Type 2 Diabetic patients.

Pulmonary function Tests	PPBS	Mean	SD	p value
FVC	<200 mg/dl	2.22	0.83	**0.002***
	≥200 mg/dl	1.75	0.71	
FEV1	<200 mg/dl	1.82	0.72	**0.001***
	≥200 mg/dl	1.38	0.59	
FEV1%	<200 mg/dl	87.04	10.46	**0.04***
	≥200 mg/dl	92.24	8.78	
PEF	<200 mg/dl	4.25	1.82	**0.002***
	≥200 mg/dl	3.24	1.56	
MIP	<200 mg/dl	51.44	15.35	**<0.001***
	≥200 mg/dl	40.92	15.09	
MEP	<200 mg/dl	56.68	18.50	**<0.001***
	≥200 mg/dl	42.82	16.85	

p value < 0.05 considered statistically significant

The mean values of FVC, FEV1, PEF, MIP, MEP in type 2 diabetic patients withpostprandial blood sugar level ≥200 mg/dl was reduced with the p valuebeing statistically significant. In type 2 diabetic patients with postprandial blood sugar level ≥200 mg/dl the mean value of FEV1% was higher with statistically significant p value**.**

Table 4: Pulmonary function test parameters in relation to duration of Type 2 Diabetic patients.

Pulmonary function	Duration of diabetes in years			p value
	1 -3 years (n=36)	3 – 5 years`(n=29)	>5 years(n=75)	

Tests							
FVC	2.05	0.73	1.89	0.69	1.76	0.80	**0.04***
FEV1	1.68	0.63	1.53	0.55	1.38	0.68	**0.03***
FEV1%	86.10	11.60	86.71	10.24	88.67	8.25	0.54
PEF	3.89	1.74	3.68	1.67	3.21	1.62	0.72
MIP	46.78	14.57	45.31	16.98	41.19	15.66	**0.028***
MEP	51.28	17.11	49.69	17.00	44.31	19.12	**0.037***

*****p value < 0.05 considered statistically significant

The mean values of FVC, FEV1, PEF, MIP, MEP in type 2 diabetic patients was reduced withincreasedduration of diabetes with the p valuebeing statistically significant. In type 2 diabetic patients with increased duration of diabetes, the mean value of FEV1% was higher with statistically significant p value**.**

Table 5: Correlation between Pulmonary function test parameters and HbA1C of Type 2 Diabetic patients. (n=140)

Pulmonary function Tests	**Pearson correlate r value**	**p value**
FVC	-0.26	**0.002***
FEV1	-0.29	**<0.001***
FEV1%	-0.17	**0.042***
PEF	-0.18	**0.035***
MIP	-0.28	**0.040***
MEP	0.10	0.15

*****p value < 0.05 considered statistically significant

The Pearson's correlation between FVC, FEV1, FEV1% PEF, MIP and HbA1C in Type 2 Diabetic patients yielded a negative correlation with statistically significant p value. Also there was no statistically significant correlation between duration of diabetes and HbA_1C levels (r=0.05, p value: 0.542).

Table 6: Correlation between Pulmonary function test parameters and Fasting plasma glucose (FPG) levels of Type 2 Diabetic patients. (n=140)

Pulmonary function Tests	**Pearson correlate r value**	**p value**
FVC	-0.231	**0.030***
FEV1	-.177	**0.047***
FEV1%	-0.202	**0.017***
PEF	-0.241	**0.032***
MIP	-0.23	**0.006***
MEP	-0.24	**0.006***

*p value < 0.05 considered statistically significant

The Pearson's correlation between FVC, FEV1, FEV1% PEF, MIP, MEP and fasting plasma glucose (FPG) levels in Type 2 Diabetic patients yielded a negative correlation with statistically significant p value.

Table 7: Correlation between Pulmonary function test parameters and Post prandial plasma glucose values of Type 2 Diabetic patients. (n=140)

Pulmonary function Tests	Pearson correlate r value	p value
FVC	-0.245	**0.044***
FEV1	-0.185	**0.029***
FEV1%	-0.188	**0.029***
PEF	-0.049	0.562
MIP	-0.200	**0.018***
MEP	-0.241	**0.041***

*p value < 0.05 considered statistically significant

The Pearson's correlation between FVC, FEV1, FEV1% PEF, MIP, MEP and post prandial plasma glucose values(PPPG) levelsin Type 2 Diabetic patients yielded a negative correlation with statistically significant p value.

Discussion

This cross-sectional observational study was conducted to assess the impairment of pulmonary function if any among the type 2 diabetes patients and to elicit the association between pulmonary function tests with glycaemic control, and duration of diabetes.

The findings of our study show that there was a statistically significant reduction in mean FVC, FEV1, PEF, MIP, MEP among type 2 diabetic patients with poor glycaemic control as indicated by HbA1C levels of above 7 % compared to patients with good glycaemic control (HbA1c<7%) (Table 1). Also, similar reduction in mean FVC, FEV1, PEF, MIP, MEP was observed in patients with fasting levels above 126 mgs% and post-prandial glucose levels above 200 mgs% in comparison to their counterparts (Table 2,3). Furthermore, among the type 2 diabetic patients with poor glycaemic control (HbA1C >7 %) the mean values FEV1% (FEV1/FVC ratio) was higher than patients with good glycaemic control. A similar association was found between levels of FEV1% and elevated levels of fasting and post-prandial plasma glucose levels (Table 1-3).

The study findings suggest that there is restrictive pattern of pulmonary impairment among the type 2 diabetes mellitus patients and development of this pulmonary impairment is strongly associated with poor glycaemic control. The restrictive pattern observed in the study can be linked to the factors such as decreased lung recoil accompanied with thickening of alveolar epithelium and pulmonary capillary basal lamina[1].

The findings of the study are consistent with the study conducted by Bharat et al [14] and Jamasiya et al [15] wherein a similar reduction in FVC and PEF was observed besides a rising FEV1 / FVC ratio among the diabetic population in comparison to the non-diabetic individuals. The possible explanation for the reduced levels of forced vital capacity and peak expiry flow along with reduced FEV1 / FVC ratio can be that microangiopathy linked to glycaemic control in diabetes mellitus along with increased glycosylation products can damage the muscular recoil System involved in the force expiration of the lung.

On the contrary, some research studies[16,17] have reported that there were no significant differences in pulmonary function parameters between diabetic individuals and non-diabetic individuals and the possible explanation might be differences in methodological, social demographic and differences in anthropometric characteristics of the study population.

Various research studies such as Tesema et al[18],Uz-Zaman et al[19], Karintholil et al[20] ,reported a similar restrictive pattern of diabetic individuals and linked the reduction in forced vital capacity and peak expiratory flow to glycemic control as indicated by HbA1c levels. Though Karintholil et

al[20] reported a negative correlation between HbA1c levels and FEV1/FVC ratio, Tesema et al[18] reported a negative correlation between fasting blood sugar levels and FEV1/FVC ratio.
The findings ofUz-Zaman et al[19] correlated well with the current study findings as both the reduction in FVC, PEF and the increment in FEV1/ FVC ratio were similarly linked to the HbA1C levels above 7%. Also, there was a significant correlation between HbA1C levels and FEV1/ FVC ratio.
Sinha et al[17] and Agarwal et al[21] observed similar findings such as the decrease in FVC%, FEV1% besides an increase in FEV1/FVC% along with rise in HbA1C levels among the diabetic individuals as indicated by a significant negative correlation between HbA1C levels and FEV1/ FVC ratio.
In our study, we also observed that in addition to glycaemic control, the duration of diabetes also plays a role in impairment of lung function in diabetic individuals as indicated by a reduction in FVC, FEV1,PEF, MIP, MEP in type 2 diabetic patients withincreasedduration of diabetes besides the mean value of FEV1% was higher with statistically significant p value**.**
Similarly, Davis et al[22] and Barett et al[23] also observed a significant negative correlation between the pulmonary function test parameters and mean duration of diabetes as observed in the current study. Charak et al[8] observed that reduction in FVC and PEF in individuals with duration of diabetes above 10 years compared to those with duration of less than 10 years.
The link between duration of diabetes and impairment of lung function can be explained by accumulation of glycosylation products and non-enzymatic glycosylation of tissues along with development of chronic microangiopathy resulting in thickening of basement membrane and reduction in elasticity of connective tissues and thus affecting the normal elastic recoil and compliance of lung.Poor respiratory muscle strength occurs as a result of increased protein catabolism.Decrease in the force generating capacity of the expiratory muscle and the reduced elastic recoiling of the lungs. Restriction of lung volume and alveolar gas transport is due to microangiopathy in the lungs[22,24,25,26].

Conclusion

The study findings indicate a restrictive pattern of pulmonary function impairment among type 2 diabetic individuals and this impairment in lung function is higher among individuals with poor glycaemic control and long duration of diabetes mellitus.

Limitations & Recommendations

The sample size of this study was relatively small, therefore studies with large sample size are needed to support the association between duration of type 2 diabetes mellitus and glycemic status. Periodic assessment of lung function by spirometry test and intensive glycaemic control can avert or delay the hyperglycaemia induced progressive lung damage in diabetic individuals.

ConflictofInterest

There are no conflicts of interest.

FundingSource

There is no funding source.

Reference

1. 1. Tripathy BB, Rastogi SS, Moses A, Moses SG. Landmarks in the history of diabetes. RSSDI Textbook of Diabetes Mellitus. 1st ed. Hyderabad: RSSDI. 2002:1-32.

2. Nerkar N, Ashok P, Purandare V R. Assessment of Forced Vital Capacity and FEV1 as Pulmonary Function Tests in Males with Type-2 Diabetes Mellitus.

3. PradeepaR, Mohan V. Indian journal of ophthalmology, Epidemiology of type 2 diabetes in

India2021 November; 69(11): 2932–2938.
4. Shah SH, Sonawane P, Nahar P, Vaidya S, Salvi S. Pulmonary function tests in type 2 diabetes mellitus and their association with glycaemic control and duration of the disease. Lung India. 2013;30(2):108-12.
5. Acharya PR, D'Souza M, Anand R, Kotian SM. Pulmonary function in type 2 diabetes mellitus: Correlation with body mass index and glycaemic control. International Journal of Scientific Study. 2016;3(11):18-23.
6. McKeever TM, Weston PJ, Hubbard R, Fogarty A. Lung function and glucose metabolism: An analysis of data from the Third National Health and Nutrition Examination Survey. American Journal of Epidemiology. 2005;161(6):546-56.
7. Walter RE, Beiser A, Givelber RJ, O'Connor GT, Gottlieb DJ. Association between glycaemic state and lung function: The Framingham Heart Study. American Journal of Respiratory Critical Care Medicine. 2003;167(6):911-16.
8.Charak G, Kaur A, Kaur S, Kocchar S. Effect of duration of Type 2 Diabetes Mellitus on Lung Function Tests. IOSR-JDMS. 2016;15(10):8-14.
9.Niazi S, Hassan SH, Ahmed I, Ashfaq A. Effects of type two diabetes mellitus on lung function parameters. Scholar Journal of Applied Medical Sciences. 2013;1(5):482-87.
10.Mohan V, Sandeep S, Deepa R, et al. Epidemiology of type 2 diabetes: Indian scenario. Indian Journal Medical Research 2007; 125:217-30.

11. Adeyeye OO, Ogbera OA, Dada AO, Bamisile RT, Brodie Mens A. Correlates of abnormal pulmonary function tests in persons with type 2 diabetes mellitus. Journal of Pulmonary and Respiratory Medicine. 2014;5(1):231.

12. Lecube A,Sampol G Muñoz X, Hernández C, Mesa J, Simo R.Type 2 diabetes impairs pulmonary function in morbidly obese women. Diabetalgia.2010;53(6): 1210–6.
13.Popov D. Is lung a target of diabetic injury? The novel pros and cons evidences. Proceedings of the Romanian Academy Series B. 2013;15(2):99–104.
14. Bharat I, Singh R, Sehgal C, Sharma S, Saha AK, Paul UK. Study of pulmonary function test in newly diagnosed diabetes in a tertiary care teaching hospital, Kishanganj, Bihar. International Journal of Innovative Research in Medical Science. 2018;3(08):2142– 2147.

15. Jamatia SN, Wangkheimayum K, Singh WA, Yumnam G. Effect of glycemic status on lung function tests in type 2 diabetes mellitus. Journal of Medical Society. 2014;28(2):69.

16. Irfan M, Jabbar A, Haque AS, Awan S, Hussain SF. Pulmonary functions in patients with diabetes mellitus. Lung India. 2011;28 (2):89.

17. Sinha S, Guleria R, Misra A, Pandey RM, Yadav R, Tiwari S. Pulmonary functions is patients with type 2 diabetes mellitus and Correlation with anthropometry and microvascular complications. Indian Journal of Medical Research. 2004 Feb; 119: 66-71.

18.Tesema DG, Gobena T, Ayalew A. Pulmonary Function Tests and Their Associated Factors Among Type 2 Diabetic Patients at Jimma Medical Center in 2019; Comparative Cross-Sectional Study. International Journal of General Medicine. 2020 Apr 8:111-9.

19. Uz-Zaman S, Banerjee J, Singhamahapatra A, Dey PK, Roy A, Roy K, Roy K. Assessment of lung function by spirometry and diffusion study and effect of glycemic control on pulmonary function in type 2 diabetes mellitus patients of the eastern India. Journal of Clinical and Diagnostic Research. 2014 Nov;8(11):BC01.

20. Karintholil AR, Aroor AR, Sabu J, Chacko J. Correlation of Pulmonary Function Tests with Anthropometry and Glycaemic Control in Type 2 Diabetes Mellitus: A Cross-sectional Study. 2021 April;15(4): OC22-OC26.

21. Agarwal AS, Fuladi AB, Mishra G, Tayade BO. Spirometry and Diffusion Studies in Patients with Type-2 Diabetes Mellitus and Their Association with Microvascular Complications. Indian Journal of Chest Disease and Allied Sciences. 2010;52(4):213-6.

22. Davis TM, Knuiman M, Kendall P, Vu H, Davis WA. Reduced pulmonary function and its associations in type 2 diabetes: The Fremantle Diabetes Study. Diabetes Research and ClinicalPractise. 2000;50(2):153-59.

23. Barrett CE, Frette C. NIDDM, impaired glucose tolerance, and pulmonary function in older adults. The Rancho Bernardo Study. Diabetes Care. 1996;19(12):1441- 44.

24. Swathi H,Sonawane P, Nahar P, Vaidya, and Salvi S.Pulmonary function tests in type 2 diabetes mellitus and their association with glycaemic control and duration of the disease. 2013; 30(2): 108–112.

25. Acharya PR, D'Souza M, Anand R, Kotian SM. Pulmonary function in type 2 diabetes mellitus: Correlation with body mass index and glycaemic control. International Journal Science Study. 2016;3(11):18-23.

26.McKeever TM, Weston PJ, Hubbard R, Fogarty A. Lung function and glucose metabolism: An analysis of data from the Third National Health and Nutrition Examination Survey. American Journal of Epidemiology. 2005;161(6):546-56.