International Journal of Medicine
pISSN 1468-3814 | eISSN 2667-7008
https://theinternationalmedicine.com/

Original Research Article *DOI: 10.61336/im/26-06-159*

PATTERN OF PULMONARY FUNCTION TESTS IN PATIENTS OF TYPE 2 DIABETES MELLITUS WITH AND WITHOUT DIABETIC POLYNEUROPATHY

Dr. Hakeem Owais Shafi[1], Dr. Rakesh Koul[2], Dr. Hilal Mohi ud Din Bhat[3], Dr. Irfan Yousuf Wani[4], Dr. Iram Manzoor[5]

[1] Senior Resident, Postgraduate Department of Medicine, Government Medical College, Srinagar, Kashmir, India.
[2] Professor and Head, Postgraduate Department of Medicine, Government Medical College, Srinagar, Kashmir, India.
[3] Assistant Professor, Postgraduate Department of Medicine, Government Medical College, Srinagar, Kashmir, India.
[4] Assistant Professor, Postgraduate Department of Medicine, Government Medical College, Srinagar, Kashmir, India.
[5] Junior Resident, Postgraduate Department of Medicine, Government Medical College, Srinagar, Kashmir, India.

Correspondence:
Dr. Hakeem Owais Shafi

Received: **May 14, 2026**
Revised: **May 23, 2026**
Accepted: **June 13, 2026**
Published: **June 25, 2026**

Abstract

Background: Type 2 Diabetes Mellitus (T2DM) is a multisystem disorder with well-recognized microvascular complications. However, pulmonary involvement remains underexplored. This study aimed to assess pulmonary function abnormalities in T2DM and examine their relationship with diabetic peripheral neuropathy (DPN). ***Methods:*** A cross-sectional analytical study was conducted on 90 patients with T2DM, divided equally into groups with and without neuropathy. Pulmonary function tests (PFTs) were performed using spirometry, and neuropathy was assessed clinically and electrophysiologically. Glycemic control and duration of diabetes were also evaluated. ***Results:*** Pulmonary dysfunction was observed in a significantly higher proportion of patients with neuropathy compared to those without. Restrictive patterns predominated. Increasing HbA1c levels and longer disease duration were associated with worsening pulmonary parameters. ***Conclusion:*** Pulmonary function impairment is closely associated with diabetic neuropathy and poor glycemic control. Routine respiratory assessment may aid in early identification of systemic complications in T2DM.

Keywords: Diabetic Polyneuropathy, Spirometry, Type 2 Diabetes Mellitus, Pulmonary Function Test, HbA1c

INTRODUCTION

Diabetes Mellitus (DM) is a multifaceted metabolic disorder characterized by ongoing hyperglycemia due to abnormalities in insulin production, insulin action, or a combination of both [1]. Diabetes Mellitus (T2DM) is the most common form of disease, encompassing over 90% of all cases. It is mainly characterized by insulin resistance and a gradual degradation of pancreatic β-cell function[1]. The global prevalence of diabetes has been increasing at an alarming rate, with an estimated 425 million individuals affected in 2017. This number is expected to increase to 645 million via 2045[2]. In India, data from ICMR-INDIAB study indicate the presence of approximately 62.4 million individuals with T2DM, along with an additional 77 million categorized as prediabetic[3].

T2DM is a systemic condition that impacts multiple organ systems, including the cardiovascular, renal, and nervous systems[4]. Long-standing hyperglycemia contributes contribution to microvascular complications, namely nephropathy, retinopathy, and neuropathy[1,5]. While pulmonary involvement has not been as thoroughly examined as other complications, emerging data indicates that diabetes is associated with changes in lung function, including decreased lung volumes and diminished respiratory muscle performance[6]. These changes are thought to result from a combination of factors such as microvascular damage, glycation-induced stiffening of connective tissue, and dysfunction of autonomic regulation[7].

Diabetic neuropathy, particularly distal symmetric polyneuropathy (DPN), represents the most common diabetic complication and major morbidity contributor[8]. It is characterized by progressive impairment of sensory and motor nerve function, largely driven by mechanisms such as oxidative stress, ischemic injury to nerves, and accumulation of advanced glycation end products[5,9]. In

addition to peripheral nerve involvement, DPN may also influence respiratory function by affecting respiratory muscles and autonomic control of breathing.

Pulmonary abnormalities observed in T2DM include reductions in forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC), or disturbances in gas exchange[10]. These functional impairments are believed to arise from structural and biochemical alterations within lung tissue induced by chronic hyperglycemia[11]. Pulmonary Function Tests (PFTs) serve as a valuable, non-invasive tool for identifying early pulmonary involvement in diabetic individuals[12].

Despite increasing recognition of lung involvement in diabetes, the specific contribution of diabetic polyneuropathy to pulmonary dysfunction remains insufficiently clarified. Some studies have reported significantly lower pulmonary function parameters in patients with DPN compared to those without neuropathy[13]; however, the exact nature of this association is yet to be fully established. Therefore, assessing pulmonary function in patients with T2DM, particularly in relation to diabetic neuropathy, is crucial for understanding systemic effects of diabetes and optimizing clinical management.

AIMS AND OBJECTIVES

Aim:

- To study the pattern of pulmonary function tests (PFTs) in patients of T2DM with and without diabetic polyneuropathy.

Objectives:

- To compare spirometric indices (FEV1, FVC, FEV1/FVC) between T2DM patients with and without diabetic polyneuropathy (DPN).
- To correlate pulmonary function parameters with glycemic status, as measured by HbA1C.
- To identify the extent to which neuropathy contributes to pulmonary impairment in patients with T2DM.

MATERIALS AND METHODS

This analytical cross-sectional study was conducted in the “Department of Medicine, Government Medical College, Srinagar,” over 18 months. The study examined T2DM patients' pulmonary function and compared results between those with and without diabetic polyneuropathy (DPN). The primary objective was to assess pulmonary function using spirometry and to determine its association with diabetic neuropathy and glycemic control.

The research included 90 T2DM patients, of whom 45 had diabetic polyneuropathy, and 45 did not. All participants were recruited from patients attending or admitted to the Department of Medicine. A detailed clinical history and physical examination were performed in all subjects, with particular emphasis on identifying features suggestive of diabetic neuropathy.

Inclusion Criteria

- Patients “diagnosed with T2DM as per American Diabetes Association (ADA) criteria
- Age between 30-60 years
- Patients who provided written informed consent

Exclusion Criteria

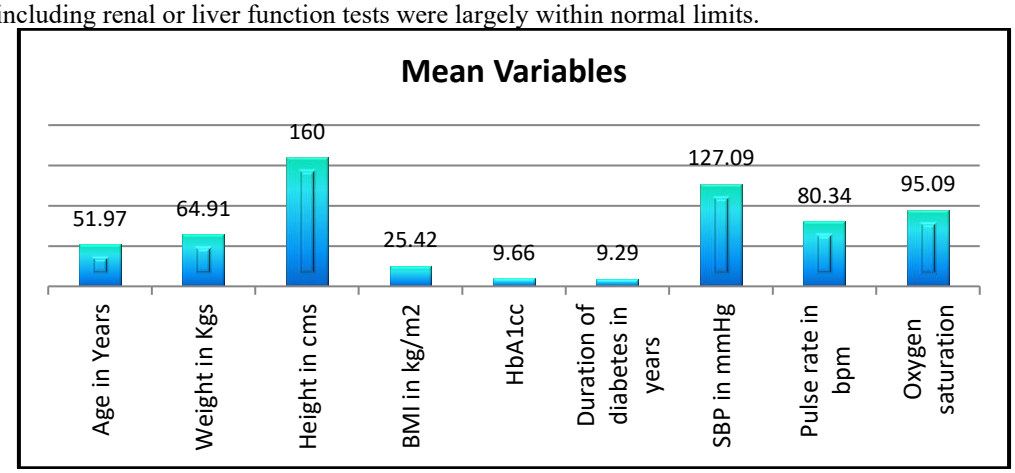
- Presence of chronic obstructive pulmonary disease (COPD), bronchial asthma, or other” significant pulmonary disorders
- History of smoking
- Renal failure or liver disease
- Use of steroids or medications affecting pulmonary function
- Neuropathies other than diabetic polyneuropathy

Neuropathy evaluation was conducted with established clinical methods, including the 10g monofilament test to measure “small fiber function, vibration perception with a 128 Hz tuning fork” for large fiber involvement, and assessment of ankle reflexes for motor function. Patients showing abnormalities in these clinical tests were further evaluated with nerve conduction studies. Glycemic control was evaluated by testing glycated hemoglobin (HbA1c) levels and reporting the duration of diabetes. These parameters were employed to assess the “correlation between glycemic state and pulmonary function. Pulmonary function tests were conducted with a Spirodoc spirometer, with critical values collected, including FEV1, FVC, FEV1/FVC ratio, Peak Expiratory Flow Rate (PEFR), or Forced Expiratory Flow (FEF 25–75%). All participants underwent a training session prior to” testing to ensure proper technique, and at least three acceptable spirometry maneuvers were recorded for each subject. Pulmonary function abnormalities were classified into restrictive, obstructive, or mixed patterns based on standard reference values.

Statistical analysis was performing using “Statistical Package for Social Sciences (SPSS) version 25.0.” Continuous variables were expressed as mean ± standard deviation, whilst categorical variables were represented as percentages. The unpaired t-test for continuous variables and the Chi-square test for categorical data were used to evaluate group differences. The relationship between “pulmonary function parameters and duration of diabetes has been assessed utilizing Pearson's correlation coefficient. A p-value below 0.05 was considered statistically” significant. The “Institutional Ethical Committee of Government Medical College, Srinagar,” authorized the study. Data confidentiality was carefully maintained, and every participant gave informed consent.

RESULTS

This study assessed pulmonary function in patients with T2DM and emphasized the correlation among diabetic polyneuropathy (DPN), glycemic control, and diabetes duration. The 90 individuals were equally divided into neuropathy and "non-neuropathy groups. The mean age of the study population was 51.97 ± 6.36 years, indicating predominance of middle-aged individuals. The mean weight and height were 64.91 ± 9.77 kg and 160.00 ± 9.21 cm, respectively, with a calculated mean BMI of 25.42 ± 4.69 kg/m², placing the average participant in the overweight category. Glycemic status was poor overall, with a mean HbA1c of 9.66 ± 2.37%. The mean duration of diabetes was" 9.29 ± 3.42 years, suggesting a chronic disease burden. Hemodynamic parameters remained relatively stable, with mean systolic blood pressure of 127.09 ± 11.46 mmHg, pulse rate of 80.34 ± 8.50 bpm, and oxygen saturation of 95.09 ± 1.25%. Hematological and biochemical parameters, including renal or liver function tests were largely within normal limits.



The study population consisted of 54 females (60%) and 36 males (40%). Neuropathy distribution was equal, with 45 patients (50%) in each group. Among females, 46.3% had neuropathy, while among males, 55.6% had neuropathy, indicating a slightly higher prevalence in males. Most participants (64.4%) belonged to the 51–60 years age group, followed by 28.9% in 41–50, and only 6.7% in 30–40 years, indicating increasing disease burden with advancing age. Neurological assessment revealed that all patients with normal reflexes belonged to the non-neuropathy group, whereas reduced reflexes were exclusively seen in neuropathy patients. Vibration sense was preserved in 100% of non-neuropathy patients, while 60% of neuropathy patients showed impairment. Similarly, the monofilament test demonstrated 68.9% impaired sensation in neuropathy patients, with 100% normal responses in non-neuropathy individuals, confirming its high specificity. Pulmonary function abnormalities were significantly associated with neuropathy. Among non-neuropathy patients, 82.2% had normal pulmonary function, compared to only 31.1% in neuropathy patients. Moderate pulmonary dysfunction was more common in the neuropathy group (37.8% vs 8.9%), while severe dysfunction was also more frequent (8.9% vs 2.2%) in the same group.

Biochemical trends demonstrated worsening glycemic control with increasing pulmonary dysfunction. Mean HbA1c increased from 8.06–8.32% in normal PFT groups to 11.65–11.98% in moderate dysfunction, indicating a strong relationship between hyperglycemia and lung impairment. A strong statistical relationship was observed between pulmonary dysfunction and glycemic status ($r = 0.672$, $p < 0.001$), duration of diabetes ($r = 0.534$, $p < 0.001$), and neuropathy severity ($r = 0.557$, $p < 0.001$), confirming that pulmonary impairment is closely linked to chronic diabetic complications.

Table 1: Pulmonary Function Distribution in Study Population

PFT Category	Number (n=90)	Percentage (%)
Normal	51	56.7%
Mild	13	14.4%
Moderate	21	23.3%
Severe	5	5.6%

Table 2: Comparison of Pulmonary Function Among Patients With or Without DPN

PFT Category	Non-Neuropathy (n=45)	Neuropathy (n=45)
Normal	37	14
Mild	3	10
Moderate	4	17
Severe	1	4

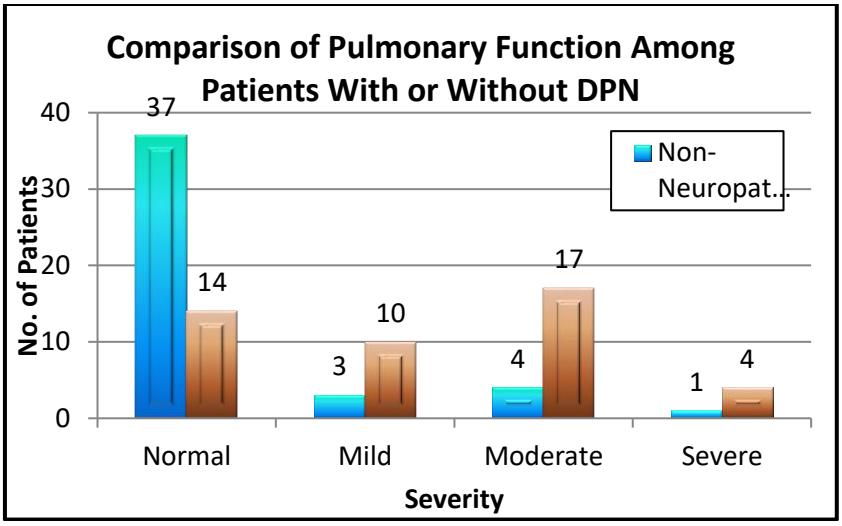
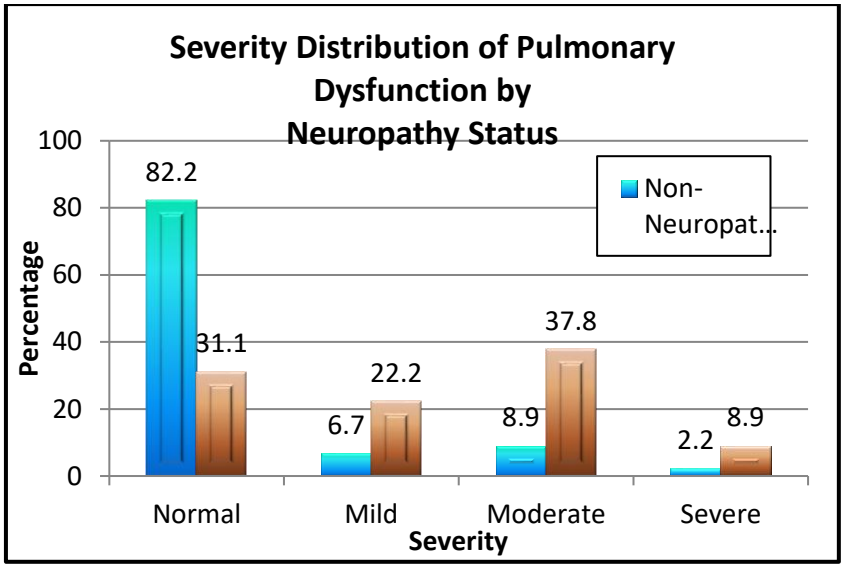


Table 3: Pulmonary Function According to Glycemic Control (HbA1c)	
PFT Category	**Mean HbA1c (%)**
Normal	8.32 ± 1.60
Mild	10.36 ± 1.86
Moderate	11.98 ± 1.34
Severe	11.35 ± 0.75

Table 4: Mean HbA1c Levels According to Duration of Diabetes	
Duration of Diabetes	**Mean HbA1c (%)**
< 5 years	6.45 ± 1.10
5–10 years	9.10 ± 2.06
10–15 years	10.84 ± 1.89
> 15 years	10.90 ± 0.12

Table 5: Severity Distribution of Pulmonary Dysfunction by Neuropathy Status		
Severity	**Non-Neuropathy (%)**	**Neuropathy (%)**
Normal	82.2%	31.1%
Mild	6.7%	22.2%
Moderate	8.9%	37.8%
Severe	2.2%	8.9%



DISCUSSION

The current study examined pulmonary function impairments in T2DM patients and their association with diabetic polyneuropathy, glycemic status and duration of illness. The findings demonstrate a clear relationship among chronic hyperglycemia, neuropathic involvement, and decline in pulmonary function. The "mean age of participants in" this research was 51.97 ± 6.36 years, with the majority (64.4%) falling within the 51–60-year age group. This age distribution is comparable to earlier observations, where pulmonary impairment in diabetes has been noted to become more apparent in middle-aged and elderly individuals due to prolonged exposure to metabolic derangements. Davis WA et al. (2004)14 reported a similar trend, while Klein OL et al. (2010)15 demonstrated that advancing age is significantly correlated with decreasing pulmonary function in patients with diabetes. The study's mean BMI was 25.42 ± 4.69 kg/m², indicating that a substantial proportion of patients were overweight. Increased body mass has been linked to restrictive ventilatory defects due to reduced chest wall compliance. Lazarus R et al. (1997)16 demonstrated that higher BMI is associated with reductions in FVC and FEV1, which corresponds with the pattern of pulmonary dysfunction observed in this study.

A notable finding was the high prevalence of pulmonary dysfunction among diabetic patients, with 43.3% showing abnormal pulmonary function and 23.3% exhibiting moderate impairment. Such findings are consistent with those reported by Sandler M et al. (1987)17, who demonstrated reduced lung volumes in diabetic individuals, suggesting that diabetes adversely affects lung elasticity and functional capacity. When pulmonary function was compared based on neuropathy status, a marked difference was observed. Only 31.1% of patients with neuropathy had normal pulmonary function, compared to 82.2% in those without neuropathy. Furthermore, moderate pulmonary dysfunction was significantly more frequent in the neuropathy group (37.8% vs 8.9%). This indicates a strong association between diabetic neuropathy and pulmonary impairment. Meo SA et al. (2006)18 reported similar observations, suggesting that neuropathy contributes to respiratory muscle weakness and reduced ventilatory performance. In addition, Sinha S et al. (2004)19 highlighted that autonomic neuropathy may influence bronchial tone and respiratory regulation, thereby impairing lung function.

The present study also demonstrated a progressive decline in pulmonary function with worsening glycemic control. Mean HbA1c levels increased from 8.32 ± 1.60% in patients with normal pulmonary function to 11.98 ± 1.34% in those with moderate dysfunction, indicating a strong association between hyperglycemia and pulmonary impairment. Walter RE et al. (2003)20 found a correlation between decreased FEV1 and FVC and elevated HbA1c levels. The decline in lung function increases with poor glycemic control, as observed by Davis WA et al. (2004)14. Pulmonary dysfunction was also discovered to be significantly correlated with diabetes duration. In the current study, HbA1c levels increased from 6.45 ± 1.10% in patients with duration of < 5 years to 10.90 ± 0.12% in those with more than 15 years of disease, reflecting the cumulative effect of chronic metabolic stress. Klein OL et al. (2010)15 reported similar findings, demonstrating that longer disease duration is associated with reduced lung capacity. Sandler M et al. (1987)17 also emphasized that prolonged hyperglycemia leads to glycation of lung connective tissue, resulting in decreased elasticity and impaired function.

Neurological assessment further reinforced the findings of this study. The monofilament test revealed sensory impairment in 68.9% of patients with neuropathy, while none of the patients without neuropathy showed impairment, indicating high diagnostic specificity. Perkins BA et al. (2001)21 also reported that monofilament testing is a reliable and sensitive method for detecting diabetic neuropathy. Correlation analysis in this study demonstrated a strong positive relationship between HbA1c levels or pulmonary "dysfunction ($r = 0.672$, $p < 0.001$), and among duration of diabetes or pulmonary impairment ($r = 0.534$, $p< 0.001$). Such" findings are consistent with those of Walter RE et al. (2003)20, who reported that chronic hyperglycemia leads to microvascular damage and structural alterations in lung tissue. Additionally, "an area under the curve (AUC) of 0.840 was shown" by receiver operating characteristic (ROC) analysis, suggesting that pulmonary function tests performed well in identifying neuropathy. This suggests that spirometry may serve as a useful non-invasive tool for early detection of systemic diabetic complications. Meo reported similar observations "SA et al. (2006)18, supporting the role of pulmonary function testing in routine evaluation of" diabetic patients.

Overall, the outcomes of current study support the concept that pulmonary dysfunction is an under-recognized complication of T2DM and is closely associated with diabetic neuropathy, poor glycemic control, or longer duration of disease.

CONCLUSION

This study demonstrates a strong relationship between diabetic peripheral neuropathy and restrictive pulmonary dysfunction in individuals with T2DM. A markedly greater proportion of patients with neuropathy (68.9%) exhibited abnormal pulmonary function compared to patients without neuropathy (17.8%). In addition, deterioration in pulmonary parameters was observed

with rising HbA1c levels and increasing duration of diabetes, underscoring the impact of poor glycemic control. The dominance of a restrictive ventilatory pattern indicates that the underlying mechanism is more likely related to neuromuscular involvement rather than primary airway pathology. These observations emphasize the importance of incorporating routine pulmonary function evaluation in diabetic patients, particularly those with neuropathy, to facilitate early identification and improve overall patient outcome.

REFERENCES

1. American Diabetes Association. Standards of medical care in diabetes - 2022. Diabetes Care, 2022; 45(Suppl 1), S185-S195. https://doi.org/10.2337/dc22-S001.
2. International Diabetes Federation. (2017). IDF Diabetes Atlas, 8th edition. International Diabetes Federation. https://diabetesatlas.org.
3. Anjana RM, Pradeepa R, Deepa M, Datta M, Sudha V, Unnikrishnan R et al. Prevalence of diabetes and prediabetes (impaired fasting glucose and/or impaired glucose tolerance) in urban and rural India: phase I results of the Indian Council of Medical Research-INdia DIABetes (ICMR-INDIAB) study. Diabetologia. 2011 Dec; 54(12): 3022-7.
4. Fowler MJ. Microvascular and macrovascular complications of diabetes. Clinical Diabetes, 2008; 26(2): 77–82. https://doi.org/10.2337/diaclin.26.2.77.
5. Feldman EL, Callaghan BC, Pop-Busui R, Zochodne DW, Wright DE, Bennett DL et al. Diabetic neuropathy. Nat Rev Dis Primers. 2019 Jun 13;5(1):41. doi: 10.1038/s41572-019-0092-1.
6. Wang D, Ma Y, Tong X, Zhang Y, Fan H. Diabetes Mellitus Contributes to Idiopathic Pulmonary Fibrosis: A Review From Clinical Appearance to Possible Pathogenesis. Front Public Health. 2020 Jun 3;8:196. doi: 10.3389/fpubh.2020.00196.
7. Fuso L, Pitocco D, Longobardi A, Zaccardi F, Contu C, Pozzuto C et al. Reduced respiratory muscle strength and endurance in type 2 diabetes mellitus. Diabetes Metab Res Rev. 2012 May;28(4):370-5. doi: 10.1002/dmrr.2284.
8. Pop-Busui R, Boulton AJ, Feldman EL, Bril V, Freeman R, Malik RA et al. Diabetic Neuropathy: A Position Statement by the American Diabetes Association. Diabetes Care. 2017 Jan;40(1):136-154. doi: 10.2337/dc16-2042.
9. Vincent AM, Russell JW, Low P, Feldman EL. Oxidative stress in the pathogenesis of diabetic neuropathy. Endocr Rev. 2004 Aug;25(4):612-28. doi: 10.1210/er.2003-0019. PMID: 15294884.
10. Lecube A, Simó R, Pallayova M, Punjabi NM, López-Cano C, Turino C et al. Pulmonary Function and Sleep Breathing: Two New Targets for Type 2 Diabetes Care. Endocr Rev. 2017 Dec 1;38(6):550-573. doi: 10.1210/er.2017-00173.
11. Shaikh GB, Kanthe P, Shaikh RB, Patil S. Type 2 diabetes mellitus and dynamic pulmonary function tests. https://digitallibrary.bldedu.ac.in/bitstream/123456789/3725/2/CORRECTED_TYPE%202%20DIABETES%20MELLITUS%20AND%20DYNAMIC%20PULMONARY%20FUNCTION%20TESTS.pdf
12. Dwivedi J, Wal P, Dash B, Ovais M, Sachan P, Verma V. Diabetic Pneumopathy- A Novel Diabetes-associated Complication: Pathophysiology, the Underlying Mechanism and Combination Medication. Endocr Metab Immune Disord Drug Targets. 2024;24(9):1027-1052. doi: 10.2174/0118715303265960230926113201.
13. Gautam P, Faraz A, Ashraf H, Singhal S. Diabetic neuropathy, a cause of pulmonary dysfunction in patients of type 2 diabetes mellitus: a prospective cross-sectional study. Bangladesh Journal of Endocrinology and Metabolism. 2023 Jan 1;2(1):35-40.
14. Davis WA, Knuiman M, Kendall P, Grange V, Davis TM. Glycemic exposure is associated with reduced pulmonary function in type 2 diabetes: the Fremantle Diabetes Study. Diabetes Care. 2004;27(3):752–757.
15. Klein OL, Aviles-Santa ML, Cai J, Collard HR, Kanaya AM, Kaplan R, et al. Hispanics/Latinos with type 2 diabetes have reduced pulmonary function. Diabetes Care. 2010;33(11):2403–2408.
16. Lazarus R, Sparrow D, Weiss ST. Effects of obesity and fat distribution on ventilatory function: the normative aging study. Chest. 1997;111(4):891–898.
17. Sandler M, Bunn AE, Stewart RI. Cross-section study of pulmonary function in patients with insulin-dependent diabetes mellitus. Am Rev Respir Dis. 1987; 135(1): 223–229.
18. Meo SA, Al-Drees AM, Arif M, Shah FA, Al-Rubean K. Lung function in type 2 Saudi diabetic patients. Saudi Med J. 2006;27(3):338–343.
19. Sinha S, Guleria R, Misra A, Pandey RM, Yadav R, Tiwari S. Pulmonary functions in patients with type 2 diabetes mellitus and correlation with anthropometry and microvascular complications. Indian J Med Res. 2004;119:66–71.
20. Walter RE, Beiser A, Givelber RJ, O'Connor GT, Gottlieb DJ. Association between glycemic state and lung function. Am J Respir Crit Care Med. 2003;167(6):911–916.
21. Perkins BA, Olaleye D, Zinman B, Bril V. Simple screening tests for peripheral neuropathy in diabetes. Diabetes Care. 2001;24(2):250–256.