

# Exercise Tolerance and Pulmonary Function among Middle Aged People with and without Diabetes Mellitus: A Pilot Study

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## Abstract

**Objective:** To assess and to compare exercise tolerance and pulmonary function among middle aged persons with type 2 Diabetes Mellitus and without.

**Methods:** A total of 30 patients, 15 with type 2 diabetes and 15 age matched controls without diabetes recruited from a tertiary hospital, participated in the study. Exercise tolerance and pulmonary function was assessed using six -minute walk test and spirometer respectively, for both the groups.

**Results:** In the statistical analysis, the control group was seen to fare better in all the parameters. When analysed between groups using t test, FEV1, ( $t=11.350$ ,  $p < 0.001$ ) FVC ( $t=6.249$ ,  $p < 0.001$ ), FEV1/FVC ( $t=13.184$ ,  $p < 0.001$ ) and 6MWT ( $t=11.74100$ ,  $p < 0.001$ ) was found to be significantly different between diabetic and normal group. Analysis using chi square test showed a significant difference in lung function between diabetic and non-diabetic participants.

**Conclusion:** Middle aged non-diabetic individuals showed normal performance in exercise tolerance and pulmonary function, whereas the Diabetic population had reduced exercise tolerance and pulmonary function. This implies that middle age could be a crucial stage for early prevention of decline in pulmonary function and exercise tolerance and also to prevent future complications in type 2 diabetic patients.

**Keywords:** Pulmonary Function Test, Type 2 diabetes mellitus, exercise tolerance, middle aged individuals.

## Introduction

According to the World Health Organization type II Diabetes mellitus (T2DM) is a chronic, metabolic disease characterized by elevated levels of blood glucose, which leads to serious damage to the heart, blood vessels, eyes, kidneys and nerves. The most common is type 2 diabetes, usually seen in adults, which occurs when the body becomes resis-

tant to insulin or doesn't make enough insulin.<sup>1</sup>The International Diabetes Federation (IDF) estimated 537 million adults worldwide between the age of 20-79 (10.5% of all adults in this age range) By 2030. This estimate is projected to rise to 642 million by 2040, and the largest increases will come from the regions experiencing economic transitions from low-income to middle-income levels. The estimates

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in 2024 showed that By 2030 643 million people will have diabetes globally, increasing to 783 million By 2045.<sup>2,3</sup>

Middle age typically spans from around the age of 40 to 60, roughly halfway between early adulthood and old age and is often characterized by various life changes, including career advancement, family responsibilities, and possibly the onset of certain health concerns associated with aging.<sup>4</sup> It has been found that middle-aged diabetic people are substantially more likely than non-diabetics to experience cardiovascular complications. Compared to those without diabetes, those with type 2 diabetes had three times the chance of dying from cardiovascular disease and twice the risk of dying from any cause.<sup>5</sup>

The lungs are possible target organs in diabetic microangiopathy.<sup>6</sup> Loss of elastic recoil causes the small airways in the lungs to dynamically collapse during expiration and diabetes even alters the level of surfactants, which changes pulmonary function. The effectiveness of respiratory pump can be affected by diabetic myopathic and neuropathic alterations. Pulmonary function abnormalities may arise from excessive inflammatory responses in the lungs due to improper control of inflammatory processes. Patients with diabetes have poor control of inflammation and have elevated levels of TNF alpha, ferritin, fibrinogen, and C-reactive protein. Autonomic neuropathy will damage the bronchial noradrenergic innervation and can disrupt the respiratory system's ability to operate and change the ventilatory response to both central and peripheral inputs.<sup>7</sup>

Pulmonary function tests (PFTs) are used to assess how the lungs work mechanically, based on standards from studies that account for age, height, and sex. Spirometry is the most useful and widely accessible test for assessing pulmonary function.<sup>8</sup> Spirometric indices can be simply interpreted by comparing them to established normal values, and they have undergone extensive validation.<sup>9</sup>

It has been proven that diabetes mellitus has adverse effects on the microvasculature, so it is quite probable that pulmonary functions may be affected in diabetes. Studies have shown that there is reduction in exercise capacity in patients with DM. It was found that diabetes influences the decrease in the strength and resistance of respiratory muscles, primarily the diaphragm.<sup>10</sup>

Exercise tolerance, exercise capacity and functional capacity are generally considered synonymous and indicate the maximal effort given during exercise testing. T2D is related with a number of co-morbidities including cardio-pulmonary disorders that have been found to significantly reduce exercise capacities.<sup>11</sup>

People with T2DM may have a reduced capacity for exercise due to a number of causes, including insulin resistance, endothelial dysfunction, poor myocardial perfusion, cerebral blood flow, and oxygenation deficiencies. They may also experience alterations in cardiac and skeletal muscle activity.<sup>12</sup> Patients with type 2 diabetes often complain of fatigue and reduced exercise capacity.<sup>13</sup> The

objective of the study is to assess and to compare exercise tolerance and pulmonary function among middle aged persons with type 2 Diabetes Mellitus and without.

The prevalence of diabetes is gradually increasing in all age groups, particularly in middle aged people. Pulmonary function and exercise tolerance are major areas in which this people may suffer deficiencies. Hence there is need for early identification of such persons with reduced exercise tolerance and pulmonary function will help in reducing and preventing complications. Further necessary interventions can be provided in order to improve their exercise tolerance and lung function.

## Material And Methodology

A comparative observational study was carried out in a tertiary hospital at Mangaluru, Karnataka over a period of 12 months from June 2023 to May 2024. The study was conducted among middle aged individuals (40-60) years with self-report or physician diagnosed Type 2 DM with duration of more than a year. A total of 30 samples was estimated for this pilot study on the basis of the study conducted by Krzysztof kuziemski et.al.<sup>10</sup> which includes 15 diabetic patients and 15 controls. Ethical clearance was obtained from the Institutional Ethical Committee. Informed consent was obtained from subjects prior to the study. Subjects were screened for inclusion and exclusion criteria and those who met the selection criteria were recruited in the study, using convenience sampling method.

Fifteen men and women diagnosed with Type 2DM more than 1 year, aged between 40-60 years without any history of smoking, metabolic or pulmonary condition were included in this study non diabetic males and females both aged between 40-60, non-smokers and no other pulmonary or metabolic conditions were the inclusion criteria for control group. Individuals with uncontrolled DM, diabetic foot, facial deformity, respiratory disorder and any other contraindication to exercise testing were excluded.

Spirometry was used to assess forced expiratory volume in one second (FEV1), forced vital capacity (FVC) and FEV1/FVC ratio. Six-minute Walk test (6MWT) was used to assess exercise tolerance.<sup>10</sup> Assessing exercise tolerance using the 6-Minute Walk Test (6MWT) involves a comprehensive evaluation process that begins with thorough preparation and baseline assessments to ensure patient stability and safety. Before the test, clinicians review the patient's medical history and current medications, taking baseline vital signs such as heart rate, blood pressure, and oxygen saturation while explaining the procedure and reassuring the patient that they can take breaks as needed. Conducted in a controlled environment on a flat, straight surface, the test requires the patient to walk as far as possible in six minutes, with the clinician providing regular encouragement and closely monitoring for signs of distress. At the end of the six minutes,

the total distance walked is measured in meters, which serves as the primary outcome metric. Additionally, any symptoms reported by the patient during the test, such as shortness of breath, fatigue, or chest pain, are documented to provide qualitative context for the results. Post-test, vital signs are again recorded to observe any significant changes, and patients may be asked to rate their perceived exertion using standardized scales. The total distance walked is then compared to normative values adjusted for age, gender, and specific health conditions to evaluate functional capacity. This multifaceted approach allows clinicians to gauge overall exercise tolerance, identifying potential limitations in daily activities and informing tailored rehabilitation programs. The 6MWT can also be repeated periodically to monitor changes in exercise tolerance over time, providing essential insights for ongoing patient management and treatment adjustments, making it a crucial tool in clinical practice for enhancing patient care and recovery strategies.

An initial examination of demographic data and medical history was carried out. A brief introduction about the study procedure was explained to all subjects. Initially the demographic data including name, age and gender were collected. Information regarding T2DM was obtained from the Self-reported or physician diagnosed using glycated hemoglobin test (HbA1c) value 6.5% or above.

Each participant's exercise tolerance was assessed using the six-minute walk test and three trials of pulmonary function test with a spirometer (FEV1, FVC and FEV1/FVC ratio) on the same day, and best reading was taken into consideration. The session was completed within 20-25 minutes.

## Statistical Analysis

The data was analyzed using Microsoft Excel and SPSS version 23.0. The categorical variables were presented as frequency, percentage and descriptive statistics using mean and standard deviation. Comparison of exercise tolerance and pulmonary function between the groups was done using unpaired t test. A  $p < 0.05$  was considered as statistically significant.

## Results

The mean age of participants was  $49.533 \pm 6.435$  years and  $51.800 \pm 5.375$  years, in control group and diabetes group respectively. Both the control and diabetes group included 8 women and 7 men each.

The comparison of Forced Expiratory Volume in one second (FEV1) between the healthy and diabetic populations revealed stark differences in lung function, suggested that individuals with diabetes exhibit markedly lower FEV1 values compared to their control group (Table 1). Also individuals with diabetes exhibit significantly reduced FVC compared to control group. A  $p$  value  $< 0.001$  strongly suggest that individuals with diabetes exhibit a reduced FEV1/FVC ratio compared to their control counterparts. (Table.1)

The comparison of the 6-minute walk test results between a healthy population and a diabetic population revealed notable differences in physical endurance. The calculated t-value of 11.741 and  $p < 0.001$  shows that individuals with diabetes exhibit reduced exercise tolerance compared to their control group (Table.1)

**Table.1: Comparison of FEV1, FVC, FEV1/FVC and 6MWT between Control group and diabetic group**

		Group	Mean	SD	t - value	p - value	N
PFT	FEV1	Control group	3.384	0.524	11.350	$p < 0.001$	15
		Diabetic group	1.471	0.390			
	FVC	Control group	3.445	0.522	6.249	$p < 0.001$	
		Diabetic group	2.265	0.512			
	FEV1/FVC	Control group	97.527	1.179	13.184	$p < 0.001$	
		Diabetic group	64.533	9.620			
Exercise Tolerance	6MWT	Control group	542.067	53.767	11.74100	$p < 0.001$	
		Diabetic group	356.600	29.186			

100% of individuals in the healthy group had normal lung function, while in the diabetic group, 53.3% showed signs of obstruction and 46.7% showed signs of restriction. This disparity highlights a notable difference in the prevalence of lung function abnormalities

between the two groups, suggesting potential respiratory complications linked to diabetes with  $p < 0.001$ . Lung function analysis using chi square test showed a significant difference between diabetic group and control group. (table 2)

Table.2: Interpretation of lung function abnormalities

	Group		Total	Chi square	p value
	Healthy group	Diabetic group			
NORMAL	100.0%	0.0%	50.0%	30.000	p<0.001
OBSTRUCTION	0.0%	53.3%	26.7%		
RESTRICTION	0.0%	46.7%	23.3%		
Total	15	15	30		
	100.0%	100.0%	100.0%		

## Discussion

Diabetes mellitus is a long-term metabolic disorder marked by high blood glucose levels. Over time, the heart, blood vessels, eyes, kidneys, and nerves can sustain damage from this condition.<sup>1</sup> The lungs are one of the most affected organs in diabetes mellitus.<sup>12</sup> Long-term records of pulmonary complications from diabetes include a tendency towards infections, abnormalities in gas exchange, aspi-ration, pulmonary oedema, broncho motor dysregulation, irregular breathing during sleep, central hypoventilation, and abnormalities in lung mechanics. Reduced lung func-tion has been linked to elevated fasting blood glucose.<sup>15</sup>

The present study is a comparative observational study design, aimed to find the effect of exercise tolerance and pulmonary function among middle aged people with and without diabetes mellitus. The participants were assessed for exercise tolerance using six-minute walk test and pul-monary function with spirometer. In the present study, com-parison of the 6-minute walk test results between a healthy population and a diabetic population revealed notable dif-ferences in physical endurance, indicating that individuals with diabetes exhibit reduced physical endurance com-pared to their control group. Some previous studies have also noted decreased exercise capacity in patients with T2DM.<sup>12,16</sup> Exercise tolerance may be diminished in indi-viduals with Type 2 Diabetes Mellitus for a variety of rea-sons, such as insulin resistance, endothelial dysfunction, inadequate cardiac perfusion, reduced cerebral blood flow, and oxygenation deficits. They might also have changes in the activity of their skeletal and cardiac muscles. Aortic compliance plays a key role in controlling blood flow in the coronary arteries, which in turn influences myocardial work capacity and lowers exercise tolerance.<sup>14</sup>

The comparison of Forced Expiratory Volume in one second (FEV1) and Forced vital capacity (FVC) between the control and diabetic groups revealed considerable differences in lung function, the diabetic group having poorer lung function from the control group. Some previously available evidence also prints to to decreased FEV1 and FVC in T2DM patients when compared to age matched controls.<sup>17,19,20</sup>

Individuals with diabetes exhibited a reduced FEV1/FVC ratio compared to their control group. Tesema DG et al. and Niazi S. et al have also found decrease in mean FEV1/FVC

in type 2 diabetics as compared to normoglycemic partici-pants.<sup>21,22</sup> Reduced forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) in diabetic patients can be attributed to various mechanisms linked to the dis-ease. Diabetes can lead to glycation of proteins in the lung tissue, causing stiffening and reduced elasticity of the lung parenchyma, which impairs lung function. Additionally, chronic hyperglycemia contributes to systemic inflamma-tion and oxidative stress, further damaging lung tissue and function.<sup>26</sup> The reduced FEV1/FVC ratio observed in diabet-ic individuals may be attributed to diabetic neuropathy, microvascular complications, and obesity, which can collec-tively affect lung function.<sup>27</sup>

All the individuals in the healthy group had normal lung function, while in the diabetic group, 53.3% showed signs of obstruction and 46.7% showed signs of restriction. This disparity highlights a notable difference in the prevalence of lung function abnormalities between the two groups, suggesting potential respiratory complications linked to diabetes with p<0.001. Rajput S et al. (2023) have found that lung functions are likely to be reduced in individu-als with type II DM. Mostly, lung dysfunction is mixed in nature (obstructive or restrictive pattern).<sup>23</sup> On the other hand Gautam R. (2011) showed that restrictive pulmonary disorder is more prevalent in Type 2 diabetes mellitus 24 and Rohling M et al. found that type 2 diabetes mellitus ex-hibit features of obstructive ventilation pattern indicating reduced lung function.<sup>25</sup>

The present study results indicate that people with T2DM can suffer from impaired lung functions, even in the absence of overt symptoms. Prompt control of diabetes and early identification of pulmonary impairment and reduced exercise tolerance is necessary for all persons suffering from T2DM. Since diabetic patients are at an increased risk of developing respiratory pathology in the form of restric-tive and obstructive lung diseases, they should be advised to participate in pulmonary rehabilitation program and for improving exercise tolerance a minimum of 150 minutes moderate intensity physical activity should be followed on a daily basis along with proper diet.

This study had some limitations that must be acknowledged. They are the lack of analysis of cause - effect relationship and relatively small sample size. Further studies can address these shortcomings.

## Conclusion

Impaired exercise tolerance and pulmonary function was seen among type 2 DM individuals when compared to the control group. Management of individuals with type 2 diabetes mellitus can significantly enhance both exercise tolerance and pulmonary function. A tailored physiotherapy program that focuses on structured exercise, including aerobic, strength, flexibility, and balance training, not only improves physical capacity but also addresses specific limitations related to pulmonary health. Physiotherapists can educate patients on proper breathing techniques and posture, which are crucial for optimizing lung function during physical activity. Additionally, ongoing support and motivation from physiotherapists can foster adherence to exercise routines and promote healthier lifestyle choices. By integrating physiotherapy into comprehensive diabetes care, patients can achieve better health outcomes, improved functional capacity, and enhanced overall well-being.

**Patient Consent:** A written consent was obtained from the patient. **ETHICAL CLEARANCE:** Obtained.

Name of the ethics committee clearing the study :Institutional Ethics Committee AJ Institute of Medical Sciences and Research Centre. Date: 13/06/2023 DCGI Reg. No. EC/NEW/INST/2020/741 Number: AJEC/REV/189/2023

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