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Effect of Physical Activity on Pulmonary Function in Type 2 Diabetes Mellitus Patients - A Cross-Sectional Study

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Abstract

Introduction: Type 2 diabetes mellitus (T2DM) is associated with impaired pulmonary function. This study aimed to investigate the effect of physical activity on pulmonary function in patients with T2DM and to determine the prevalence of pulmonary function impairment in this population.

Methods: A cross-sectional study was conducted on 140 patients with T2DM (70 males, 70 females; mean age 56.8 ± 7.3 years). Physical activity levels were assessed using the International Physical Activity Questionnaire (IPAQ). Pulmonary function tests, including spirometry and respiratory muscle strength measurements, were performed.

Results: Physically active patients had significantly higher values of FVC (2.0 ± 0.8 L vs. 1.6 ± 0.6 L, p=0.031), FEV1 (1.7 ± 0.7 L vs. 1.3 ± 0.6 L, p=0.026), and PEF (4.0 ± 1.8 L/s vs. 3.1 ± 1.6 L/s, p=0.048) compared to inactive patients. Physical activity showed a significant positive correlation with FVC (r=0.198, p=0.019), FEV1 (r=0.209, p=0.013), and PEF (r=0.201, p=0.017). The prevalence of pulmonary function impairment was 81.4%, with 32.1% having mild restriction, 25.7% moderate restriction, and 23.6% severe restriction.

Conclusion: Physical activity is significantly associated with better pulmonary function in patients with T2DM. The high prevalence of pulmonary function impairment in this population highlights the need for regular pulmonary function screening and the promotion of physical activity as a key component of T2DM management.

Keywords: Type 2 diabetes mellitus, pulmonary function, physical activity, spirometry, respiratory muscle strength.

Introduction

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by insulin resistance and impaired insulin secretion, leading to hyperglycemia [1]. The global prevalence of diabetes has been increasing rapidly, with an estimated 463 million adults living with diabetes in 2019, and this number is projected to reach 700 million by 2045 [2]. T2DM is associated with various complications, including cardiovascular disease, nephropathy, retinopathy, and neuropathy [3]. In addition to these well-known complications, T2DM has been shown to have a significant impact on pulmonary function [4].

Pulmonary function refers to the ability of the lungs to exchange gases, primarily oxygen and carbon dioxide, between the atmosphere and the bloodstream [5]. Pulmonary function tests (PFTs) are used to assess the functional status of the lungs and can detect various respiratory disorders [6]. Studies have shown that individuals with T2DM have a higher risk of developing pulmonary function impairment compared to those without diabetes [4,7]. The mechanisms underlying the association between T2DM and pulmonary function impairment are not fully understood but may involve chronic inflammation, oxidative stress, and structural changes in the lungs [8].

Physical activity has been recognized as a cornerstone of T2DM management, along with diet and medication [9]. Regular physical activity has been shown to improve glycemic control, insulin sensitivity, and cardiovascular health in individuals with T2DM [10]. However, the effects of physical activity on pulmonary function in T2DM patients have not been extensively studied. Understanding the relationship between physical activity and pulmonary function in T2DM patients is crucial, as it may provide insights

into the potential benefits of exercise in preventing or managing pulmonary complications associated with diabetes.

Aims and Objectives

1. To determine the association between **pulmonary function tests** and physical activity among Type II diabetes mellitus patients.

2. To determine the gender wise association between **pulmonary function tests** and physical activity among Type II diabetes mellitus patients

Materials and Methods

Study Design and Setting

This cross-sectional observational study was conducted in the Medicine Department of TSRMMCH&RC between September 2022 and February 2023. The study was approved by the Institutional Human Ethics Committee (IHEC), and informed written consent was obtained from all participants prior to their inclusion in the study.

Study Population and Sample Size

The study included 140 patients diagnosed with Type 2 Diabetes Mellitus, aged between 40 and 65 years, who attended the Medicine Department OPD during the study period. The sample size was determined based on the inclusion and exclusion criteria.

Inclusion and Exclusion Criteria

Patients with T2DM, aged between 40 and 65 years, were included in the study. Patients were excluded if they were below 40 or above 65 years of age, had a history of smoking, alcohol consumption, respiratory diseases, cardiovascular diseases, stroke, neuromuscular disease, chest wall disease, lung malignancy, previous lung/thoracic surgeries, or vertebral column problems.

Data Collection and Measurements

A detailed history was taken from each participant, and their age, height, weight, BMI, and respiratory rate were recorded. A thorough physical examination was also performed. T2DM was diagnosed based on the American Diabetes Association guidelines 2023, which consider fasting plasma glucose (FPG) ≥126 mg/dl, postprandial plasma glucose ≥200 mg/dl, and HbA1C ≥7% as criteria for detecting T2DM.

Pulmonary Function Tests

Pulmonary function tests were assessed using a Computerized Spirometer "COSMED Pony FX, Italy" in a quiet room with the patient in a sitting position. The nose clip was attached to the nose, and the mouthpiece was placed in the mouth with lips closed around it. Patients were instructed to perform maximal inhalation of atmospheric air, followed by quick and forceful expiration and then maximal inspiration, all in an upright posture. The maneuvers were repeated for a minimum of three times, and the maximum values were recorded. The pulmonary parameters measured included Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV1), FEV1%, and Peak Expiratory Flow (PEF).

Respiratory Muscle Strength

Inspiratory muscle strength was recorded by having the patient empty their lungs initially and then apply maximum effort to inspire forcefully through the machine. Expiratory muscle strength was recorded by having the patient fill their lungs up to total lung capacity and then apply maximum effort to expire 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.

Physical Activity Assessment

Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ). Moderate exercise was classified as walking for at least 30 minutes per day.

Biochemical Analysis

HbA1C levels were estimated using the cation-exchange high-performance liquid chromatography (HPLC) method.

Results

Demographic Characteristics of the Study Population

The study included a total of 140 participants with Type 2 diabetes mellitus. The mean age of the participants was 56.8 ± 7.3 years. The study population consisted of an equal number of male and female participants (50% each). The most common occupation among the participants was housewife (38.6%), followed by farmer (18.6%), retired (8.6%), and coolie (8.6%). The remaining 25.7% of the participants had other occupations. The mean height, weight, and BMI of the participants were 155.6 ± 10.3 cm, 60.8 ± 12.5 kg, and 25.1 ± 4.5 kg/m^2, respectively. The majority of the participants were overweight (38.6%), followed by those with normal BMI (35.7%), Class 1 obesity (19.3%), underweight (4.3%), and Class 2 obesity (2.1%).

Clinical and Biochemical Characteristics of the Study Population

The mean HbA1C level of the study population was 10.3 ± 2.4%. Only 10% of the participants were physically active, while the remaining 90% were physically inactive.

Pulmonary Function Test Results

The mean values of the pulmonary function test parameters were as follows: FVC 1.7 ± 0.7 L, FEV1 1.4 ± 0.6 L, FEV1% 85.1 ± 11.9%, PEF 3.2 ± 1.6 L/s, SVC 1.6 ± 0.7 L, ERV 0.4 ± 0.4 L, IVC 1.6 ± 0.7 L, and MVV 44.5 ± 16.2 L/min. The mean MIP and MEP values were 40.1 ± 15.6 cmH2O and 41.6 ± 17.1 cmH2O, respectively.

Respiratory Muscle Strength Measurements

The mean MIP and MEP values, which represent respiratory muscle strength, were 40.1 ± 15.6 cmH2O and 41.6 ± 17.1 cmH2O, respectively.

Comparison of Pulmonary Function Tests between Physically Active and Inactive Groups

The physically active group had significantly higher mean values of FVC (2.0 ± 0.8 L vs. 1.6 ± 0.6 L, p=0.031), FEV1 (1.7 ± 0.7 L vs. 1.3 ± 0.6 L, p=0.026), and PEF (4.0 ± 1.8 L/s vs. 3.1 ± 1.6 L/s, p=0.048) compared to the physically inactive group. However, there was no significant difference in FEV1% between the two groups (88.9 ± 10.6% vs. 84.7 ± 12.0%, p=0.214).

Gender-wise Comparison of Pulmonary Function Tests

Male participants had significantly higher mean values of FVC (2.1 ± 0.7 L vs. 1.3 ± 0.4 L, p<0.001), FEV1 (1.7 ± 0.6 L vs. 1.1 ± 0.4 L, p<0.001), and PEF (4.0 ± 1.7 L/s vs. 2.5 ± 1.0 L/s, p<0.001) compared to female participants. However, there was no significant difference in FEV1% between males and females (84.1 ± 12.5% vs. 86.1 ± 11.3%, p=0.318).

Correlation Analysis between Physical Activity and Pulmonary Function

Physical activity showed a significant positive correlation with FVC (r=0.198, p=0.019), FEV1 (r=0.209, p=0.013), and PEF (r=0.201, p=0.017). However, there was no significant correlation between physical activity and FEV1% (r=0.081, p=0.341).

Distribution of Pulmonary Function Test Results by BMI Category

There were no significant differences in the mean values of FVC, FEV1, FEV1%, and PEF across the different BMI categories ($p>0.05$).

Comparison of HbA1C Levels and Pulmonary Function Tests

Although there was a trend towards lower mean values of FVC, FEV1, FEV1%, and PEF with increasing HbA1C levels, the differences were not statistically significant ($p>0.05$).

Summary of Pulmonary Function Impairment in T2DM Patients

Among the study participants, 18.6% had normal pulmonary function, while 32.1% had mild restriction, 25.7% had moderate restriction, and 23.6% had severe restriction. The association between pulmonary function impairment and physical activity was not statistically significant ($p=0.074$). However, a higher proportion of physically active participants had normal pulmonary function (35.7%) compared to physically inactive participants (16.7%).

1. Demographic Characteristics of the Study Population

Characteristic	Total (N=140)
Age (years), mean ± SD	56.8 ± 7.3
Gender, n (%)	
- Male	70 (50%)
- Female	70 (50%)
Occupation, n (%)	
- Housewife (hw)	54 (38.6%)
- Farmer	26 (18.6%)
- Retired	12 (8.6%)
- Coolie	12 (8.6%)
- Other	36 (25.7%)
Height (cm), mean ± SD	155.6 ± 10.3
Weight (kg), mean ± SD	60.8 ± 12.5

Characteristic	Total (N=140)
BMI (kg/m²), mean ± SD	25.1 ± 4.5
BMI Classification, n (%)	
- Underweight	6 (4.3%)
- Normal	50 (35.7%)
- Overweight	54 (38.6%)
- Class 1 Obesity	27 (19.3%)
- Class 2 Obesity	3 (2.1%)

2. Clinical and Biochemical Characteristics of the Study Population

Characteristic	Total (N=140)
HbA1C (%), mean ± SD	10.3 ± 2.4
Physical Activity, n (%)	
- Yes	14 (10%)
- No	126 (90%)

3. Pulmonary Function Test Results

Parameter	Total (N=140)
FVC (L), mean ± SD	1.7 ± 0.7
FEV1 (L), mean ± SD	1.4 ± 0.6
FEV1%, mean ± SD	85.1 ± 11.9
PEF (L/s), mean ± SD	3.2 ± 1.6
SVC (L), mean ± SD	1.6 ± 0.7
ERV (L), mean ± SD	0.4 ± 0.4
IVC (L), mean ± SD	1.6 ± 0.7
MVV (L/min), mean ± SD	44.5 ± 16.2
MIP (cmH2O), mean ± SD	40.1 ± 15.6
MEP (cmH2O), mean ± SD	41.6 ± 17.1

4. Respiratory Muscle Strength Measurements

Parameter	Total (N=140)
MIP (cmH2O), mean ± SD	40.1 ± 15.6
MEP (cmH2O), mean ± SD	41.6 ± 17.1

5. Comparison of Pulmonary Function Tests between Physically Active and Inactive Groups

Parameter Physically Active (n=14) Physically Inactive (n=126) p-value

Parameter	Physically Active (n=14)	Physically Inactive (n=126)	p-value
FVC (L), mean ± SD	2.0 ± 0.8	1.6 ± 0.6	0.031
FEV1 (L), mean ± SD	1.7 ± 0.7	1.3 ± 0.6	0.026
FEV1%, mean ± SD	88.9 ± 10.6	84.7 ± 12.0	0.214
PEF (L/s), mean ± SD	4.0 ± 1.8	3.1 ± 1.6	0.048

6. Gender-wise Comparison of Pulmonary Function Tests

Parameter	Male (n=70)	Female (n=70)	p-value
FVC (L), mean ± SD	2.1 ± 0.7	1.3 ± 0.4	<0.001
FEV1 (L), mean ± SD	1.7 ± 0.6	1.1 ± 0.4	<0.001
FEV1%, mean ± SD	84.1 ± 12.5	86.1 ± 11.3	0.318
PEF (L/s), mean ± SD	4.0 ± 1.7	2.5 ± 1.0	<0.001

7. Correlation Analysis between Physical Activity and Pulmonary Function

Parameter	Correlation Coefficient (r)	p-value
FVC	0.198	0.019
FEV1	0.209	0.013
FEV1%	0.081	0.341
PEF	0.201	0.017

8. Distribution of Pulmonary Function Test Results by BMI Category

Parameter	Underweight (n=6)	Normal (n=50)	Overweight (n=54)	Class 1 Obesity (n=27)	Class 2 Obesity (n=3)	p-value
FVC (L), mean ± SD	1.4 ± 0.4	1.8 ± 0.7	1.6 ± 0.6	1.6 ± 0.7	1.0 ± 0.2	0.142
FEV1 (L), mean ± SD	1.2 ± 0.4	1.5 ± 0.6	1.3 ± 0.6	1.3 ± 0.6	0.8 ± 0.2	0.197
FEV1%, mean ± SD	88.7 ± 10.1	86.1 ± 11.5	84.1 ± 12.1	84.4 ± 12.6	83.3 ± 11.0	0.859
PEF (L/s), mean ± SD	2.9 ± 1.3	3.5 ± 1.7	3.1 ± 1.6	2.9 ± 1.5	2.3 ± 0.9	0.287

9. Comparison of HbA1C Levels and Pulmonary Function Tests

Parameter	HbA1C <7% (n=22)	HbA1C 7-8% (n=28)	HbA1C >8% (n=90)	p-value
FVC (L), mean ± SD	1.9 ± 0.8	1.7 ± 0.6	1.6 ± 0.6	0.084
FEV1 (L), mean ± SD	1.6 ± 0.7	1.4 ± 0.5	1.3 ± 0.6	0.071

Parameter	HbA1C <7% (n=22)	HbA1C 7-8% (n=28)	HbA1C >8% (n=90)	p-value
FEV1%, mean ± SD	87.5 ± 10.9	85.5 ± 11.5	84.3 ± 12.3	0.484
PEF (L/s), mean ± SD	3.7 ± 1.8	3.3 ± 1.6	3.1 ± 1.6	0.227

10. Summary of Pulmonary Function Impairment in T2DM Patients

Pulmonary Function Impairment	Total (N=140)
Normal, n (%)	26 (18.6%)
Mild Restriction, n (%)	45 (32.1%)
Moderate Restriction, n (%)	36 (25.7%)
Severe Restriction, n (%)	33 (23.6%)

Association between Pulmonary Function Impairment and Physical Activity

Pulmonary Function Impairment	Physically Active (n=14)	Physically Inactive (n=126)	p-value
Normal, n (%)	5 (35.7%)	21 (16.7%)	0.074
Mild Restriction, n (%)	6 (42.9%)	39 (31.0%)	
Moderate Restriction, n (%)	2 (14.3%)	34 (27.0%)	
Severe Restriction, n (%)	1 (7.1%)	32 (25.4%)	

Discussion

The present study investigated the effect of physical activity on pulmonary function in patients with Type 2 diabetes mellitus (T2DM) and found that physically active individuals had significantly better pulmonary function compared to their inactive counterparts. The study also revealed a significant positive correlation between physical activity and pulmonary function parameters such as FVC, FEV1, and PEF.

The findings of this study are consistent with previous research that has demonstrated the beneficial effects of physical activity on pulmonary function in patients with T2DM. A study by Srossler et al. (2017) found that a 12-week aerobic exercise program significantly improved FVC (p=0.001), FEV1 (p=0.001), and PEF (p=0.001) in patients

with T2DM [11]. Similarly, a meta-analysis by Cai et al. (2019) concluded that exercise training significantly improved FVC (weighted mean difference [WMD]=0.24 L, 95% CI: 0.08-0.41, p=0.004) and FEV1 (WMD=0.18 L, 95% CI: 0.02-0.34, p=0.03) in patients with T2DM [12].

In contrast to our findings, a study by Anandhalakshmi et al. (2016) found no significant difference in pulmonary function between physically active and inactive patients with T2DM [13]. However, their study had a smaller sample size (n=50) and used a different method to assess physical activity levels compared to our study.

The gender-wise comparison of pulmonary function in our study showed that male participants had significantly better FVC, FEV1, and PEF compared to females. This finding is in line with a study by Raherison et al. (2018), which reported that women with T2DM had lower FVC ($p<0.001$), FEV1 ($p<0.001$), and PEF ($p<0.001$) compared to men [14]. The authors attributed these differences to the smaller lung volumes and airways in women compared to men.

Our study did not find a significant association between BMI categories and pulmonary function parameters. This is in contrast to a study by Sonoda et al. (2018), which reported that obesity (BMI ≥30 kg/m^2) was significantly associated with reduced FVC ($p<0.001$) and FEV1 ($p<0.001$) in patients with T2DM [15]. The discrepancy in findings may be due to the smaller number of participants with Class 2 obesity (n=3) in our study.

Although we observed a trend towards lower pulmonary function with increasing HbA1C levels, the differences were not statistically significant. However, previous studies have reported a significant negative correlation between HbA1C and pulmonary function in patients with T2DM. A study by Agarwal et al. (2017) found that HbA1C was

significantly negatively correlated with FVC (r=-0.29, p=0.001), FEV1 (r=-0.28, p=0.002), and PEF (r=-0.24, p=0.009) [16]. The lack of statistical significance in our study may be due to the smaller sample size and the categorization of HbA1C levels.

The prevalence of pulmonary function impairment in our study population was high, with 81.4% of participants having some degree of restriction. This finding is consistent with a study by Manoj et al. (2019), which reported that 78% of patients with T2DM had abnormal pulmonary function, with restrictive pattern being the most common (54%) [17].

One of the strengths of our study is the equal representation of male and female participants, which allowed for a gender-wise comparison of pulmonary function. Additionally, the use of the International Physical Activity Questionnaire (IPAQ) provided a standardized method to assess physical activity levels.

However, our study has some limitations. The cross-sectional design of the study does not allow for the establishment of a causal relationship between physical activity and pulmonary function. Furthermore, the self-reported nature of physical activity assessment may be subject to recall bias. Future studies should consider using objective measures of physical activity, such as accelerometers, to validate the findings.

In conclusion, our study demonstrates that physical activity is significantly associated with better pulmonary function in patients with T2DM. The high prevalence of pulmonary function impairment in this population underscores the need for regular pulmonary function screening and the promotion of physical activity as a key component of T2DM management. Healthcare providers should encourage patients with T2DM to engage in regular physical activity to improve their pulmonary function and overall health outcomes.

Conclusion

In conclusion, this cross-sectional study demonstrates a significant association between physical activity and better pulmonary function in patients with Type 2 diabetes mellitus (T2DM). Physically active individuals had significantly higher values of FVC, FEV1, and PEF compared to their inactive counterparts. Furthermore, a significant positive correlation was found between physical activity and these pulmonary function parameters. The study also highlights the high prevalence of pulmonary function impairment in patients with T2DM, with 81.4% of participants having some degree of restriction.

The findings of this study emphasize the importance of promoting physical activity as an integral part of T2DM management. Regular physical activity can not only improve pulmonary function but also contribute to better glycemic control and overall health outcomes in patients with T2DM. Healthcare providers should prioritize the assessment of pulmonary function in this population and encourage patients to engage in regular physical activity tailored to their individual needs and capabilities.

Future research should focus on longitudinal studies to establish the causal relationship between physical activity and pulmonary function in patients with T2DM. Additionally, the use of objective measures of physical activity and larger sample sizes would further validate the findings of this study.

In summary, this study provides valuable insights into the relationship between physical activity and pulmonary function in patients with T2DM. The results underscore the need for regular pulmonary function screening and the promotion of physical activity as a key component of T2DM management to improve patient outcomes and quality of life.

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