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RESEARCH ARTICLE

Assessment of pulmonary functions in type 2 diabetes mellitus: Its correlation with glycemic control and body mass index

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ABSTRACT

Background: Pulmonary function is an independent risk factor for mortality in diabetes mellitus. Impaired pulmonary function, especially decreased alveolar gas exchange, can occur in cases with type 2 diabetes mellitus. Pulmonary function parameters such as forced expiratory volume at the first second (FEV1), forced vital capacity (FVC), FEV1/FVC, peak expiratory flow rate (PEFR), and $FEF_{25–75\%}$ have significant changes in diabetic cases than healthy individuals. **Aims and Objectives:** This study was designed to evaluate the pulmonary functions in type 2 diabetic cases and its correlation with body mass index (BMI) and glycemic control. **Materials and Methods:** A total of 100 type 2 diabetic cases and 100 age- and sex-matched control subjects between 31 and 60 years were recruited. A 2 ml blood was collected to estimate blood glucose levels and hemoglobin A1c (HbA1c). Spirometer was used to measure the various lung function parameters like forced vital capacity (FVC), forced expiratory volume at first second (FEV1), peak expiratory flow rate (PEFR), FEV1/FVC and $FEF_{25-75\%}$. **Results:** The mean difference of age, height, weight, and BMI was statistically not significant ($P > 0.05$). The mean FEV1, FVC, PEFR, and $FEF_{25–75\%}$ were significantly lesser in type 2 diabetic cases than control subjects. The mean FVC, FEV1, $FEF_{25–75\%}$, and PEFR were low in cases with HbA1c <7 compared to the cases with HbA1c >7. The mean differences between pulmonary function tests were statistically not significant. There was a negative correlation between FVC, FEV1, and HbA1c levels. **Conclusion:** The pulmonary functions were reduced in type 2 diabetes cases. It is necessary to undergo pulmonary function testing periodically in diabetic cases. Regular respiratory workouts help to strengthen respiratory muscles and firm glycemic control can improve the pulmonary function in type 2 diabetic cases.

KEYWORDS: Type 2 Diabetes Mellitus; Forced Vital Capacity; Forced Expiratory Volume at the First Second; Peak Expiratory Flow Rate

INTRODUCTION

Diabetes mellitus is a complex metabolic disorder becoming a major health hazard globally. In India, the incidence of diabetes is enormously increasing and according to the WHO, by 2025, India will be world diabetic capital.[1] The International Diabetes Federation estimated that by 2030, around 87 million people will suffer from diabetes in India.[2] Diabetes mellitus is characterized by chronic hyperglycemia with impairments in the metabolism of carbohydrate, fat, and protein due to insufficient insulin production.[3]

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The diabetes-associated respiratory complications may result in changes in lung volumes, diffusion, and elastic properties of lungs as well as respiratory musculature performance.[4] Pulmonary function is an independent risk

factor for mortality in diabetes mellitus.[5] A study by van den Borst *et al*. stated that irrespective of body mass index (BMI), duration of disease, smoking, and glycemic control, there is a statistically significant impairment in pulmonary function.[6] Pulmonary function parameters such as forced expiratory volume at the first second (FEV1), forced vital capacity (FVC), FEV1/FVC, peak expiratory flow rate (PEFR), and $FEF_{25–75\%}$ have significant changes in diabetic cases than healthy individuals.[7] Studies suggested that pulmonary function such as FVC and FEV1 was significantly lower in diabetics than non-diabetics.[8] The present study was designed to evaluate the pulmonary functions in type 2 diabetic cases and its correlation with factors affecting hemoglobin A1c (HbA1c) levels.

MATERIALS AND METHODS

The present study was conducted in the Department of Physiology, Kamineni Academy of Medical Sciences and research Center, Hyderabad, from January 2019 to December 2019. A total of 100 cases clinically diagnosed with diabetes mellitus between the age group of 31 and 60 years were selected and 100 age- and sex-matched healthy subjects were recruited as control subjects. Cases with fasting blood glucose level >126 mg/dl and postprandial blood glucose >200 mg/dl were included in the study. Cases with cardiovascular complications and chronic respiratory complications such as chronic obstructive pulmonary disease, asthma, smokers, and musculoskeletal disorders were excluded from the study. Informed consent was obtained from all the study participants. The study protocol was approved by the Institutional Ethics Committee (No: KAMSR/IEC/12/44).

A total of 2 ml blood sample given for the routine investigation were collected from the study participants before and after their normal diet to measure blood glucose levels and HbA1c levels. Glucose oxidase method was used to measure fasting and postprandial blood glucose level, and glycated hemoglobin (HbA1c) level was assessed using glycohemoglobin-HbA1 test kit method as per the manufacturer's protocol. Spirometer was used to measure the various lung function parameters like forced vital capacity (FVC), forced expiratory volume at first second (FEV1), peak expiratory flow rate (PEFR), FEV1/FVC and $FEF_{25-75\%}$. Data were collected into the Microsoft Excel and were analyzed by SPSS statistical software version 16. The Student's *t*-test was used to compare the means of quantitative data. Correlation analysis was done using Pearson's correlation analysis.

RESULTS

The mean age in cases was 43.54 ± 6.21 and in control subjects was 43.18 ± 5.56. The mean height in cases was 160.22 ± 7.63 and in control subjects 161.08 ± 7.35. The mean weight in cases was 59.6 ± 8.24 and in controls was 60.88 ± 8.46. The mean BMI in cases was 26.58 ± 2.89 and in control subjects 26.45 ± 3.74. The mean difference of age, height, weight, and BMI was statistically not significant [Table 1]. Table 2 shows comparison of pulmonary function tests between cases and control subjects. The mean FVC, FEV1, $FEF_{25–75\%}$, and PEFR were low in cases with HbA1c <7 compared to the cases with HbA1c >7. The mean difference among these parameters

Table 1: Demographic values of the study participants

Parameters	Cases (*n*=100) (Mean±SD)	Controls (*n*=100) (Mean±SD)	*P* value
Age (in years)	43.54±6.21	43.18±5.56	0.782
Height (in cm)	160.22±7.63	161.08±7.35	0.526
Weight (in kg)	59.6±8.24	60.88±8.46	0.248
BMI (kg/m^2)	26.58±2.89	26.45±3.74	0.631

BMI: Body mass index

Table 2: Comparison of pulmonary function tests between cases and control subjects

Parameters	Cases (*n*=100) (Mean±SD)	Controls (*n*=100) (Mean±SD)	*P* value
FVC	81.22±10.08	92.48±12.72	0.003
FEV1	78.53±10.26	90.89±11.18	0.001
FEV1/FVC	84.06±4.72	83.28±5.14	0.437
$FEF_{25–75\%}$	68.24±18.56	72.95±14.38	0.225
PEFR	86.73±13.44	93.52±12.39	0.042

FVC: Forced vital capacity, FEV1: Forced expiratory volume at the first second, PEFR: Peak expiratory flow rate.

Table 3: Comparison of pulmonary function tests among cases with HbA1c <7 and >7

Parameters	Cases with HbA1c <7 (Mean±SD)	Cases with HbA1c >7 (Mean±SD)	*P* value
FVC	87.23±14.69	80.59±3.26	0.521
FEV1	81.13±11.85	75.34±12.56	0.433
FEV1/FVC	82.52±6.41	83.65±6.63	0.864
$FEF_{25–75\%}$	69.24±12.36	66.87±14.68	0.382
PEFR	90.58±13.76	83.79±12.48	0.248

FVC: Forced vital capacity, FEV1: Forced expiratory volume at the first second, PEFR: Peak expiratory flow rate,

Table 4: Comparison of pulmonary function tests among cases with BMI <25 and >25

Parameters	Cases with BMI <25 (Mean±SD)	Cases with BMI >25 (Mean±SD)	*P* value
FVC	78.65±10.09	84.57±11.93	0.621
FEV1	75.41±9.33	78.54±10.02	0.737
FEV1/FVC	84.04±4.97	83.99±5.73	0.824
$FEF_{25–75\%}$	62.27±13.69	68.89±13.21	0.652
PEFR	84.33±11.24	84.65±12.69	0.983

FVC: Forced vital capacity, FEV1: Forced expiratory volume at the first second, PEFR: Peak expiratory flow rate, BMI: Body mass index

Table 5: Pearson's correlation of pulmonary function tests with HbA1c and BMI

Parameters	Pearson's correlation (r^2) of PFT with HbA1c in cases		Pearson's correlation (r^2) of PFT with BMI			
			Cases		Controls	
	r^2 value	*P* value	r^2 value	*P* value	r^2 value	*P* value
FVC	−0.304	0.228	−0.064	0.284	−0.039	0.653
FEV1	−0.022	0.369	−0.022	0.837	−0.023	0.698
FEV1/FVC	0.421	0.054	0.195	0.219	0.124	0.441
$FEF_{25–75\%}$	0.189	0.468	0.098	0.458	0.029	0.608
PEFR	0.039	0.782	0.043	0.427	0.021	0.284

FVC: Forced vital capacity, FEV1: Forced expiratory volume at the first second, PEFR: Peak expiratory flow rate, BMI: Body mass index

was not statistically significant [Table 3]. Table 4 describes comparison of pulmonary function tests among cases with BMI <25 and >25. Table 5 depicts Pearson's correlation of pulmonary function tests with HbA1c and BMI.

DISCUSSION

Diabetes mellitus is the multisystem disorder that affects multiple organs and accompanied by a certain complication that may affect cardiovascular, renal, and neurological systems.[9] Studies suggest that pulmonary function test with type 2 diabetes showed controvertible outcomes. Few studies showed a reduction in lung volume and few studies showed that lung volume remains the same.[10,11] The present study was designed to assess the pulmonary functions in type 2 diabetic cases and its correlation with factors affecting HbA1c levels. A total of 100 type 2 diabetic cases and 100 age- and sex-matched control subjects between 31 and 60 years were recruited. In the present study, the mean difference of age, height, weight, and BMI was statistically not significant [Table 1]. In this study, the mean FVC value was 81.22 ± 10.08 and 92.48 ± 12.72 in cases and control subjects, respectively, and the mean difference was statistically significant ($P < 0.003$). The mean FEV1 value in cases was 78.53 ± 10.26 and in controls was 90.89 ± 11.18. The mean difference was statistically significant ($P < 0.001$). The mean value of FEV1/FVC was 84.06 ± 4.72 and 83.28 ± 5.14 in cases and controls, respectively, and the mean difference was statistically not significant ($P = 0.437$). The mean PEFR in cases was 86.73 and in control subjects 93.52 [Table 2]. The mean FVC, FEV1, $FEF_{25–75\%}$, and PEFR were low in cases with HbA1c <7 compared to the cases with HbA1c >7. The mean difference among these parameters was not statistically significant [Table 3]. The mean values of FVC, FEV1, $FEF_{25–75\%}$, and PEFR are higher in cases with BMI >25 than BMI<25 [Table 4]. In this study, there was a negative correlation between FVC, FEV1, and HbA1c levels [Table 5].

A study by Jamatia *et al*. found that the mean difference of age, sex, height, weight, and BMI was statistically not significant ($P > 0.05$).[10] Kim *et al*. found that the mean difference of age and BMI was statistically significant.[12] The mean difference was statistically significant ($P < 0.042$). A study by Jamatia *et al*. stated that FVC and PEFR were found to be higher in control subjects than diabetic cases.[10] Marvisi *et al*. and Sinha *et al*. in their study stated that FVC, FEV1, and PEFR were higher in control subjects than diabetic cases.[13,14] A study by Mandava and Gopathi found that the values of pulmonary functions were decreased in diabetic cases. Poor airflow limitation was an important predictor of mortality in type 2 diabetes.[15] A study by Kim *et al*. in the diabetic group found that the FEV1 and FVC were decreased.[12] A study by Anandhalakshmi *et al*. found that the values of FVC, FEV1, and PEFR were significantly lower in type 2 diabetes cases than control subjects.[16] The above similar results were noticed by the studies which noted decreased pulmonary function in diabetes.[17,18] A study by Davis *et al*. and McKeever *et al*. stated that pulmonary function such as FEV1 and FVC was significantly reduced in diabetic cases than control subjects.[19,20] A study by Walter *et al*. found a larger reduction in the levels of FVC than FEV1.[21] Singh *et al*. in their study found that the mean values of FVC, FEV1, and DLCO were less in the diabetic group than the control group. The mean difference was statistically not significant.[22] A study by Anandhalakshmi *et al*. found that FEV1 and FEV1/FVC were significantly lower in diabetic cases with HbA1c <7 than HbA1c >7.[16] The levels of FEV1 and FVC were more in the diabetic cases with HbA1c <7 than HbA1c <7. The mean difference was statistically significant.[22] A study by Acharya *et al*. found no correlation between HbA1c levels and pulmonary function parameters.[23] A study by Kim *et al*. found that overall pulmonary function was negatively correlated with FPG and HbA1c levels.[12]

A study by van den Borst *et al*. stated that irrespective of BMI, duration of disease, smoking, and glycemic control, there is statistically significant impairment in pulmonary function.[6] Pulmonary function parameters such as FEV1, FVC, FEV1/FVC, PEFR, and $FEF_{25–75\%}$ have significant changes in diabetic cases than healthy individuals.[7] In this study, the mean outcome of values of FVC, FEV1, PEFR, and $FEF_{25–75\%}$ was less in type 2 diabetes cases than control subjects. The findings are correlating with the findings of several studies.[12,16-22] This study has few limitations such as

the questionnaire is not discriminate the type 2 and type-1 diabetes. Further studies are required to study the status of pulmonary function tests in type 1 diabetes. Further studies are needed to assess the clinical outcomes and long-term changes in lung function in type 2 diabetes mellitus.

CONCLUSION

The outcome of this study concludes that the pulmonary functions were reduced in Type 2 diabetes cases. It is necessary to undergo pulmonary function testing periodically in diabetic cases. Regular respiratory workouts help to strengthen respiratory muscles and firm glycemic control can improve the pulmonary function in type 2 diabetic cases.

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