Original Article

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Correlation of Pulmonary Function Tests with Anthropometry and Glycaemic Control in Type 2 Diabetes Mellitus: A Cross-sectional Study

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ABSTRACT

Introduction: Diabetic patients are found to have reduced lung functions compared to their controls and their relationship with the duration of diabetes, glycaemic control, and Body Mass Index (BMI) is poorly characterised.

Aim: To determine the correlation between the pulmonary function abnormalities with anthropometry, glycaemic control, and duration of diabetes in type 2 diabetic patients.

Materials and Methods: A total of 80 type 2 diabetic patients were studied. BMI, Waist Circumference (WC), Waist-Hip Ratio (WHR), Fasting, postprandial blood sugar and glycosylated haemoglobin (HbA1c) were assessed from July 2018 to September 2018. Spirometry was done in accordance with the guidelines from the American Thoracic Society (ATS). Reduced pulmonary functions were defined as patients with restrictive Forced Expired Volume in 1 second (FEV1)/Forced Vital Capacity (FVC) ≥0.7 and FVC <80% predicted or obstructive (FEV1/FVC <0.7) impairment. Statistical analysis was done using ANOVA test and Karl Pearson Correlation coefficient.

Results: The mean values of FEV1/FVC (0.8±0.08) and FVC% predicted (60.29±11.39) showed a restrictive pattern. FEF (25-75%) (r=0.241, p=0.031) and Peak Expiratory Flow Rate (PEFR) (r=0.245, p=0.029) positively correlated with duration of diabetes. BMI had a negative correlation with FVC% predicted (r=0.239, p=0.033). A negative correlation between FEV1% and Waist Circumference (WC) was observed (r=-0.232, p=0.038). HbA1c negatively correlated to FEV1/FVC (r=-0.227, p=0.043).

Conclusion: Patients with type 2 Diabetes Mellitus (DM) were found to have an asymptomatic restrictive pulmonary impairment. Increased duration of diabetes, increased BMI, increased WC was associated with decreased lung functions in diabetics.

Keywords: Blood sugar, Body mass index, Respiratory function tests, Waist circumference, Waist-hip ratio

INTRODUCTION

The Diabetes Mellitus (DM) is a major global public health problem. The most common type of DM is Type 2 which accounts for around 95% cases in adults. According to the 8th International Diabetes Federation (IDF) atlas 2017, it is estimated that 425 million people in the age group of 20-79 years worldwide have diabetes. In India, 72.946 million have diabetes. By 2045, there will be nearly 629 million people globally with diabetes and India would overtake China by reaching 134.3 million people with diabetes [1].

Type 2 DM complications such as chronic kidney disease, heart failure, retinopathy, and neuropathy may already have developed in late detection. The abundant connective tissue and extensive microcirculation of the lung raise the possibility that the lung may also be a target organ [2]. However, its effect on the lungs is poorly characterised [3]. Duration of DM and glycaemic control has varied impacts on pulmonary functions [4]. The increased systemic inflammation in DM may result in pulmonary inflammation-causing airway damage [5]. Microangiopathy in the lungs causes restriction of lung volume and alveolar gas transport [6]. Decreased pulmonary capillary blood volume, decreased membrane diffusing capacity, reduced elastic recoil, diminished respiratory muscle performance, chronic low-grade inflammation, and autonomic neuropathy involving respiratory muscles are the other changes [7]. Lung functions in diabetics have shown variable results [2,4,7].

People with a higher BMI are more susceptible to diabetes and its complications. High body fat increases insulin resistance in muscles, liver, adipose tissue which increases body insulin production and causes impaired glucose tolerance [8,9]. Asians are genetically predisposed to diabetes hence risks for diabetes and its complications are high even for normal BMI [10]. Central obesity can influence respiratory mechanics. WC is a better indicator of a health risk as it measures abdominal fat which correlates to intra-abdominal fat [11]. The age of the individual is negatively correlated with lung function indices [12].

Studies evaluating the lung functions and their relationship with HbA1c and duration of diabetes are less frequently done in India. It was observed in various studies that increase in mean HbA1c was associated with a decrease in FVC and FEV1 [3,4,7,13] and others stating the effect is not significant [2,9].

Hence, the present study was conducted to assess the pulmonary functions in diabetic patients and correlate it with anthropometry, duration of DM and glycaemic controls keeping in mind the conflicting previous observations.

MATERIALS AND METHODS

This was a prospective, cross-sectional study conducted at Father Muller Medical College and Hospital, in coastal Karnataka, India. Ethical approval was obtained prior to initiation of the study (FMMCIEC/CCM/364/2018). Patients attending the outpatient service fulfilling the inclusion criteria were included in the study from July 2018 to September 2018.

Inclusion criteria: All the patients with type 2 DM more than 18 years of age attending the Outpatient Department (OPD) service during the study time period were included in the study.

Exclusion criteria: Patients with a history of smoking, bronchial asthma, Chronic Obstructive Pulmonary Disease (COPD), industrial dust exposure, and other major cardiopulmonary illness were excluded from the study.

A written informed consent was obtained from all the patients. A detailed history regarding the duration of diabetes, treatment, and complications were taken. Stratification based on the duration of disease and treatment was done. Parameters evaluated were as follows:

Anthropometric Measurements

1. Height in centimeters (cm)
2. Weight in kilograms (kg) was measured using an analog weighing machine.
3. Body Mass Index (BMI) by Quetelet's Index in Kg/m². It was divided into subgroups based on Asia-Pacific BMI criteria values [14]:
    - <18.5 Kg/m² Underweight
    - 18.5-22.9 Kg/m² Normal
    - 23-24.9 Kg/m² Overweight
    - 25-29.9 Kg/m² Pre-obese
    - >30 Kg/m² Obese
4. Waist Circumference in centimeters (WC): It was determined by applying a tape measure to the midpoint between the inferior margin of the last rib and the crest of the Ilium. It was stratified into the following groups according to the cut-offs for South Asians [15].
    - Males:<78, 78-89, ≥90 cm
    - Females:72-79, ≥80 cm
5. Hip circumference in centimeters (HC): measured over the widest part of buttocks.
6. Waist to Hip Ratio (WHR) was calculated. It was classified into:
    - Males:<0.90, 0.90-0.99, ≥1.00 cm
    - Females:<0.80, 0.80-0.84, ≥0.85 cm

Biochemical Investigations

About 2 mL of venous blood was collected in Ethylene diaminetetraacetic Acid (EDTA) tube

1. Fasting blood sugar by hexokinase method after 12 hours of fast.
2. Postprandial blood sugar by hexokinase method after 2 hours of the meal.
3. Glycosylated Haemoglobin (HbA1c) measured using high-performance liquid chromatography. It is subdivided into:
    - 6-7.5 good control
    - >7.5 poor control

Pulmonary Function Tests

Spirometry was done by a specially trained technician using Easy One Connect Flow directed spirometry and following the guidelines from the American Thoracic Society (ATS) [15]. It was done without the administration of a bronchodilator. The spirometer was factory calibrated and did not require further calibration. The quality of the test, prediction of values according to National Health and Nutrition Examination Survey (NHANES) III, and interpretation of spirometry data according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria of 2008 mentioned in Hardie JA et. al [16] was performed automatically by the spirometer. Spirometry was repeated atleast three times to ensure reproducibility and validity and the best of three acceptable measurements were taken. The variables were recorded both in absolute volume as well as percentage predicted based on regression equations. Spirometry measures:

1. Forced Vital Capacity (FVC)
2. Forced Expired Volume in 1 second (FEV1)
3. Peak Expiratory Flow Rate (PEFR)
4. Forced Expiratory Flow (FEF 25-75%)
5. FEV1/FVC ratio

STATISTICAL ANALYSIS

Results were tabulated using Microsoft Excel 2007. The collected data were analysed by frequency, percentage, mean, standard deviation. Further evaluation of the data by comparing the means of more than two different groups was performed by using the ANOVA test and the linear relationship between two continuous variables was compared using Karl Pearson Correlation coefficient. The analysis was done in Statistical Package for the Social Science (SPSS) version 23.0. A p-value <0.05 was taken as statistically significant.

RESULTS

A total of 80 diabetic patients were studied. The mean age of the study population was 58.43±10.73 years, with a minimum age of 35 years and maximum age of 81 years [Table/Fig-1]. The duration of diabetes was <10 years in the majority of the patients (47.5%). The average duration of diabetes was 12.36 years and the average age of onset was 46.07 years [Table/Fig-2].

Variables	Patients Mean±SD	Range
Age (years)	58.43±10.73	35.00-81.00
Height (cm)	161.16±9.51	143.00-181.00
Weight (kg)	64.26±11.77	40.00-92.00
BMI (Kg/m²)	24.71±3.52	12.30-32.90
WC (cm)	94.90±10.16	68.00-119.00
HC (cm)	110.41±9.35	93.00-135.00
Waist/Hip ratio	0.86±0.07	0.71-1.04
FBS (mg/dL)	155.85±58.81	64.00-328.00
PPBS (mg/dL)	248.29±93.47	98.00-583.00
HbA1c (%)	7.85±1.57	6.10-14.10
FVC (L)	2.21±0.74	0.78-4.03
FVC%pred	60.29±11.39	27.00-82.00
FEV1 (L)	1.76±0.63	0.59-3.29
FEV1% pred	62.01±12.79	27.00-86.00
FEVI/FVC	0.80±0.08	0.50-1.00
FEV1/FVC% pred	103.56±9.82	64.00-130.00
FEF25-75% (L/S)	1.93±0.94	0.12-4.20
FEF 25-75% (% pred)	75.05±30.06	6.00-155.0
PEF (L/m)	4.57±1.86	1.26-11.14
PEF (% pred)	62.83±20.39	23.00-140.00

[Table/Fig-1]: Demographics of the study population (n=80).
Pred-predicted; n: Number of subjects; cm: Centimeters; kg: Kilograms; BMI: Body mass index; WC: Waist circumference; HC: Hip circumference; FBS: Fasting blood sugar; PPBS: Post-prandial blood sugar; HbA1c: Glycosylated haemoglobin; FVC: Forced vital capacity; FEV1: Fored expired volume in 1 second; FEF: Forced expiratory flow; PEF: Peak expiratory flow; Pred: Predicted

Most of the study population was under treatment and 60 of them were on oral hypoglycaemic agents. The mean HbA1c value was 7.85±1.57%. Most of the patients belonged to the group of BMI range of 25-29.9 Kg/m². The mean WC and WHR were 94.90±10.16 cm and 0.86±0.07, respectively [Table/Fig-2].

Relationship between BMI and Pulmonary Function Tests

A decrease in the mean FEV1, FVC, and PEF values were seen in obese patients compared to the pre-obese. Mean FVC was reduced in the pre-obese patients when compared with the normal BMI patients [Table/Fig-3]. BMI showed an inverse relationship with FEV1, FVC, FEF25-75%, PEFR. A statistically significant correlation was seen with BMI and FVC% (r=-0.239, p=0.033).

Waist Circumference (WC) and Pulmonary Function Tests

[Table/Fig-4] shows that FEV1, FEF25-75% and PEFR was lower in male patients with WC >90 than the male patients with WC <78. Females with WC >80 had decreased FEF25-75% compared to females with WC 72-79. WC has an inverse relationship with

Parameters		Frequency n (%)
Sex	Female	35 (43.8)
	Male	45 (56.2)
BMI (kg/m²)	<18.5	2 (2.5)
	18.5-22.9	24 (30.0)
	23-24.9	17 (21.2)
	25-29.9	32 (40.0)
	>30	5 (6.3)
WC (cm) Males	<78	3 (3.8)
	78-89	6 (7.5)
	>90	36 (45.0)
Females	72-79	4 (5.0)
	>80	31 (38.7)
Waist/Hip Males	<0.90	35 (43.7)
	0.90-0.99	9 (11.3)
	>1.00	1 (1.3)
Females	<0.80	5 (6.2)
	0.80-0.84	12 (15.0)
	>0.85	18 (22.5)
Duration of diabetes (years)	1-10	38 (47.5)
	11-20	27 (33.8)
	>20	15 (18.7)
Treatment	Diet	3 (3.7)
	Insulin	12 (15.0)
	Insulin and OHA	5 (6.3)
	OHA	60 (75.0)
HbA1c	6-7.5	51 (63.8)
	>7.5	29 (36.2)

[Table/Fig-2]: Data according to the stratifications of each parameter.

Body mass index	FEV1 (L) FEV1 (%Pred)	FVC (L) FVC (%Pred)	FEV1/FVC (%pred)	FEF25-75% (L/s) FEF25-75% (%Pred)	PEF (L/m) PEF (%Pred)
p-value	0.13	0.033	0.678	0.709	0.459
r (Pearson correlation)	-0.171	-0.239*	0.047	-0.042	-0.084
Underweight	2.23±0.37 (69.50+2.12)	2.82±0.56 (68.50+2.12)	79.40±2.68	2.20±0.64 (74.50±16.26)	6.45±0.58 (76.50±16.26)
Normal	1.69±0.65 (62.21±12.07)	2.21±0.73 (62.46±9.89)	77.99±9.09	1.83±0.86 (74.29±26.23)	4.24±2.38 59.96±26.95)
Overweight	1.93±0.68 (64.94+13.94	2.38±0.80 (61.76+12.31)	81.07±6.65	2.12±1.00 (78.06±31.70)	4.90±1.47 (65.82±16.70)
Pre-obese	1.74±0.60 (61.31+12.05)	2.16±0.70 (59.06+10.33)	80.35±7.41	1.89±1.01 (72.81±30.99)	4.59±1.58 (63.13±16.91)
Obese	1.43±0.63 (52.60±17.59)	1.74±0.82 (49.40±18.28)	83.98±9.99	1.97±0.93 (83.00±46.85)	4.12±2.08 (59.00±20.88)

[Table/Fig-3]: Comparison of subgroups of BMI and pulmonary function tests.
ANOVA test p-value >0.05, Pred=Predicted*Correlation to be significant at 0.05 level

pulmonary function parameters. A statistically significant correlation was found with WC and FEV1% (r=-0.232, p=0.038).

Waist/hip Ratio and Pulmonary Function Parameters

[Table/Fig-5] shows that FEV1, FVC, FEV1/FVC, FEF25-75% was reduced in the male group with WHR >1.00 than in the group with WHR of the range 0.90-0.99.

There was no remarkable variation in pulmonary function parameters of the female groups. WHR had a positive correlation to all the pulmonary function parameters but was statistically not significant except for FVC% (r=0.000).

Duration of Diabetes and Pulmonary Functions

[Table/Fig-6] depicts that there was no significant reduction of pulmonary function parameters when compared with diabetes of

Waist circumference (cm)	FEV1(L) FEV1 (%Pred)	FVC (L) FVC (%Pred)	FEV1/FVC (%pred)	FEF25-75% (L/s) FEF25-75% (%Pred)	PEF (L/m) PEF (%Pred)
p-value	0.038	0.206	0.437	0.196	0.334
r (Pearson correlation)	-0.232*	-0.143	-0.088	-0.146	-0.109
Males					
<78	1.94±0.85 68.33+3.055	2.27±0.85 62.33+5.68	84.43±6.40	2.02±0.91 75±9.64	4.72±1.87 70.33±33.23
78-89	1.44±0.57 52.50+15.65	1.86±0.50 52.50+7.06	74.83±13.6	1.49±0.89 61.50±33.72	3.86±1.83 52.50±20.86
>90	1.84±0.64 63.06+12.87	2.31±0.74 61.22±12.06	79.52±7.64	1.93±1.07 71.47±28.33	4.45±1.94 58.72±21.86
Females					
72-79	1.51±0.59 63.50+5.80	1.84±0.73 58.25±5.12	82.35±2.21	1.91±0.82 93.75±18.08	4.13±2.37 65.50±16.84
>80	1.73±0.63 61.84+13.00	2.20±0.77 60.77±12.01	80.82±7.25	2.01±0.83 79.42±33.10	4.89±1.75 68.52±16.76

[Table/Fig-4]: Comparison of categories of Waist Circumference (WC) and pulmonary function tests.
ANOVA test p-value >0.05, Pred=predicted, Correlation to be significant at 0.05 level

Waist to Hip Ratio (WHR)	FEV1 (L) FEV1 (%Pred)	FVC (L) FVC (%Pred)	FEV1/FVC (%pred)	FEF25-75% (L/s) FEF25-75% (%Pred)	PEF (L/m) PEF (%Pred)
p-value	0.671	0.999	0.419	0.416	0.924
r (Pearson correlation)	0.048	0.000	0.092	0.084	0.011
Males					
<0.90	1.73±0.62 (62.23±13.63)	2.19±0.69 (60.86±11.46)	78.41±8.57	1.74±0.98 (67.71±25.48)	4.29±1.95 (59.37±23.58)
0.90-0.99	2.04±0.74 (61.22±13.30	2.49±0.86 (57.67±12.57)	82.31±8.98	2.39±1.17 (80.22±37.63	4.56±1.73 (53.67±16.54)
>1.00	1.8300 (61.00)	2.2900 (57.00)	79.900	1.8300 (75.00)	6.3500 (79.00)
Females					
<0.80	1.82±0.66 (63.80±7.79)	2.25±0.76 (60.40±7.43	80.54±4.89	2.11±1.02 (82.20±21.54)	5.28±2.59 (68.60±20.35)
0.80-0.84	1.61±0.56 (59.83±12.86)	2.16±0.69 (62.67±10.16	78.35±6.64	1.87±0.60 (73.33±25.01)	4.25±1.85 (61.92±19.42
>0.85	1.74±0.67 (63.00±13.35)	2.14±0.85 (59.06±13.23	82.90±7.15	2.05±0.91 (85.89±38.12)	5.04±1.54 (72.22±12.69)

[Table/Fig-5]: Comparisons of gender-based groups of Waist Circumference (WC) to hip circumference ratio and pulmonary function parameters.
ANOVA test p-value >0.05

Duration of diabetes (years)	FEV1(L) FEV1(%Pred)	FVC(L) FVC(%Pred)	FEV1/FVC (% pred)	FEF25-75% (L/s) FEF25-75% (%Pred)	PEF (L/m) PEF (%Pred)* *ANOVA test p value=0.018
p-value	0.906	0.460	0.053	0.031	0.029
r (Pearson correlation)	-0.013	-0.084	0.217	0.241*	0.245*
1-10	1.79+0.68 (61.55+13.41)	2.29+0.78 (61.18+11.56	78.72+8.33	1.84+0.91 (68.97+25.25)	4.23+1.74 (56.26+17.70)
11-20	1.70+0.56 (62.41+12.94	2.14+0.67 (60.15+11.73)	79.89+7.48	1.87+0.92 (75.89+31.38)	4.94+1.97 (70.11+21.60)
>20	1.80+0.69 (62.47+11.69)	2.16+0.78 (58.27+10.79)	83.46+6.82	2.29+1.02 (88.93+35.73	4.80+1.92 (66.33+20.46

[Table/Fig-6]: Comparison of subgroups of the duration of diabetes with pulmonary functions.
*ANOVA test p-value=0.018

duration <10 years and >20 years. FEV1/FVC and FEF (25-75%) were increased in diabetes >20 years. The correlation between duration of diabetes and FEF25-75% and PEFR was statistically significant. There was a negative correlation of duration of diabetes with FEV1(r=-0.013, p=0.906) and FVC (r=-0.084, p=0.460) which was statistically not significant.

Glycaemic Control and Pulmonary Function Parameters

[Table/Fig-7] depicts a lack of variation in the mean values of pulmonary functions in the groups of HbA1c. HbA1c significantly (p=0.043) and negatively (r=-0.227) correlated to FEV1/FVC%. The correlation of blood sugar values with pulmonary function parameters was not statistically significant.

HbA1c	FEV1 (L) FEV1 (%Pred)	FVC(L) FVC (%Pred)	FEV1/FVC (%pred)	FEF25-75% (L/s) FEF25-75% (%Pred)	PEF (L/m) PEF (%Pred)
p-value	0.466	0.126	0.043	0.448	0.162
r (Pearson correlation)	0.083	0.172	-0.227*	-0.086	-0.158
6-7.5	1.69±0.57 (61.18±12.41)	2.12±0.67 (59.00±11.33)	80.68±7.80	1.89±0.87 (76.82±30.39)	4.56±1.71 (64.25±20.20)
>7.5	1.87±0.71 (63.48±13.52)	2.36±0.82 (62.55±11.32)	78.81±8.04	1.99±1.05 (71.93±29.73)	4.58±2.11 (60.31±20.82)

[Table/Fig-7]: Comparison of groups of HbA1c and pulmonary function parameters.
ANOVA test p-value >0.05

DISCUSSION

The relationship between the duration of diabetes and lung functions remains controversial. Various studies on diabetes and lung impairment have variable results, with a few reporting minimal changes and others showing significant lung abnormalities [2,4,7]. This study aimed to assess the extent of impairment in lung function based on anthropometry, glycaemic control, and duration of diabetes.

This study showed that the mean values of all the lung function parameters were decreased than the normal values in the patients. Mean FEV1/FVC was higher than the normal range (103.56±9.82). A similar trend was observed in studies done by Shah SH et al., Niazi S et al., [4,7]. A large population Framingham heart study showed similar results with increased FEV1/FVC suggesting restrictive physiology [5].

Regarding the duration of diabetes, the present study showed a statistically significant positive correlation with FEF25-75%, PEFR, and negative insignificant correlation with FVC and FEV1. FEV1/FVC was increased in subjects with a duration of diabetes >20 years. This is partially comparable to a study done by Acharya PR et al., which suggests subclinical restrictive impairment [2]. Similar results were found in a study done by Shah SH et al., and Kanya Kumari DH et al., [4,13]. A study done by Adeyeye OO et al., showed that the increase in age and longer duration of diabetes was associated with reduced pulmonary functions [9]. Studies were done by Davis TM et al., and Sreeja K et al., also showed a decrease in PEFR [18,19]. A study by Charak G et al., and Shravya KG et al., shows a reduction in FVC and PEFR in diabetes >10 years compared to diabetes <10 years [6,20]. Hence, the restrictive pulmonary function impairments are remarkable especially, after 10 years diabetes.

Some studies have reported a strong negative correlation of Pulmonary Function Test (PFT) with the duration of diabetes [18,21]. The decrease in pulmonary functions could be due to the biochemical alterations of collagen, elastin in lungs and the chronic hyperglycemia leads to non-enzymatic glycosylation of proteins which results in Microangiopathy [5,22]. Respiratory muscle weakness due to autonomic and phrenic neuropathy could also be a reason [22,23]. The basal lamina thickening is in the same magnitude as in the kidney and lungs [22]. The possible explanation for the lack of a statistically significant reduction in all lung function parameters could be the small sample size in this study. Also, the effect of age on the lungs was not taken into consideration.

In this study, HbA1c showed a negative correlation with PFT, however, the correlation was statistically significant only with FEV1/FVC. Similar results are observed in other studies [3,18]. However, studies were done by Acharya PR et al., Adeyeye OO et al., and Kim HY et al., found no correlation with HbA1c and PFT [2,9,24]. The lack of a significant correlation of HbA1c with the other pulmonary functions shown in the index study could be because the majority of these patients had good Glycaemic control. Also, there was no correlation between Fasting Blood Sugar (FBS) and Post Prandial Blood Sugar (PPBS) with PFT. This contrasts with a study done by Walter RE et al., which showed a decrease in FEV1 and FVC with increased FBS [5]. However, the correlation of glycaemic control with PFT should be done at frequent intervals for a longer duration of time to elucidate the relationship.

BMI was found to be negatively correlated to pulmonary function tests except for FEV1/FVC. A negative and statistically significant relation was found between BMI and FVC% (predicted). It was found that the mean values of PFTs except FEV1/FVC were reduced in pre-obese and obese patients compared to patients with normal BMI. Studies done in Nigeria found that BMI correlated negatively with pulmonary function tests [4,9,12]. Study by Kim HY et al., showed that BMI was significantly related to restrictive lung impairment [24]. The reason could be obesity-associated chest wall compliance, metabolic syndrome, and chronic inflammation [9]. However, a study was done by Acharya PR et al., and Van den Borst B et al., shows no correlation between BMI and pulmonary functions [2,25].

It was also found that WC correlated negatively with all pulmonary functions. A statistically significant correlation was found only with FVC. Wehrmeister FC et al., shows a potential negative relationship between WC and pulmonary functions especially with FVC and FEV1 [11].

Limitation(s)

Firstly, due to the time-bound nature, this study was conducted only on a small population. Secondly, authors were unable to include other lung measurements like Vital Capacity (VC), Total Lung Capacity (TLC), Diffusing Capacity for Carbon Monoxide (DLCO), and Residual Volume (RV) since we lacked the required equipment. Measurement of these would have helped to understand more about the sub-clinical restriction and respiratory muscle weakness.

CONCLUSION(S)

This study hints at the possibility of increasing restrictive impairment in pulmonary function with increasing duration of diabetes. However, a clinical manifestation of this impairment was not observed. Increased duration of diabetes increased BMI, increased WC in males were correlated with decreased lung functions in diabetes.

Further studies with a larger study population over a long observation course would be needed to elucidate a clearer relationship between duration of diabetes, plasma glucose concentration, and body habitus with pulmonary function tests.

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