PULMONARY FUNCTION TESTS AND THEIR ASSOCIATED FACTORS AMONG TYPE 2 DIABETIC PATIENTS AT JIMMA MEDICAL CENTER, JIMMA, SOUTHWEST ETHIOPIA, 2019: COMPARATIVE CROSS-SECTIONAL STUDY

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A THESIS TO BE PRESENTED TO THE DEPARTMENT OF BIOMEDICAL SCIENCES, INSTITUTE OF HEALTH, JIMMA UNIVERSITY; IN PARTIAL FULFILLMENT FOR THE REQUIREMENT FOR MASTER OF SCIENCE DEGREE IN MEDICAL PHYSIOLOGY

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JIMMA, ETHIOPIA

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ABSTRACT

***Background**: Impairments of lung function due to type 2 Diabetes Mellitus (DM) have been less addressed in our country even though they have a marked impact on life of people and may lead to morbidity and mortality.*

***Objective**: The aim of the present study was to assess pulmonary function tests (PFTs) and identify their associated factors among type 2 diabetic patients at Jimma Medical Center (JMC), Jimma, Southwest Ethiopia, 2019.*

***Methods**: A comparative cross-sectional study was conducted at JMC, Jimma, Southwest Ethiopia among 298 study participants from 01, April to 30, May, 2019. A face to face interview with semi-structured questionnaire was conducted. Forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), ratio of FEV_1/FVC, peak expiratory flow (PEF) and forced expiratory flow (FEF_{25-75}) were recorded by using digital Spirometer. The Collected data were analysed by using SPSS version 23. Independent samples t test, simple and multiple linear regression analysis were used.*

***Results:** Out of the total of 298 sample size, 145 type 2 diabetics and 145 non-diabetic subjects participated in this study with the overall response rate of 97.3%. The present study indicated that means of the PFTs among type 2 diabetics were significantly reduced when compared to their matched non-diabetics (FVC(%) (m =73.7 ± 13.8 vs m=93.8 ± 12.3), FEV_1 (%) (m =76.4 ± 13.4 vs m=93.3±12.4), FEV_1/FVC (%) (m =78.99 ± 11.4 vs m=96.6 ± 9.33), PEF (L/s) (m = 3.91±0.28 vs m=5.03 ± 0.35), and FEF_{25-75} (L/s) (m =2.89 ± 0.75 vs m=3.39 ± 0.82)). This study also indicated that body mass index (BMI) (β = -1.93, $p<0.001$) and fasting blood sugar (FBS) (β = -0.22, $p<0.001$) were negative predictors of FVC%. BMI (β = -1.93, $p<0.001$) and FBS (β = -0.29, $p<0.001$) were negative predictors of FEV1%. BMI were (β = -1.403, $p<0.001$) was negative predictor of mean FEV_1/FVC. BMI (β = -1.39 $p<0.001$) and FBS (β =-0.15, $p<0.001$) were negative predictors of mean of PEF(L/s). BMI (β = -0.075, $p<0.001$) and FBS (β = -0.075, $p<0.001$) were negative predictors of FEF_{25-75} (L/s)*

***Conclusion**: Compared to the non-diabetic participants, type 2 diabetics had signicantly reduced the PFTs. BMI and FBS were independent risk factors of the PFTs among the diabetic patients.*

***Key words** : Type 2 DM, PFTs, Associated factors, Jimma Medical Center*

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LIST OF ABBREVIATIONS

BMI	Body Mass Index
CI	Confidence Interval
DM	Diabetic Mellitus
FBS	Fasting Blood Sugar
FEF_{25-75}	Forced Expiratory Flow at Average Flow between 25% and 75% of the FVC
FEV_1	Forced Expired Volume in One Second
FVC	Forced Vital Capacity
HC	Hip Circumference
IDF	International Diabetic Federation
JMC	Jimma Medical Center
OPD	Outpatient Department
PEF	Peak Expiratory Flow
PFTs	Pulmonary Function Tests
SD	Standard Deviation
USD	US Dollars
WC	Waist Circumfrence
WHR	Waist to Hip Ratio

1. INTRODUCTION

1.1 Background

Diabetes mellitus (DM) is a systemic metabolic disorder characterized by the presence of chronic hyperglycemia accompanied by changes in the metabolism of carbohydrates, lipids and proteins (1). The two major forms of diabetes are type 1 diabetes and type 2 diabetes. Type 1 diabetes is characterized by absolute deficiency of insulin due to autoimmune destruction of pancreatic β-cells. It accounts about 10% diabetes cases worldwide. Type 2 diabetes is characterized by insulin resistance, reduced insulin production, and increased hepatic glucose production. Over 90% of diabetes mellitus cases are type 2 diabetes mellitus (2).

Globally, the International Diabetes Federation (IDF) reported that prevalence of diabetes in adults aged 20–79 years was estimated to be 8.8% (424.9 million) in 2017 and is predicted to rise to 10.4% (629 million) by 2045. About three quarters (79%) of those with diabetes were living in low and middle income countries in 2017 (3). The IDF also estimated that people with diabetes in Africa will increase from 3.8% in 2015 to 4.2% in 2017 (3,4). The Ethiopian Diabetes Association estimated 2-3% prevalence of D in 2013 and 1.33 million cases in 2013 in Ethiopia (5). IDF Atlas reported that number of people live with diabetes in Ethiopia was 5.2% (2,567,900 cases) in 2017 (3).

Type 2 diabetes is a multisystem disorders that may precipitate certain complications in neural, cardiovascular, renal systems and also organs and tissues like skin, liver, collagen and elastic fibers (6). The microvascular complications may appear early within 5 to 10 years and the macrovascular complications may appear within 15 to 20 years from the onset of diabetes (7).

The presence of an extensive pulmonary microvascular circulation and abundant connective tissue raises the possibility that the lung may be a target organ of the pathologic processes induced by chronic hyperglycemia (8). The pulmonary alveolar-capillary network is the largest microvascular organ in the body with a large reserve. This means that a substantial large loss in the microvascular bed can be tolerated without developing any significant pulmonary symptoms. This leads to deranged pulmonary function continuing for a long time and being discovered only at a late stage in the diabetics (9,10).

The pathophysiology of diabetic lung is complex and multifactorial and not completely understood. The currently known underlying mechanisms for lung dysfunction in patients with type 2 diabetes include microangiopathy of alveolar capillaries and pulmonary arterioles (11), glycosylation of tissue proteins (12), oxidative stress (13), chronic low-grade inflammation (14), and autonomic neuropathy involving the respiratory muscles (15).

Pulmonary function tests (PFTs) are noninvasive physiologic tests that show how well the lungs are working (16). The tests measure lung volume, capacity, rates of flow, and gas exchange. Pulmonary functions are generally determined by the strength of respiratory muscles, compliance of the thoracic cavity, airway resistance and elastic recoil of the lungs (17).

Pulmonary function parameters are unique as there is no constant or single 'normal' value or range. These parameters vary by sociodemiographic factors and changing anthropometric characteristics. Thus, every person will have a different 'normal' or expected value and that too is not constant but ever-changing with growth and even in an individual with every year of age (16, 17).

Spirometry is by far the most frequently performed investigation to evaluate pulmonary function. It is important in the screening, diagnosis and monitoring of respiratory diseases. It is also regarded as an integral component of any respiratory medical surveillance programs (18).

Forced vital capacity (FVC) indicates how much air the lungs can hold. Forced expiratory volume in one second (FEV_1) indicates how well the large and medium-sized airways are functioning. The ratio of FEV_1/FVC is a more sensitive indicator of airway obstruction than FVC or FEV1 alone. Peak expiratory flow (PEF) referes to mechanical properties of the lung, like lung compliance and elastic recoil of lungs and reflecting larger airway function. Forced expiratory flow (FEF_{25-75}) is known as maximum mid expiratory flow and a measure of patency of small airways (16,19).

1.2 Statement of the problem

DM is a global health problem which causes multiorgan damage including lung (6).
Globally, IDF reported that 5 million deaths were attributable to diabetes among people aged 20–99 years in 2017. The total global healthcare expenditure due to diabetes for people aged 20–79 years was estimated at USD 727 billion in 2017 and is expected to increase by 7% to USD 776 billion by 2045 (3).

In India (i.e. Karad), prevalence of impaired pulmonary function was 86% among patients with type 2 DM in 2014 (20). Among these, the prevalence of restrictive, obstructive, and mixed patterns of impaired pulmonary function were 12%, 24%, and 50% respectively. In South Korea, prevalence of abnormal pulmonary function was 38.4% among patients with type 2 DM in 2017. Among these, the prevalence of restrictive and obstructive patterns of impaired pulmonary functions were 18.4% and 20% respectively (21).

In the African region, IDF reported that 321,100 deaths were due to diabetes in 2015. In Africa, the IDF estimates that healthcare expenditure due to diabetes in 2015 was USD 3.4 billion and is estimated to increase to USD 5.5 billion in 2040 (4). In Nigeria, prevalence of impaired pulmonary function was 57% among patients with type 2 DM in 2014. Among these, the prevalence of restrictive, obstructive, and mixed patterns of impaired pulmonary functions were 38%, 11% and 8% respectively (22).

In Ethiopia, IDF reported that diabetes related deaths in age range of 20-79 was 34,262 in 2013 and the number is expected to rise to 1.8 million by the year 2030 (5). Impaired lung functions in type 2 diabetes have not been received sufficient attention from health care community. This is may be due to lack of routine screening of PFTs among the diabetics, type 2 diabetics are subclinical at early stage, lack of national spirometric guidelines and policy on spirometry, lack of previous regional or national level studies conducted on this area and inadequate trained personnel in spirometry at diabetic clinic. As a result, pulmonary complication among the diabetics may be under-recognized clinically (23,24).

A 10% decrease in FEV_1 was associated with a 12% increase in all-cause mortality among patients with type 2 DM (25).

Pulmonary function tests among type 2 diabetic patients have demonstrated varied in previous studies, and frequently contradicting results with some studies indicating a reduction of spirometric parameters, whereas others have demonstrated no change compared with non-diabetics (26,27, 28, 29).

Several previous studies reported that fasting blood sugar (FBS), anthropometric factors and socio-demiographicfactors have stated varied with frequently contradicting findings on PFTs among the type 2 diabetics (30,31,32). Unlike of the previous studies conducted on this area, the current study included physical activity since regular exercise may improve respiratory muscle strength, increase thoracic mobility and hence may have positive effect on the PFTs (33). So, the purpose of this study was to assess PFTs and their associated factors among type 2 diabetic patients at Jimma Medical Center (JMC).

1.3 Significance of the Study

The result of the this study will help patients with type 2 DM to be screened early for pulmonary function risks.

The finding of this study will draw the attention of health care providers in early screening of type 2 diabetic patients for impaired pulmonary functions.

This study also provide input to policy makers to design appropriate policy to perform PFTs screening in type 2 diabetics and also serve as a motivation for further investigations in this area.

Moreover, it will also provide baseline information for individuals who are interested to study in this area.

2. LITERATURE REVIEW

2.1 Comparison of the PFTs among type 2 diabetics and non-diabetic individuals

A large community-based study conducted at Western Australia in 2004 showed that type 2 diabetic patients had significantly reduced FVC, FEV1 and PEF compared to non diabetic participants (31).

Comparative cross-sectional Study conducted at Bihar, India in 2018 revealed that FVC, FEV1, FEV1/FVC, PEF, and FEF_{25-75} were statistically reduced among 50 diabetic patients and 50 normal healthy controls (26). A study done at Andhra Pradesh, India in 2016 indicated that all of the PFTs were significantly decreased among 100 type 2 diabetic patients as compared to non-diabetic participants (27). According to study conducted at Acharya VinobhaBhave Rural Hospital, India in 2016 indicated that there was significant reduction in all the PFT parameters (FVC%, FEV1% and FEV1/FVC among 50 diabetics as compared to 50 controls (30). Another study conducted in Karnataka, India in 2016 showed that type 2 diabetic patients have significantly lesser values of FVC, FEV1, PEF, and FEV1/ FVC as compared to normoglycemic subjects (32).

According to study carried out at Imphal, India in 2014 showed that FEV1/FVC was increased among 50 type 2 diabetic patients as compared to non-diabetic participants (28). Another study conducted in Anantapur, India in 2018 indicated that FEV1/FVC was increased among 20 type 2 diabetic patients as compared to non-diabetic participants (34).

Study conducted at Saudi Arabia in 2006 showed that type 2 diabetic patients had significant reduction in FVC, FEV1, and PEF as compared to their matched controls (35). A study conducted at Pakistan in 2011 reported that diabetes patients showed a significant reduction in the FVC and FEV_1 relative to non-diabetic controls. There was no significant difference noted in the FEV_1/FVC and FEF_{25-75} between the groups (36).

A comparative cross-sectional study done at Al-Azhar University, Egypt in 2015 indicated that FVC, FEV_1, and PEF were statically reduced among 45 type 2 diabetics when compared to the control group. On the other hand, no significant difference was found between the two groups as regards FEV_1/FVC (37). According to study conducted at Khartoum state, Sudan in 2018 showed that there were no significant differences between the means of FVC, FEV_1 and FEV_1/FVC among the diabetic patients and their matched control group. However, diabetic patients showed significant reduction in PEF (29) According to study carried out at Ghana in 2014 reported that compared with subjects without diabetes, type 2 diabetics had lower mean residual FVC and FEV1. However, FEF_{25-75} did not achieve statistical significance (38).

2.2 Factor affecting the PFTs among patients with type 2 DM

2.2.1 Pulmonary function tests between socio-demiographic factors, height and weight among type 2 diabetics

Study conducted at Ghana in 2014 indicated that the effect of height on FEF_{25-75} % (β=0.270, p=0.022) and the effect of gender on FVC (β =0.252, p=0.031) were significant at the 0.05 level. Age and weight were not significantly affect the PFTs (38).

2.2.2 Pulmonary function tests and FBS

A case control study done at Kangra, India in 2015 indicated that FBS were negative insignificantly correlated with the PFTs by study involving 90 patients with type 2 DM (39). Another study conducted at Imphal, India in 2014 indicated that on comparison of the FBS values with the PFTs, no statistical significance was found (28). Another study performed at AcharyaVinobhaBhave Rural Hospital, India in 2016 indicated that strong positive correlation was seen between FBS and FEV1/FVC among 50 type 2 diabetics (30).

A case control study carried out at Ghana, in 2014 showed that there were a weak negative linear association between FVC, FEV_1 and FBS. The ratio FEVI/FVC ratio and FEF_{25-75} were positively weak associated with FBS among 108 patients with type 2 DM (38).

2.2.3 Pulmonary function tests and body mass index (BMI)

A study done at Kangra, India in 2015 indicated that BMI were negative insignificantly correlated with the PFTs (39). A study conducted at Lagos State University Teaching Hospital, Nigeria in 2014 revealed that there were no significant association between BMI and PEF and FEV1. However, there was a positive statistical association between FVC and BMI (22).

According to study done at Ghana in 2014, none of the spirometric indices is strongly correlated with the indices of BMI (38).

2.2.4 Pulmonary function tests between waist circumference (WC) and waist to hip ratio (WHR)

A study conducted at India in 2012 that reported an inverse relationship between WC and pulmonary function parameters (39). Another study conducted at India in 2012 indicated that all the spirometric indices were negatively correlated with WHR and WC (40).

According to study done at Ghana in 2014, all the spirometric indices were negatively correlated with WHR and WC (38).

2.2.5 Pulmonary function tests and physical activity

According to study conducted at India in 2013 indicated that athletic group were having higher mean value of FVC, FEV1, PEF, FEV1/ FVC ratio as compared to sedentary group (41).

According to study conducted at khartum, Sudan in 2018 showed that type 2 diabetic subjects who regularly exercise showed slight increase in pulmonary function data (29).

2.3 Conceptual framework of the study

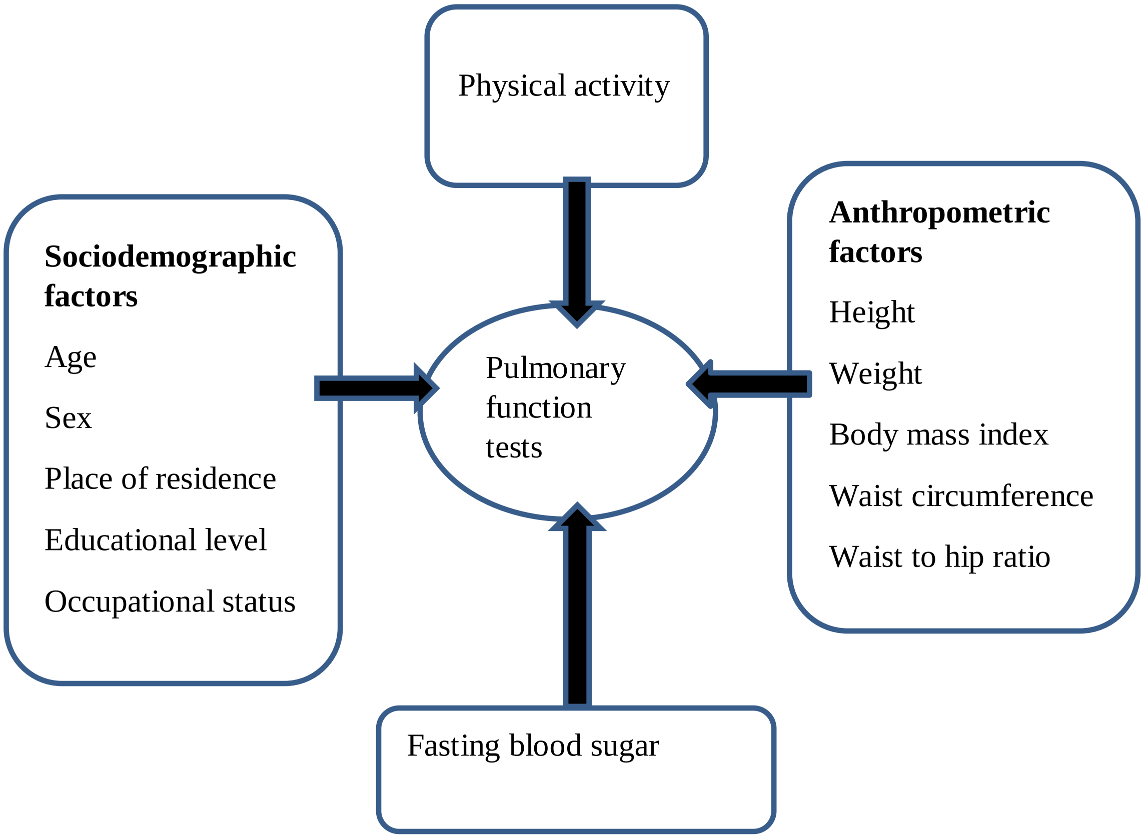

Figure 1: Schematic diagram illustrating conceptual framework for assessment of PFTs and their associated factors among type 2 diabetics and non-diabetic individuals

3. OBJECTIVES

3.1 General objective

The general objective of this study was to assess pulmonary function tests and their associated factors among type 2 diabetic patients at JMC, Jimma, Southwest Ethiopia, in 2019.

3.2 Specific objectives

1. To compare pulmonary function tests among type 2 diabetic patients and non-diabetic participants at JMC, in 2019
2. To identify factors affecting pulmonary function tests among type 2 diabetics and non-diabetic participants at JMC, in 2019

4. MATERIALS AND METHODS

4.1 Study area and period

This study was conducted at JMC, which is located in Jimma town, 356 km Southwest from the capital city of Ethiopia, Addis Ababa.

JMC serves over 500 outpatient visits daily and 523 inpatient beds and with a catchment population of over 15 million.

This study was conducted from 01, April - 30, May, 2019.

4.2 Study design

Institutional based comparative cross-sectional study design was conducted.

4.3 Population

4.3.1 Source population

Case group: All type 2 diabetic patients attending diabetic clinic outpatient department (OPD) at JMC.

Control group: Non-diabetic individuals attending outpatients/ inpatients at JMC.

4.3.2 Study population

Case group: All sampled type 2 diabetic patients who attended diabetic clinic OPD at JMC during the data collection period.

Control group: All age, sex, height and weight matched non-diabetic individuals who attended outpatients/ inpatients at JMC during the data collection period.

4.4 Eligibility criteria

4.4.1 Inclusion criteria

Case group: All type 2 diabetic patients with age greater than 30 years, the patients presented at diabetic clinic OPD between 8:00 AM and 12:00 AM O'clock.

Control group : All age, sex, height and weight matched non-diabetic individuals with type 2 diabetics, age greater than 30 years, attendants of outpatients / inpatients presented in JMC between between 8:00 AM and 12:00 AM O'clock and overnight fasted individuals for eight hours.

4.4.2 Exclusion criteria

Case group: All patients with cardiorespiratory diseases, pregnant, history of any abdominal or thoracic surgery of last three months, cigarette smoker, cleaners, wood and cobblestone workers

Control group: Individuals with pre-diabetes, cardiorespiratory diseases, pregnant, history of any abdominal or thoracic surgery of last three months, cigarette smokers, cleaners, wood and cobblestone workers

4.5 Sample size determination and sampling technique

4.5.1 Sample size determination

The sample size was calculated by using double proportion formula with an assumption of 95% confidence interval and power of 80%. Prevalence of abnormal pulmonary functions among type 2 diabetic patients and non-diabetic participants were 17.6% and 6.3% respectively, which were taken from a research conducted at Ghana, in 2014 (38).

$$n = \frac{(r+1)(Z\alpha/2+Z\beta)2 \ p(1-p)}{r(p1-p2)2}$$

Where as ; n = Sample size in each group

$p_1 = 0.176$, $p_2 = 0.063$

p = average proportion $(p_1+p_2)/2$

$\beta = 20\%$, $z\beta = 0.84$, $\alpha = 0.05$, $z\alpha/_2 = 1.96$

r =ratio of number of participants of cases to controls (1 in this case)

$$n = \frac{(1+1) *(1.96+0.84)^2 *0.1195*(1-0.1195)}{1(0.176-0.063)^2} = \frac{(15.68)*(0.11)}{0.0128} = 1.723/0.0128=135.5$$

Therefore, the total sample size for study participants were **298** with 10% non-response rate (**149** type 2 diabetics and **149** for non-diabetic individuals).

4.5.2 Sampling method and procedure

Case group: Systematic random sampling method was employed to select type 2 diabetic patients. Average number of type 2 diabetic patients attending the diabetic clinic in one month were estimated to be 1685 and the total sample size for type 2 diabetic patients were 149. Then, the sampling interval was determined (k=11). The first eligible study participant was selected randomly. Then every other eligible patient visiting the clinic during the data collection period was interviewed until the desired sample size was achieved.

Control group: Those individuals matched with type 2 diabetics fit in terms of age, sex, height and weight were conveniently selected from attendants of inpatients or outpatients at JMC until the desired sample sized was achieved.

4.6 Data collection procedures

Data on socio-demographic characteristics, anthropometric and other factors were collected through a face-to-face interview using a semi-structured questionnaire by qualified data collectors.

4.6.1 Anthropometric measurements

Weight was measured with participants barefoot and with light clothing using Digital Scale, and was recorded to the nearest of 0.1kg. Height was measured using Stadiometer with participants in a standing position and without shoes, with shoulders in normal alignment. Body mass index (in kg/m2) was calculated for each participants as the individual's weight (in kilogram) divided by the square of his or her height (in meter).

In the measurement of waist and hip circumference, each participant was made to stand with his arms at the sides, feet positioned close together. Waist circumference was measured at the midpoint between the lower margin of the last palpable ribs and the top of the iliac crest. The hip circumference was measured around the widest portion of the buttocks. Waist circumference was measured at the end of a normal expiration. Both WC and HC was measured in centimeters. Waist to hip ratio was calculated by dividing WC by hip circumference.

4.6.2 Measurements of FBS

Case group: Level of fasting blood glucose was taken from patient's registration book.

Control group: Fasting blood glucose measurements were done by a laboratory technologist to ascertain diabetes. After an overnight fasting (≥8 hours), plasma glucose was determined using the glucose meter Accu-Chek Active system. The Accu-Chek Active system used a capillary blood sample which was set to plasma serum standard. This glucose measurement was carried out immediately after sample collection and the results were recorded in the data sheet. The diagnosis of DM was based on the American Diabetes Association diabetes mellitus classification criteria with fasting blood glucose of $\geq$ 126 mg/dl being considered as positive for DM; impaired fasting glucose, FBG: $\geq$110 mg/dl to <126 mg/dl.

4.6.3 Procedure of the pulmonary function testing

The pulmonary function parameters were measured by digital spirometer (SP10, CONTEC MEDICAL SYSTEMS CO., LTD, China).

The PFTs were conducted according to American Thoracic Society / European Respiratory Society/ guideline in a quiet room in sitting position by a qualified personnel (17). The spirometry was done in morning between 8:00 AM and 12:00 AM daily. The participants ID, age, height, gender, weight were inputted into the equipment.

In the forced vital capacity maneuver, the participant was made to assume correct posture (head slightly elevated), mouthpiece was attached to the spirometer and the participant asked to breathe in fully until the lungs feel full. The participant was then asked to hold his/her breath long enough to seal his/her lips tightly around the mouthpiece. He/she was then asked to hold his or her nose tightly and to blast the air out as forcibly and fast as possible until there is no more air left to expel. The participant was verbally encouraged to keep blowing and keep blowing during this phase and watched to make sure a good mouth seal around the mouthpiece. The procedure was repeated at least three acceptable and repeatable blows for a maximum of 8 efforts (17,19).

The procedure was abandoned and rescheduled if a participant was unable to produce an acceptable and repeatable spirogram after 8 attempts. Mouth pieces of the spirometer were cleaned routinely and disinfected by 75% alcohol before the procedure and calibration was strictly seen.

4.7 Study variables

4.7.1 Dependent variables

Pulmonary function parameters (FVC, FEV_1, FEV_1/FVC, PEF, FEF_{25-75})

4.7.2 Independent variables

Sex, age, place of residence, occupational status, educational level, weight, height, BMI, WC, WHR, FBS, physical activity

4.8 Operational definitions

- ***Acceptability Criteria****: Good start of test without any hesitation, no coughing / glottic closure, no variable flow, no early termination (> 6 sec), no air leak*
- ***Reproducibility criteria****: The test is without excessive variability; the two largest values for FVC and the two largest values for* FEV_1 *should vary by no more than 0.15L.*
- ***Physical activity****: Throughout a week, including activity for work, during transport and leisure time, adults should do at least*

  • 150 minutes of moderate-intensity physical activity OR

  • 75 minutes of vigorous-intensity physical activity OR
- ***Vigorous physical activity****: ploughing, cutting crops, gardening (digging), grinding (with pestle), labouring (shovelling sand), loading furniture (stoves, fridge), instructing spinning (fitness), cycle driving, soccer, tennis, fast swimming, sawing hardwood.*

  A person reaching any of the following criteria is classified in this category:

  - Vigorous-intensity activity on at least 3 days achieving a minimum of at least 1,500 MET-minutes/week OR

  - 7 or more days of any combination of walking, moderate- or vigorous intensity activities achieving a minimum of at least 3,000 MET-minutes per week.
- ***Moderate physical activity****: cleaning, washing, gardening, milking cows (by hand), planting and harvesting crops. digging dry soil (with spade), weaving, woodwork (chiselling, sawing softwood), mixing cement (with shovel), labouring, walking with load on head, drawing water. A person not meeting the criteria for the "high" category, but meeting any of the following criteria is classified in this category:*

- 3 or more days of vigorous-intensity activity of at least 20 minutes per day OR

- 5 or more days of moderate-intensity activity or walking of at least 30 minutes per day OR

- 5 or more days of any combination of walking, moderate- or vigorous intensity activities achieving a minimum of at least 600 MET-minutes per week.

- ***Low physical activity***

  A person not meeting any of the above mentioned criteria falls in this category.

4.9 Data processing and analysis

The collected data were entered into Epi-data version 4.4.1 and cleaned and analyzed using the SPSS version 23 software package.

Independent sample t-test was used to determine whether the difference between the two means of the PFTs were statistically significant or not among type 2 diabetics and non-diabetic participants. The assumptions of independent sample t-test (normality and homoscedasticity based up on results of Shapiro-Wilk and Levene's tests) were checked.

Variables were entered in to the simple linear regression model and those found to be significantly associated with the dependent variables were entered into multiple linear regression with enter method. The assumptions of linear regression (linearity, normality, homoscedasticity, outliers and multicollinearity) were checked.

A 95% confidence interval was used and p value < 0.05 was considered as statistically significant. The continuous variables were expressed by computing mean and standard deviation whereas categorical variables were expressed as frequency and percent. They were presented in the form of tables.

4.10 Data quality assurance

The Questionnaire were translated from English to Amharic and Afan Oromo then back to English by another person to ensure consistency of translation. Before starting the data collection, pre-test was performed at Shanan Gibe Hospital on 5% of the total sample size and modification from the pre-test was made accordingly.

Training was given to the data collectors and supervisor regarding purpose of the study, measurement techniques and ethical issues by principal investigator. Regular supervisions were carried out to monitor the work. The manufacturer's instructions of the machine were strictly followed. All collected data were examined for completeness and consistency during data management, storage and analysis.

4.11 Ethical consideration

This study was carried out after obtaining ethical approval from Jimma University Ethics Review Board. Letter of request for cooperation was sent to Jimma Medical Center, medical director office, and coordinator of diabetic clinic OPD.

Informed verbal/written consent was gathered from each participant after a comprehensive explanation of the purpose and procedure of the study. The study participants were informed that they had a full right to refuse or discontinue participating at any point of the study. Any information obtained in each course of the study was kept confidential. Participants identified with hypoglycemia, diabetes and severe reduction in the PFTs were informed to contact physicians for further investigation and management.

4.12 Dissemination plan

The findings of this study will be presented to Jimma University Institute of Health, Department of Biomedical Sciences as part of master of science degree in Medical Physiology thesis and will be submitted to Jimma University Post Graduate School. It will also get shared to JMC. Efforts will be made to present the findings on scientific conferences and to publish it on scientific journal.

5. RESULTS

5.1 Socio-demiographic characteristics of the respondents

Out of the total of 298 sample size, 290 (145 type 2 diabetics and 145 non-diabetic individuals) participated in this study, giving a response rate of 97.3%.

Majority of the respondents with type 2 DM, 80 (55.2 %), were males and the same sex distribution for non-diabetic participants. The mean age of type 2 diabetic patients and non-diabetic participants were found to be 52.2 years ± 9.75 and 51.5 years ± 9.79 respectively.

More than half, 77 (53.1%) and 92 (63.4%), of type 2 diabetic patients and non-diabetic participants were reside in urban. As per occupation, majority of the type 2 diabetic patients and non-diabetic participants were government employees with 43 (29.7%) and 38 (26.2%). Regarding educational level, majority of the respondents with type 2 DM 47 (32.4 %) and non-diabetic participants 41 (28.28%) were illiterate (table 1).

Table 1: Frequency distribution of socio-demiographiccharacteristics of the respondents at JMC, Jimma, Southwest Ethiopia, 01,April-30,May,2019, (n=290)

Variables		Type 2 diabetic patients, (n=145)		Non-diabetic participants, (n=145)	
Sex		Frequency	Percent	Frequency	Percent
	Male	80	55.2	80	55.2
	Female	65	44.8	65	44.8
Age (years)		52.2 ± 9.75		51.5 ± 9.79	
Place of residence	Urban	77	53.1	92	63.4
	Rural	68	46.9	53	36.6
Occupational status	Government employees	48	33.1	39	26.9
	Merchants	35	24.1	32	22.1
	Farmers	30	20.7	31	21.4
	House wives	26	17.9	36	24.8
	Others*	6	4.1	7	4.8
Educational level	Illiterate	47	32.4	41	28.28
	Elementary	3	2.06	6	4.14
	Secodary	10	6.89	39	26.89
	Diploma	43	29.66	29	20.0
	Frist degree & above	42	28.97	30	20.68

**Self employees, Students, religious leaders*

5.2 Anthropometric and clinical characteristics of the respondents

The mean height of type 2 diabetics and non-diabetic respondents were 1.66 m ± 0.089 and 1.65 m ± 0.098 respectively. The mean weight of patients with type 2 diabetes and non-diabetic participants were 73 kg ±11.5 and 71.9 kg ±11 respectively. The mean FBS of patients with type 2 DM and non-diabetic participants were 144.7 mg/dl ± 30.5 and 88.1 mg/dl ± 11.2 respectively (table 2).

Table 2: Anthropometric and clinical parameters of the respondents at JMC, Jimma, Southwest Ethiopia, 01,April-30,May, 2019, (n=290)

Parameters	Patients with type 2 DM, (n=145)	Non-diabetic participants, (n=145)
	mean ±SD	mean ±SD
Height (m)	1.66 ± 0.089	1.65 ± 0.098
Weight (kg)	73.0 ± 11.5	71.9 ± 11.0
BMI (kg/m^2)	26.5 ± 3.12	26.14 ± 3.21
WC (cm)	92.2 ± 13.5	92.6 ± 10.1
WHR	1.0002 ± 0.09	0.99 ± 0.065
FBS (mg/dl)	144.7 ± 30.5	88.1 ± 11.2

Abbrevation: SD±Standard Deviation

5.3 Comparison of means of the PFTs among type 2 diabetics and non-diabetic participants

An independent samples t-test was performed to compare means of FVC, FEV1, FEV1/FVC, PEF and FEF_{25-75} among type 2 diabetic patients and non-diabetic participants. Assumptions of the independent samples t- test (normality and homogeneity) were performed and met based on findings of Shapiro-Wilk and Levene's tests when p value > 0.05.

The present study showed that there was significantly reduced mean of FVC(%) among type 2 diabetic patients (m = 73.7 ± 13.8) compared to non-diabetic participants (m=93.8 ± 12.3, p<0.001). The study also indicated that mean of FEV_1(%) was significantly reduced among type 2 diabetic patients (M = 76.4 ± 13.4) when compared to non-diabetic participants (m=93.3 ± 12.4, p<0.001).

This study also revealed that there was a significant reduction in the mean score of FEV1/FVC (%) among type 2 diabetic patients (m = 78.99 ± 11.4) when compared to non-diabetic participants (m = 96.6 ± 9.33, p<0.001).

The current study also indicated that the mean of PEF(L/s) was significantly reduced among type 2 diabetic patients (m = 3.91 ± 0.28) when compared to non-diabetic participants (m=5.03 ± 0.35, p<0.001). There was a significantly reduced mean score of FEF_{25-75} (L/s) among type 2 diabetic patients (m = 2.89 ± 0.75) compared to non-diabetic participants (m=3.39 ± 0.82, p<0.001) (table 3).

Table 3: Comparison of the means of PFTs among type 2 diabetic patients and non-diabetic participants at JMC, Jimma, Southwest Ethiopia, 01,April-30,May, 2019, (n=290)

Spirometric parameters	Study participants	mean	SD	t test	p value	CI
FVC (%)	Type 2 diabetic patients	73.7	13.8	-13.114	< 0.001	(-23.2,-17.1)
	Non-diabetic participants	93.8	12.3			
FEV_1(%)	Type 2 diabetic patients	76.4	13.4	-11.099	< 0.001	(-19.8,-13.9)
	Non-diabetic participants	93.3	12.4			
FEV_1/FVC (%)	Type 2 diabetic patients	78.9	11.4	-14.440	< 0.001	(-20.0,-15.2)
	Non-diabetic participants	96.6	9.33			
PEF(l/s)	Type 2 diabetic patients	3.91	0.28	-30.12	< 0.001	(-1.19, -1.05)
	Non-diabetic participants	5.03	0.35			
FEF_{25-75} (l/s)	type 2 diabetic patients	2.89	0.75	-5.336	< 0.001	(-0.67,-0.31)
	Non-diabetic participants	3.39	0.82			

Note: The mean difference is highly significant at p<0.01.

Abbreviations: DM=Diabetes Mellitus; l/s=liter per second; CI=Confidence Iinterval; SD± Standard Deviation

5.4 Predictors of the pulmonary function tests among type 2 diabetic patients

5.4.1 Simple linear regression model showing predictors of PFTs among type 2 diabetic patients

A simple linear regression was calculated to predict participants' FVC (%), FEV1 (%), FEV1/FVC (%), PEF (L/s), and FEF_{25-75} (L/s) based upon different variables. The assumptions of simple linear regression (normality, homogeneity, outlier, and linearity) was checked and met.

There was significant association between the PFTs and age. Variables like sex (male taken as reference), place of residence (rural taken as reference), occupational status (merchant taken as reference), educational level (primary school taken as reference) had not linear association with the PFTs since p > 0.05 (table 4).

Table 4: Simple linear regression model showing socio-demiographicpredictors of the PFTs among type 2 diabetic patients at JMC, Jimma, Southwest Ethiopia, 01,April-30,May,2019, (n=145)

Spirometric parameters		Socio-demiographicvariables		
		Age	Sex: Female	Place: Urban
FVC %	β	-0.355	-2.53	4.58
	CI	(-0.58,-0.13)	(-7.08, 2.02)	(-0.35,9.5)
	p value	0.004*	0.27	0.068
FEV1 %	β	-0.406	-4.1	2.12
	CI	(0.71,-0.09)	(-10.23, 2.02)	(-4.58, 8.82)
	p value	0.016*	0.19	0.53
FEV1/FVC %	β	-0.291	3.37	-0.78
	CI	(-0.53,-0.05)	(-1.31, 8.05)	(-5.9,4.4)
	p value	0.02*	0.56	0.76
PEF (l/s)	β	-0.034	-0.002*	0.094
	CI	(-0.06,-0.01)	(-0.09, 0.09)	(-0.006, 0.194)
	p value	0.001**	0.96	0.065
FEF_{25-75} (l/s)	β	-0.013	-0.22	0.18
	CI	(-0.03, -0.001))	(-0.46, 0.03)	(-0.09,0.45
	p value	0.049*	0.086	0.19

*Note: *significant (P<0.05), β: regression coefficient*

Negative values of β show that the corresponding factors were negative predictors of the PFTs.

A simple linear regression revealed significant association between the PFTs and the anthropometric variables like weight, height, WC, WHR, & BMI (table 5).

Table 5: Simple linear regression model showing anthropometric predictors of PFTs among type 2 diabetic patients at JMC, Jimma, Southwest Ethiopia, 01,April-30,May,2019, (n=145)

Spirometric parameters		Anthropometric variables				
		Weight	Height	WC	WHR	BMI
FVC %	β	-0.54	9.89	-0.42	-61.6	-2.39
	CI	(-0.72, -0.36)	(15,20)	(-0.57,-0.26)	(-85.6,-37.6)	(-3.0, -1.77)
	p value	0.001**	0.04*	0.001**	0.001**	0.001**
FEV_1 %	β	-0.96	19.09	-0.8	-106.53	-4.21
	CI	(-1.2.-0.74)	(1,4)	(-0.98,-0.62)	(-136,-76.1)	(-4.9, -3.51)
	p value	0.001**	0.027*	0.001**	0.001**	0.001**
FEV1/FVC %	β	-0.38	4.68	-0.28	-30.951	-1.77
	CI	(-0.57,-0.18)	(12,17)	(-0.4,-0.10)	(-57.3, -4.6)	(-2.46, -1.1)
	p value	0.001**	0.04*	0.001**	0.001**	0.001**
PEF %	β	-0.05	0.064	-0.05	-0.03	-5.99
	CI	(-0.07, -0.04)	(5,11)	(-0.06, -0.04	(-0.04,-0.02)	(-8.30, -3.69)
	p value	0.001**	0.031*	0.001**	0.001**	0.001**
FEF_{25-75} %	β	-0.03	-0.123	-0.028	-3.82	-0.145
	CI	(-0.04, -0.02)	(31,33)	(-0.04, -0.02)	(-5.08, -2.6)	(-0.18, -0.11)
	p value	0.001**	0.04*	0.001**	0.001**	0.001**

*Note: *Significant (P<0.05), **highly significant (P<0.01), β: regression coefficient*

A simple linear regression revealed significant association among the PFTs and low physical activity (when vigorous activity taken as reference) FBS. Moderate physical activity had not show linearity with the PFTs (table 6).

Table 6: Simple linear regression model showing other predictors of PFTs among type 2 diabetic patients at JMC, Jimma, Southwest Ethiopia, 01,April-30,May,2019, (n=145)

Spirometric parameters		Variables		
		Physical activity		Fasting blood sugar
		Low	Moderate	
FVC	β	-12.67	1.46	-0.31
	CI	(-16.9,-8.44	(-3,11,6.06)	(-0.37,-0.26)
	p value	0.001**	0.53	0.001**
FEV1	β	-15.8	-1.67	-0.46
	CI	(-21.6, -9.99)	(-7.84,4.51)	(-0.52,-0.38)
	p value	0.001**	0.59	0.001**
FEV1/FVC	β	-7.99	0.016	-0.163
	CI	(-12.6, -3.32)	(-4.71,4.74)	(-0.24,-0.09)
	p value	0.001**	0.99	0.001**
PEF	β	-0.15	-0.011	-0.023
	CI	(-0.24, -0.06)	(-0.1,0.8)	(-0.03, -0.02)
	p value	0.001**	0.82	0.001**
FEF25-75	β	-0.84	0.052	-0.02
	CI	(-0.84, -0.37)	(-0.19,0.3)	(-0.02, -0.01)
	p value	0.001**	0.68	0.001**

*Note: **highly significant (P<0.01), β: regression coefficient*

The reference group for physical activity was vigorous physical activity

5.4.2 Multiple linear regression model showing predictors of PFTs among type 2 diabetic patients

Multiple linear regression analysis was employed to determine the best linear combinations of age, weight, WC, WHR, Height, BMI, FBS, and low physical activity which were significant in simple linear regression model. The assumptions of multiple linear regression like multicollinearity is met.

A unit change in BMI (kg/m^2) results in a 0.88 percentage decrease in FVC when FBS held constant (β = -0.88, CI: (-1.76,-0.006, p<0.001). A unit change in FBS (mg/dl) results in a 0.22 percentage decrease in FVC when BMI kept constant (β = -0.22, CI: (-0.29,-0.15), p<0.001, R^2 =0.51, constant=114.997).

A unit change in BMI (kg/m^2) results in a 1.93 percentage decrease in FEV_1 when FBS held constant(β = -1.93, CI (-2.9,-0.96, p<0.001). A unit change in FBS (mg/dl) results in a 0.29 percentage decrease in FEV_1 when BMI kept constant (β = -0.29, CI: (-0.37,-0.21), p<0.001, R^2 =0.679, constant=222.919). A unit change in BMI (kg/m^2) results in a 1.93 percentage decrease in FEV_1/FVC when FBS held constant (β = -1.403, CI: (-2.46,-0.097, p<0.001, R^2 =0.187, constant=79.445).

A unit change in BMI (kg/m^2) results in a 1.39 liter per second decrease in PEF when FBS held constant (β = -1.39, CI: (-2.73,-0.06), p<0.001). A unit change in FBS (mg/dl) results in a 0.15 liter per second decrease in PEF when BMI kept constant (β = -0.15, CI: (-0.27,-0.04), p<0.001, R^2 =0.419, constant=14.664).

A unit change in BMI (kg/m^2) results in a 0.075 liter per second decrease in FEF_{25-75} when FBS held constant (β = -0.075, CI (-0.123,-0.026), p<0.001). A unit change in FBS (mg/dl) results in a 0.009 liter per second decrease in FEF_{25-75} when BMI kept constant (β = -0.009, CI: (-0.013,-0.005), p<0.001, R^2 =0.493, constant=7.49 (table 7).

Table 7: Multiple linear regression model showing predictors of PFTs among type 2 diabetic patients at JMC, Jimma, Southwest Ethiopia, 01,April - 30,May, 2019, (n=145)

Spirometric parameters		Variables							
		Age	Weight	Height	WC	WHR	BMI	FBS	Low physical activity
FVC	β	-0.04	-0.02	-0.41	0.26	-0.31	-0.88	-0.22	-2.53
	p value	0.98	0.86	0.92	0.098	0.12	0.048**	0.001**	0.26
	CI	(0.2, 0.21)	(-0.24, 0.20)	(-0.92, 0.11)	(-0.5, 0.57	(-0.69, 0.08)	(-1.76, -0.006	(-0.29, -0.15	(-6.9, 1.91)
FEV1	β	0.17	-0.06	-0.34	-0.04	-0.14	-1.93	-0.29	-0.55
	p value	0.14	0.064	0.24	0.83	0.22	0.001**	0.001**	0.83
	CI	(-0.06, 0.4)	(-0.3, 0.19)	(-0.9, 0.23)	(-0.38, 0.31)	(-0.57, 0.30)	(-2.9, -0.96)	(-0.37, -0.21)	(-5.5, 4.4)
FEV1/ FVC	β	-0.05	-0.06	0.005	0.09	-0.014	-1.28	-0.06	-2.85
	p value	0.7	0.71	0.99	0.69	0.96	0.034*	0.24	0.35
	CI	(-0.33, 0.22)	(-0.36, 0.24)	(-0.69, 0.702)	(-0.34, 0.51)	(-0.54, 0.51)	(-2.46, -0.097)	(-0.16, 0.04)	(-8.84, 3.13)
PEF	β	0.03	-0.01	-0.39	0.104	-0.22	-1.39	-0.15	-6.38
	p value	0.86	0.96	0.32	0.67	0.48	0.04*	0.01**	0.06
	CI	(-0.28, 0.34)	(-0.35, 0.33)	(-1.18, 0.39)	(-0.37, 0.58)	(-0.81, 0.38)	(-2.73, -0.06)	(-0.27, -0.04)	(-13.1, 0.36)
FEF_{25-75}	β	0.008	0.003	-0.02	-0.001	-0.008	-0.075	-0.009	-0.116
	p value	0.16	0.58	0.17	0.88	0.48	0.003*	0.003*	0.36
	CI	(-0.003, 0.02)	(-0.01, 0.02)	(-0.05, 0.01)	(-0.02, 0.02)	(-0.03, 0.04)	(-0.03, 0.01)	(-0.01, -0.01)	(-0.36, 0.13)

*Note: *Significant (P<0.05), **highly significant (P<0.01), β: regression coefficient*

The reference group for physical activity was vigorous physical activity.

5.5 Predictors of the PFTs among non-diabetic participants

A simple linear regression revealed that no significant association between the PFTs and age, sex (male taken as refrence), occupation (merchant taken as refrence), education (primary school students taken as refrence), weight, height, WC,WHR, BMI, FBS, and physical activity (vigorous physical activity taken as refrence) among non-diabetic participants since $p > 0.05$ (table 8).

Table 8: Simple linear regression model showing predictors of PFTs among non-diabetic participants at JMC, Jimma, Southwest Ethiopia, 01,April-30,May,2019, (n=145)

Spirometric parameters	PFTs									
	FVC		FEV_1		FEV_1/FVC		PEF		FEF_{25-75}	
	β	p value	β	p value	β	p value	β	p value	β	p value
Age	0.047	0.628	-0.03	0.77	0.026	0.72	-0.004	0.76	-0.004	0.54
Female	-1.23	0.27	-0.205	0.18	1.680	0.16	-0.001	0.96	-0.11	0.86
Weight	0.002	0.98	-0.032	0.74	-0.005	0.9	0.001	0.98	-0.003	0.62
Height	4.36	0.69	-3.29	0.78	2.82	0.73	1.78	0.19	0.37	0.63
WC	0.002	0.98	-0.064	0.45	0.016	0.78	-0.012	0.229	-0.012	0.3
WHR	-0.021	0.79	5.66	0.73	-15.2	0.17	-0.72	0.71	0.23	0.83
BMI	-0.18	0.54	-0.08	0.83	-0.146	0.52	-0.046	0.24	-0.02	0.33
FBS	-0.23	0.7	0.016	0.87	-0.085	0.19	0.009	0.41	0.002	0.72
Moderate activity	0.98	0.64	-2.28	0.28	1.96	0.17	-0.37	0.1	-0.302	0.28
low physical activity	2.23	0.29	3.38	0.15	-0.64	0.69	0.189	0.49	0.323	0.034

Note: The reference group for sex (male taken as refrence), and physical activity (vigorous physical activity taken as refrence).

6. DISCUSSION

The present study showed that means of FVC and FEV_1 were significantly reduced among type 2 diabetic patients, which were in line with the study carried out in Egypt (37), Ghana (38), Saudi Arabia (35), Pakistan (36), India (26) and Wester Australia (31). This reduction may be attributed to the thickening of the alveolar epithelium and the pulmonary capillary basal lamina and also due to the reduced recoiling of the lung which prevent lung expansion so, the volume and elastic recoil of the lung were reduced in type-2 diabetic patients (11,12).

On the other hand, the findings of the present study were not in line with the study in Sudan (26), which indicated that means of FVC and FEV_1 between the diabetic patients and their matched control group showed no significant differences. The possible explanation for the difference may be due to methodological, socio-demiographic factors and anthropometric variation.

In the present study there was a significant decrease in mean of FEV_1/FVC in type 2 diabetics as compared to normoglyemic participants. This result of study was in agreement with study conducted in Saudi Arabia (35), India (27) and Wester Australia (31). The alteration in collagen and elastin ratio is the main factor in the diabetic patients. This study was not in line with study done in Ghana, Sudan, Egypt and Pakistan, which reported that means of FEV_1/FVC between the diabetic patients and their matched control group showed no significant differences. This difference may may due to variation in methodology, socio-demiographic and anthropometric characteristics of the participants. This finding was also not in line with study done in India, which indicated that FEV_1/FVC was statistically increased among diabetics when compared to non-diabetic participants (28,34). This may be due to difference in methodology, socio-demiographic and anthropometric characteristics of the participants.

In this study, mean of PEF was significantly reduced among the diabetics which was in line with study conducted in Sudan (29), Egypt (37) and India (26). The possible explanation for this reduction was reduction of force generating capacity of the expiratory muscle and the reduced recoiling of the lungs (11).

In the current study, the mean of FEF_{25-75} was significantly reduced among the type 2 diabetics. This finding was in agreement with the study conducted in India (26,27). Forced expiration is supported by recoil forces and muscular of the respiratory system. Decrease in muscular and recoiling forces of the respiratory system because of increased glycosylation and microangiopathy is responsible for significant decrease in FEF_{25-75} (11). This study was not in line with study done in Ghana (38), Egypt (37) and Pakistan (36) which reported that means of FEV_1/FVC between the diabetic patients and their matched control group showed no significant differences. This may be due to difference in methodology, socio-demiographic and anthropometric characteristics of the participants.

The present study indicated that BMI was independent risk factor of FVC, FEV_1, FEV_1/FVC, PEF and FEF_{25-75} . These findings may be due to BMI is associated with reduced chest wall compliance and increased airway resistance and hence lead to deranged PFTs (14).

The current study indicated that FBS was independent risk factor of the means for FVC, FEV_1, FEV_1/FVC, PEF and FEF_{25-75} . This reduction may be attributed to the sustained hyperglycemia causing glycosylation of lung collagen and hence less compliant lung parenchyma leading to abnormal pulmonary function tests (11,12).

Static lung volume parameters and pulmonary diffusion capacity for carbon monoxide were not recorded since equipments to measure the parameters were not available.

7. CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

Compared to the non-diabetic participants, type 2 diabetics had signicantly reduced the PFTs. FBS and BMI were independent risk factors of the PFTs among the diabetics unlike that of non-diabetic participants.

7.2 Recommendations

For Federal Ministry of Health

- The ministry of health should design a screening program of routine PFTs.

For Jimma Medical Center

- Health care providers should screen all type 2 diabetic patients by performing PFTs during their initial visits and every two years to ascertain the status of lung function.
- Health care providers should screen all type 2 diabetic patients with higher BMI and FBS to ascertain the status of lungs.

For further researchers

- Future longitudinal studies are needed to explain a causal relationship between decreased lung function and risk factors among the diabetes.
- Future studies are needed to confirm reduction of the PFTs with static lung volume parameters and pulmonary diffusion capacity for carbon monoxide.

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ANNEXES: QUESTIONNAIRE

ANNEXES ONE: QUESTIONNAIRE IN ENGLISH VERSION

Consent Form

Hello, my name is_________. I came here as data collector to assess status of lung function among type 2 diabetics and non-diabetics for the partial fulfillment of a Master's Degree in Medical Physiology. I request you to participate in this study. Your participation in this study is entirely voluntary. The length of time for participation will take about 30 minutes and the place where the entire procedure takes place will be in this hospital. Any information that will be obtained regarding you in this study will be kept confidential and will be disclosed only with your permission. If you undergo all questions, tests and procedures, recommendations will be done according to the findings of this study.

Are you willing to participate? Yes or No

If yes, sign here ____________________

Part I. Socio-demiographicCharacteristics

1. Sex (Record Male / Female as observed)

Male =1 Female=2

2. How old are you? ______ years

3. Where do you live now?

Urban = 1 Rural = 2

4. What is the highest level of education you have completed ?______

5. What is your main work over the past 12 months ?______

Part II. Anthropometric Measurement

6. Height________ meters

7. Weight________ kg

8. Body Mass Index ________ kg/m^2

9. Waist Circumference ________ cm

10. Hip Circumference ________ cm

11. Waist to Hip Ratio ________

Part III. Other factors

12. Fasting blood sugar ________mg/dl

Part IV. Physical Activity

Physical activity			
13	During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling that cause large increases in breathing or heart rate for at least 10 minutes continuously?	______________days.	If no skip to 16
14	If yes, in a typical week, on how many days' do you do vigorous-physical activities?	______________days.	
15	If yes, how much time do you spend doing vigorous-intensity sports, fitness or recreational activities on a typical day?	______hrs. ______minutes.	

16	During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, tennis or activities that cause a small increase in breathing or heart rate such as active walking, for at least 10 minutes continuously?	_______________days.	If no skip to 19.
17	If yes, in a typical week, on how many days' do you do you do any moderate intensity sports, fitness or recreational (leisure) activities	_____________days.	
18	If yes, how much time do you spend doing any moderate intensity sports, fitness or recreational (leisure) activities?	____________hrs. _____________minutes.	
19	How much time do you usually spend sitting or reclining on a typical day?	_____________hrs.	

Part V. Pulmonary Function Tests

PFT Parameters		1^{st} Acceptable record	2^{nd} Acceptable record	3^{rd} Acceptable record	Best taken	Remark
FVC	L					
	%					
FEV_1	L					
	%					
FEV_1/FVC (%)						
PEF	L/s					
	%					
FEF25-75 (L/s)						

Thank you for your participation!

ANNEXES TWO: QUESTIONNAIRE IN AMHARIC VERSION

የቃለ-መጠይቅ ቅፅ

እኔ____________________እባላለዉ፡፡ በሕክምና ፊዚዮሎጂ ውስጥ በከፊል የ “የስኳር ህመምተኞች” እና የስኳር ህመምተኞች ባልሆኑ የመተንፈሻ አካላት ተግባር ሁኔታ ጥናት የሚዉል መረጃ ለመሰብሰብ ነዉ የመጣሁት ፡፡ በዚህ ጥናት ውስጥ እንዲሳተፉ እጠይቃለሁ ፡፡ በዚህ ጥናት ውስጥ ያለዎት ተሳትፎ ሙሉ በሙሉ በፈቃደኝነት ነው፡፡

የተሳትፎው የጊዜ ርዝመት 30 ደቂቃዎችን ይወስዳል እናም አጠቃላይ የአሰራር ሂደት የሚከናወነው ቦታ በዚህ ሆስፒታል ውስጥ ይሆናል። በዚህ ጥናት ውስጥ እርስዎን የሚመለከት ማንኛውም መረጃ በምስጢር የሚጠበቅ ሲሆን በእርስዎ ፈቃድ ብቻ ይገለጻል ።

ለመሳተፍ ፈቃደኛ ነዎት? አዎ ወይም አይደለም

አዎ ከሆነ ፣ እዚህ ይፈርሙ__________________

ክፍል I : የስነሕዝብ ባህሪዎች

1. ፆታ (ወንድ / ሴት ይመዝግቡ)

ወንድ = 1 ሴት = 2

2. ዕድሜዎ ስንት ነው? _______ ዓመት

3. አሁን የት ነው የሚኖሩት?

ከተማ = 1 ገጠር = 2

4. ያጠናቀቁት የትምህርት ደረጃ ምንድነው/ስንት ነዉ? _______

5. ላለፉት 12 ወራቶች ዋና ሥራዎ ምንድ ነበር? _______

ክፍል II : አንትሮፖሜትሪክ ልኬቶች

6. ቁመት _________ ሜትር

7. ክብደት_________ ኪ.ግ.

8. ቦዲ ማስ ኢነዴክስ _________ ኪ.ግ / ሜ^2

9. የወገብ ስፋት _________ ሴሜ

10. የሂፕ ስፋት _________ ሴ.ሜ.

11. ወገብ እስከ ሂፕ ሬሽዮ _________ ሴ.ሜ.

ክፍል III : ሌሎች ምክንያቶች

12. የደም ስኳር መጠን_________ ሚ.ግ/ዴ.ሊ

ክፍል Iv፡ የአካል ብቃት እንቅስቃሴ

የአካል ብቃት እንቅስቃሴ			
13	በአለፉት 7 ቀናት ውስጥ እንደ ከባድ ማንሳት ፣ መቆፈር ፣ ኤሮቢክስ ፣ ወይም በፍጥነት የመተንፈስን ወይም የልብ ምት ፍጥነትን የሚጨምር ፈጣን ብስክሌት መንዳት የመሳሰሉ የአካል ብቃት እንቅስቃሴ ምን ያህል ቀናቶች ነበሩት?	________________ቀናት	
14	አዎ ከሆነ ፣ ባንድ ሳምንት ፣ ስንት ቀናትን ያህል ጠንካራ የአካል እንቅስቃሴዎችን ያደርጋሉ?	________________ቀናት	
15	መልስዎ አዎ ከሆነ ፣ በአንድ ቀን ውስጥ ጠንካራ-ጠንካራ ስፖርቶችን ፣ የአካል ብቃት እንቅስቃሴዎችን ወይም የመዝናኛ እንቅስቃሴዎችን ምን ያህል ጊዜ ያሳልፋሉ?	_______ሰዓት_______ደቂቃ	
16	በአለፉት 7 ቀናት ውስጥ በመደበኛ ፍጥነት ብስክሌት መንዳት ፣ ቴኒስ ወይም ትንፋሽን ወይም የልብ ምትን በትንሹ የሚጨምሩትን	________________ቀናት	

	እንቅስቃሴ ያለማቋረጥ ለምን ያህል ቀናትን ሠሩ?		
17	አዎ ከሆነ ፣ በአንድ ሳምንት ፣ ስንት ቀናትን ነው ማንኛውንም መጠነኛ የስፖርት ፣ የአካል ብቃት ወይም የመዝናኛ እንቅስቃሴዎችን የምታደርገው	_____________ቀናት	
18	መልስዎ አዎ ከሆነ ፣ መጠነኛ የሆነ የስፖርት ፣ የአካል ብቃት ወይም የመዝናኛ እንቅስቃሴዎችን ለማድረግ ምን ያህል ጊዜ ያጠፋሉ?	______ሰዓት______ደቂቃ	
19	ባንድ ቀን ለመቀመጥ ወይም ለማረፍ ምን ያህል ጊዜ ያጠፋሉ?	______ሰዓት	

ክፍል V፡ የመተንፈሻ አካላት ተግባር ልኬቶች

PFT መለኪያዎች		1st ተቀባይነት ያለው መዝገብ	2nd ተቀባይነት ያለው መዝገብ	3rd ተቀባይነት ያለው መዝገብ	Best taken	Remark
FVC	L					
	%					
FEV_1	L					
	%					

FEV_1/FVC (%)						
PEF	L/s					
	%					
FEF25-75 (L/s)						

ለተሳትፎዎ እናመሰግናለን!

ANNEXES THREE: QUESTIONNAIRE IN OROMIC VERSION

Guyyaa ___________

Coodii ____________

Foormii Waliigaltee

Maqaan koo ________________ jedhamaa. Kan dhufe Jimma Yuunivarsitii irrayi. Kaayyoon Qorannoo kiyyaa jimma yuunivarsitii keessatti dalagaan sombaa namoota dhukkaba Sukkaraa qabanii fi kan dhukkuba Sukkaraa hin qabnee keessatti wal bukkee madaaluu dha. Dhumarratti, bu'aa qorannichaa irratti hunda'ee, qaama dhimmi ilaaluutti ni oofama. Tarii dalagaan Somba keetii rakkoo yoo qabatee specialist Ogeessa fayyaa waliin mari'achuun furmaatni akka barbaaddamu ni godhama yookan hordoffin fulduratti sif godhama. Qo'annoo kana keessatti akka hirmattuf si gaafadha. Kunis guutumatti fedhii kee irratti kan hundaa'u dha. Hirmannaan kee daqiiqaa soddama hin kan caallef yoo ta'u; Kunis Hospitaala kana keessatti xummuru ni dandeenya. Bu'aan qorannoo kana keessatti argamu kan si 'in wal qabatuu iccitiin kan eeggamuu fi maqaa kee illee barreessuun akka hin barbaachifnee dursaa sitti himuun barbaada. Kanaf hirmaachuu yookan hirmaachuu dhiisuun mirga kee ti.

Yoo hirmachuu fedhii qabatte, mallattoo kee mirkanneessi___________

Caasaa duraa: Diimoograafii (haala ummataa) ilaachisee

1. Saala __________ dhiira, _________dubara

2. Umurii ______________ waggaan

3. Bakka jireenya essaa _________

4. Sadarkaa barumsaa _________

5. Hojiin kee maalii? _________

Kutaa 2ffaa: Haala safartuu qaamaa irratti hundaa'ee

6. Dheerina __________ m

7. Ulfaatina_________kg

8. BMI ___________kg/m2

9. WC_______cm

10. HC______cm

11. WHR________

Kutaa 3ffaa: Baayina sukkaaraa ilaalchisee

12. FBS _______mg/dl

Kutaa Afraffaan: Haala sochii gahumsa qaama ilaalchisee

13	Guyyota torban darban keessatti sochii qaamaa ykn hojii cimaa dhahannaa onnee ykn hargansuu akkan dabalu kan akka ulfaatina kaasuu, lafa qotuu, eeroobiksii ykn biskileettii saffisaan oofuu walitti fufiinsan daqiiqaaa 10f hojjettee?	Guyyoota______________	
14	Torbeetti guyyoota meeqaf sochii qaamaa cimaa hojjetta?	Guyyoota______________	
15	Guyyaatti turtii hagamiif sochii qaamaa cimaa hojjetta?	Sa'aatii______Daqiiqaa ______	
16	Guyyota torban darban keessatti sochii qaamaa giddu galeessaa dhahannaa onnee ykn hargansuu hanga tokko dabalu kan akka ulfaatina salphaa kaasuu, teenisii taphachuu qotuu, eeroobiksii ykn biskileettii suuta oofuu walitti fufiinsan daqiiqaaa 10f hojjettee?	Guyyoota______________	
17	Torbeetti guyyoota meeqaf sochii qaamaa cimaa hojjetta?	Guyyoota____________	
18	Guyyaatti turtii hagamiif sochii qaamaa giddu galeessaa hojjetta?	Sa'aatii______Daqiiqaa ______	
19	Guyyatti yeroo (sa'aatii) hagamii taa'uudhaan dabarsita?	Sa'aatii____________	

Kutaa 5ffaa. Waa'ee safartuu dalagaa sombaa

Safartuu		Yaali duraa	Yaalii 2ffaa	Yaalii 3ffaa	Hundarra filatama	Yaada
FVC	L					
	%					
FEV_1	L					
	%					
FEV_1/FVC (%)						
PEF	L/s					
	%					
FEF25-75 (L/s)						

Hirmannaa keetiif galatoomi

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ASSURANCE OF INVESTIGATOR

I, the undersigned, declare that this thesis is my original work, has not been presented for a degree in this or any other university and that all sources of materials used for the thesis have been fully acknowledged.

Name of the student : **Dereje Gemeda**

Signature __________________ Date: December 4, 2019

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