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Development of diagnostic tools for pathologies of respiratory system using Pulmonary Function Test (PFT)

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Abstract – *Pulmonary function test (PFT) is a test generally used to detect the abnormalities associated with the respiration cycle. Spirometry is a technique considered as a gold standard for the acquisition of the various parameters of the human respiration which includes FVC, FEV1, FEV1/FVC, and PEF, VT. Based on the acquired parameters, the human respiratory diseases like Asthma, pulmonary fibrosis, cystic fibrosis, respiratory bronchitis and other deficiencies can be identified. This document presents a diagnostic tool using virtual instrument which creates a user friendly graphical control and monitoring of a system. The flow-volume and volume-time graphs are been displayed on the Virtual Instrument. Comparison of the obtained graph can be done with the graph of a normal person and the disease like Asthma can be detected. It gives accurate and real time data analysis .*

Key Words: **PFT, spirometry, flow vs. volume &volume vs. time graph**

1 .INTRODUCTION

Obstructive or restrictive lung disease are the two main classifications of the respiratory lung diseases. Among which Asthma is one of the major pathological disorders. Asthma is a lung disease which is common long term inflammatory. In year 2013, 242 million people globally had asthma up from 183 million in year 1990.[1] It is characterized by reversible airflow obstruction. Wheezing, coughing, shortness of breath and chest tightness are the common symptoms of this disease. These symptoms may be observed a few times in a day or few times per week. Depending on the seriousness it may become worse during night or after exercise. According to the frequency of symptoms, Asthma can be clinically classified depending on the values of forced expiratory volume in one second (FEV1) and forced vital capacity (FVC). Pathologies of respiratory system like Asthma can be identified using PFT (pulmonary function test).[2]The primary purpose of pulmonary function testing is to identify the severity of pulmonary impairment. For performing the PFT, spirometry is the technique using an instrument named spirometer. It is the single best test for asthma because Spirometry is considered the best technique for diagnosing the obstructive lung disease. Spirometer includes pulmonary mechanics test which includes measurements of FVC, FEV1, FEV1/FVC ratio, FEF values and forced exhalation flow. Measuring pulmonary mechanics identifies airway obstruction by assessing the ability of the lungs to move large volumes of air quickly through the airways .The use of a fixed lower limit of normal for the FEV1/FVC ratio as proposed by the Global Initiative for Obstructive Lung Disease (GOLD) lacks a scientific basis and results in misclassifying patients at either end of the age spectrum.[3] Young patients are classified as "normal" when airflow obstruction is present, and older patients are classified as showing obstruction when no airflow obstruction is present. The use of the GOLD threshold for identifying airway obstruction should be discouraged in clinical practice where or when computerized predicted values are available. The result collected by the spirometrer device is used to generate a pneumotachograph which can help to assess conditions of the patient's lungs. The data collected through the PFT will be analyzed on the LabVIEW based user friendly VI. This method is noninvasive and the data acquisition can be done at real time. The previous invented methods for asthma detection based on PFT are unable to provide the real time data analysis with the proper accuracy. The test results are reflection of human respiratory status. The diagnosis can be done on the rate of individual's inhalation and exhalation. Diseases like Asthma, Chronic Obstructive Pulmonary Disease (COPD), restrictive diseases are responsible for making changes in graphical representation of flow-volume. [4]So depending on deviation we can establish a methodology of detecting a disease.

2. METHODOLOGY

The basic aim of this research is to develop a diagnostic tool which can efficiently characterize the lung function measuring the lung capacities using an instrument named spirometer. Spirometer measures the volumetric airflow of lung during inhalation and exhalation which allows to diagnose the seriousness of the disease like asthma. [5]The spirometer can lead to number of information including the parameters like, forced expiratory volume (FEV), forced vital capacity (FVC), and tidal volume (TV). FEV is the volume of air exhaled after a short period of constant effort. FVC is the volume of air exhaled by a forced maximal exhalation after a full inhalation. [6]TV is the volume of air inhaled and exhaled at rest.

2.1 Data Acquisition

1).TEST PROCEDURE: -

I. Patient is asked to take the deepest breath

II. Then exhale into the sensor with a force as hard as possible for at least 6 seconds.

III. The patient has to inhale and exhale only through his mouth so soft nose clips may be used to clip his nose airway for prevention of air escape through the nose.

IV. Filter mouthpieces may be used to prevent the spread of microorganisms.

V. The test is completed by recording the data with a protocol which is,

• Normal inhalation forced exhalation within a span of 3 seconds

2) SYSTEM SETUP: -

Hardware requirements:-

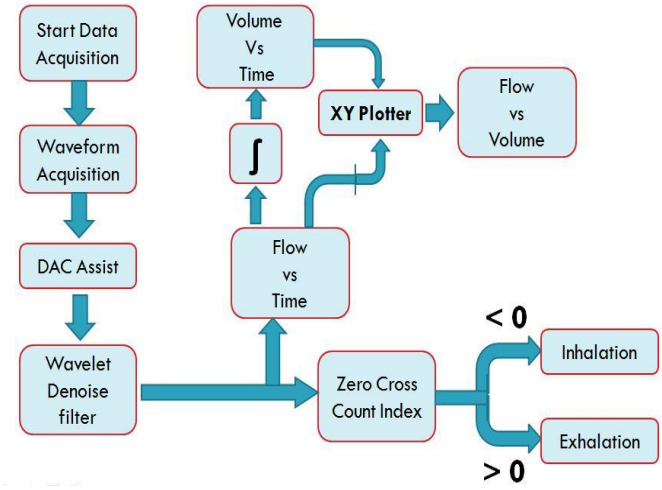
- NI ELVIS II Series Benchtop Workstation
- Vernier Spirometer (Order code SPR-BTA)
- NI ELVIS II Series Prototyping Board
- Vernier Analog Proto Board Connector
- High-speed USB 2.0 cable

Software requirements:-

- NI LabVIEW
- NI Biomedical Startup Kit 3.0
- NI ELVIS tool kit

2.2 Signal Processing

Air flow rate in spirometer is measured by a differential pressure transducer which directly results in amount of air flow rate(L/s). Integrating the flow rate as a function of time results in Volume (L). The system's basic components is differential pressure sensor called spirometer measures pressure difference created between the front and back surface of the mesh screen placed at the center of the flow head. Outputs of spirometer is in voltage proportional to amount of air inhaled or exhaled which is in the range of 20 mV-50mV.The greater the airflow passing through the screen, the greater the differential pressure. This results directly into the measurement of air flow rate (L/s) generating flow vs. time graph. Volume in (L) is calculated by integrating the flow rate as a function of time in (s). The volume vs time graph is obtained by plotting the corresponding values on the XY plotter. This processed signal is being displayed on the front panel of the LabVIEW display panel. This display panel consist of various basic information of the patient like the age, sex, height, name, etc.. is composed of a flow transducer device (Venturi tube), differential pressure sensor, conditioning circuits and LabVIEW VI.



The pressure sensor measures the difference in pressure between sections of the Venturi device and the conditioning circuits consist of a differential amplifier with a gain of 100 and a low-pass filter with a 3dB rolloff at 26 Hz. These circuits serve to increase the signal magnitude to the volt scale and filter out high-frequency noise (especially 60 Hz noise). The frequency spectrum of interest for spirometry is typically 0-20 Hz. We calibrated our sensor and signal conditioning circuits as a single system in order to obtain an equation for conversion of voltage output to measured pressure difference. We accomplished this by applying a range of known pressures to the sensor, using a pump and manometer from a blood pressure cuff, and recording the circuit output. The conditioned signal is acquired and analyzed by our LabVIEW VI. The data acquisition portion of the VI reads the voltage data and converts the values to pressure difference using our calibration equation and then converts the pressure difference to volumetric flow rate (Q) using the theoretical relationship above.[7] Once a measurement is complete, the analysis portion of the VI integrates flow for the entire data set to obtain volume vs. time and flow vs. volume. It also calculates the parameters PEF, FVC, FEV1 and FEV1/ FVC. The VI front panel displays these parameters as well as graphs of the volume data.

2.3 Acquired results

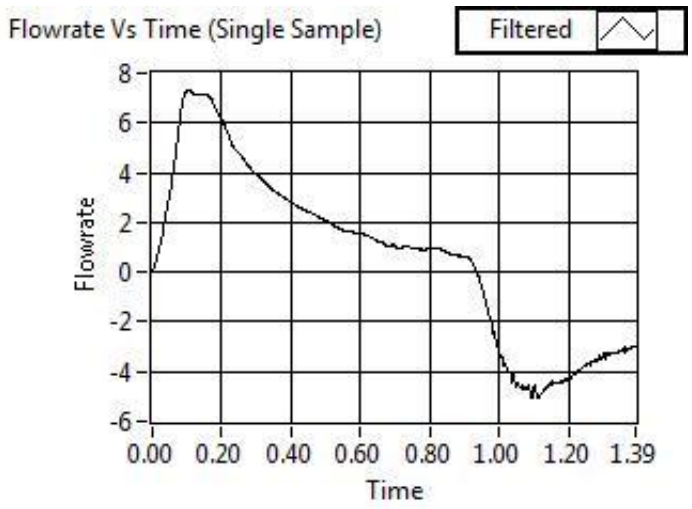


Figure 1: Flowrate vs. Time graph

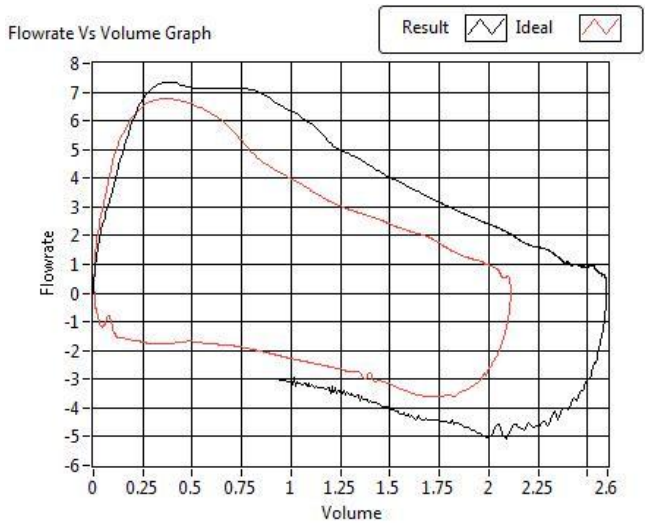


Figure 2: Volume vs. time graph

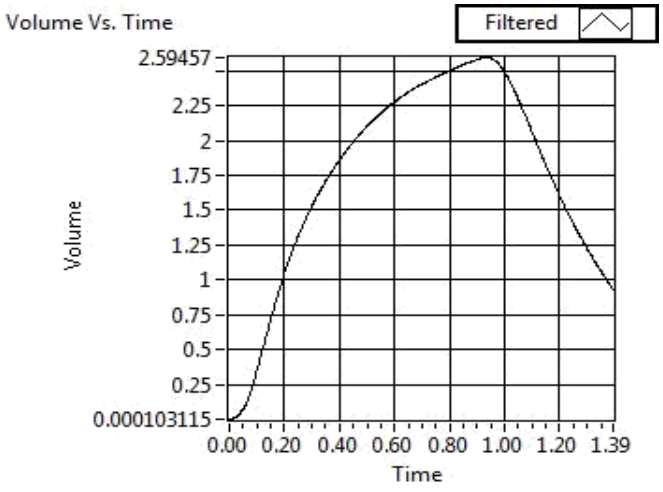


Figure 3: Flow rate vs. volume graph

Name	Reg. No.	Gender	Age	Weight	FVC	FEV1	FEV1/FVC	% Ratio
Khushali Desai	101	F	24	51.3	2.35	1.5	0.64	64.07%
Sameer Ashra	109	M	26	64.3	2.59	2.49	0.96	96.01%
Heena Koshiya	113	F	25	62.2	3.49	3.4	0.97	97.02%
Nidhi Patel	114	F	25	53.5	2.14	2.1	0.98	86.99%
Divya Shah	116	F	24	47.5	4.03	4.03	0.99	99.01%
Jaimin Suthar	117	M	21	57.1	2.61	2.39	0.91	91.30%
Sapna Parekh	118	F	15	49.7	1.28	0.8	0.62	62.45%
Archna Solanki	120	F	17	38.8	1.76	1.56	0.88	87.85%
Chintan Patel	122	M	19	48.2	2.17	1.71	0.79	79.33%
Riddhi Singh	125	F	20	53.6	0.53	0.51	0.43	43.12%
Balkrishna Parmar	129	M	35	50.3	2.09	1.25	0.56	56.87%
Sebastian P.I	131	M	38	79.8	3.71	2.42	0.65	65.30%
Sunil Desai	132	M	42	68.6	1.03	0.57	0.56	56.32%
Suresh Pandya	135	M	45	74.8	1.23	0.82	0.76	66.32%
Mahendra Solanki	138	M	29	74.1	1.81	1.12	0.61	61.84%
Kishan Swadiya	142	M	34	58.2	1.2	0.59	0.49	49.42%

Table 1: Patient's data set

3. CONCLUSIONS

In this study, a method of the PFT to find the various respiratory parameters and generates the graphical results is been developed. It is a real time examination method to detect the lung capacity of an individual with a non-invasive technique. This method is developed using a spirometer as a sensor which detects the pressure difference on the two sides of the diaphragm and generates a flow vs. time graph. After performing various operations on a signal finally a flow-rate vs. volume graph is generated. FVC and FEV1 are detected from the obtained flow and volume graphs.FEV1/FVC ratio is then calculated from the obtained parameters. From the obtained data the person's lungs capacity can be evaluated.

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