

Coupled Mobile Phone Period with peak Flow Meter Enables Real-Time Lung Purpose Assessment

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Abstract— Asthma is a illness that affects above 300 million people worldwide and is disproportionately noted in the growing globe whereas air contamination is from time to time extra prevalent. This illness can scope in severity, provoking the airways of the lungs to constrict and inflame, and no recognized therapies can completely and perpetually ameliorate the disease's results on the respiratory system. Doctors can, though, delight most chronic and acute asthma symptoms alongside medication regimens. It is consequently vital to develop precise mechanisms to monitor the illness symptoms so doctors can seize appropriate steps to delight the patient alongside proper medication.

One competent method to trail asthma symptoms is to monitor a patient's peak expiratory flow (PEF). There are presently countless disparate handheld PEF monitors commercially obtainable, and these tolerate from a collection of disparate limitations. Countless present PEF meters are inaccurate, inconvenient to use, bulky, luxurious, and scarcely contain real-time data plotting capabilities. We have crafted a user-friendly, precise, and reasonably inexpensive external mobile mechanism accessory that records and stores the user's PEF, and graphs this data above time. We additionally have crafted a rehearse software interface to onward this stored data electronically. E-mail forwarding and "telemedicine" skills will give physicians a larger method to monitor the patient's PEF above era, grasping to a supplementary convenient method for physicians to make appropriate adjustments in patient medication regimens

I. INTRODUCTION

ASTHMA is a common pulmonary disease that affects approximately 300 million people worldwide. In the United States, an estimated 22 million people have asthma, 6 million of whom are children. Complications resulting from

asthma in the adult accounts for 13.9 million workplace visits, 423,000 hospitalizations and 2 million emergency room visits per year and the annual cost for asthma treatments in the United States are nearly \$6 billion.

Asthma affects each patient uniquely and therefore requires specialized and customized treatment schedules. Because of this, health care professionals have recommended the use of asthma monitoring plans in order to better characterize the symptoms, triggers, and severity of the disease in each patient. The asthma action plan is the cornerstone of the National Asthma Education and Prevention Program's Third Expert Panel Report, which describes guidelines for the diagnosis and management of asthma. This medication and management plan is based directly on daily measurements of peak expiratory flow (PEF) rates that patients directly obtain

themselves. The use of PEF to determine the disease state in asthmatic patients has been established to be an accurate and repeatable non-invasive test. PEF is defined as the maximum speed of expiration, thus determining the level of obstruction in the airway.

A healthy patient that does not have asthma would have a higher PEF reading than a severely asthmatic patient. The information gathered from PEF tests help health care professionals determine a patient's lung functionality, asthma severity, and treatment options.

Patients who have adhered to an asthma monitoring regimen using PEF have seen the frequency of severe asthma episodes reduced. The efficacy of an asthma monitoring plan using PEF cuts, though, after patients deviate from their their prescribed medical action plan or fail to follow the plan entirely. Traditional methods have not been extremely prosperous mainly because these methods require more effort and commitment than most patients can easily devote. New ways to incorporate mobile phones into health care have many advantages, and there is at least one recent report of a digital mobile phone diary that

helps to increase patient compliance with frequent monitoring.

A surge towards full-body physiological monitoring via real-time sensors and mobile devices is evident in recent literature and research. Biomarkers being measured range from sweat rates, to cardiac function, to breathing patterns and heart rates. The goal of such a complete measurement system is to provide 24-hour quantification of health indicators. Research is also being done to integrate personal readings into data mining systems that correlate an individual's bio-readings to environmental factors to predict future health issues.

A novel approach to simplify the data collection and sharing process was investigated to a convenient, precise, and handy PEF mechanism that enables patients to use the device in any setting. This paper outlines the sensor development and in-instrumentation steps required to enable real-time collection of PEF data from patients onto mobile phone or computing de-vices (e.g., iPhone™, iPad™, Droid™). The PEF device in this study functions when patients exhale into a specially designed tube containing a differential pressure sensor. A custom circuit, mounted to the underside of the device, calibrates the output range to appropriately match the input voltage ranges of a personal mobile device. The signal is then transferred to the mobile device via the universal headphone jack microphone line, such that proprietary wiring diagrams for dual in-line package (DIP) connections or docking station interfaces are not required with a personal mobile device. A differential pressure sensor (*) was placed on either side of a constriction diaphragm and a custom recording circuit was attached to the exterior of the device.

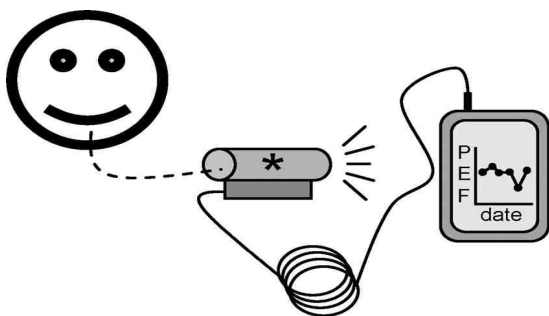


Fig1. An external peak flow meter was constructed to interface. This signal was acquired into the personal mobile device as an "audio" signal through the headphone jack of

the device. PEF was recorded over time and plotted, and could be e-mailed to track patient disease progress.

II. MATERIALS AND METHODS

A Design and Construction of the Peak Expiratory Flow (PEF) Sensor and Package Enclosure

A customized low-cost PEF sensor was designed. It is a thin-plate orifice volume flow meter. In this kind of flow meter, a head defeat is generated in the flow by an obstruction. The volume flow rate is proportional to the square origin of the head defeat

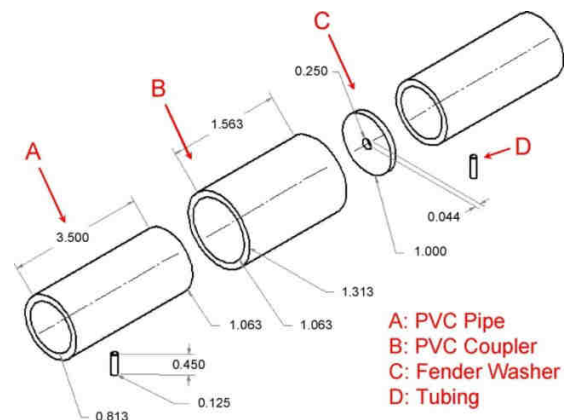


Fig 2. Exploded view of PEF sensor construction

The mechanism was crafted employing countless servings of design 40 polyvinyl chloride (PVC) pipe, alongside specific diameters, that encased a average fender washer that replaced as the thin-plate orifice at that PEF measurements might be taken. A differential pressure sensor (Omega PX74-1.5DV) was safeguarded to opposite factions of the fender washer to attain a differential pressure drop reading.

In order to develop an precise sensor, distinct consideration was given to the dimensions of the physical utilized and portions were selected to safeguard the mechanism should not wrongly preclude maximum exhaled gulp flows. To ascertain the optimal dimensions, it is early vital to understand the maximum flow rate normally noted in youthful healthy adults. In the works, this was discovered to be concerning 680–700 L/min. Calculations were gave employing twice this worth to safeguard that the PEF sensor

had an higher detection check that exceeded the maximum PEF benefits of healthy, non-asthmatic individuals.

The selected average fender washer (0.250 inches inner diameter, 1.000 inches beyond diameter, 0.044 inches thickness) was safeguarded amid two PVC pipes of equal size. One more PVC pipe coupler (1.063 inches inner diameter, 1.313 inches beyond diameter, 1.565 inches length) was press fitted onto the encounter above the fender washer. The worth of the discharge coefficient for these dimensions and Reynolds numbers fluctuating from 1.85 to 1.48 (for flow rates fluctuating from 100 L/min to 800 L/min) was estimated. All materials selected for this mechanism own physical properties that can tolerate external and requested forces.

B. Custom Electronic Interface Joining Mobile Device to PEF

A rehearse route interface was crafted to link the PEF sensor to a confidential mobile device. For this discover, an Apple iPad™ and an Apple iPhone™ were utilized as the confidential mobile device. Contact amid the rehearse route and differential pressure sensor was instituted employing a Wheatstone connection route configuration, that acquired the voltage gesture from the differential pressure sensor. A enumerated housing made of brushed aluminum was made to package the custom circuit and 9 Volt battery manipulation supply for the differential pressure sensor

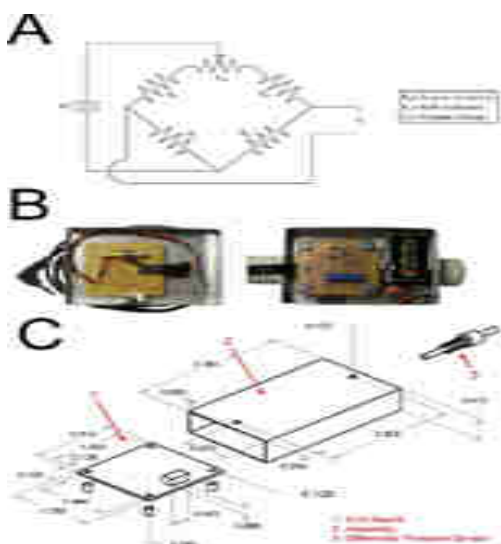


Fig. 3. A custom electronic interface was designed to

connect the peak flow meter to the personal mobile device. All dimensions are in inches. (A) Dia-gram for a circuit to filter the signal prior to data acquisition. (B) Completed PCB board interface. (C) Exploded view of custom housing designed to house circuitry.

The PEF sensor and the rehearse route were assembled together by relating the differential pressure sensor to the circuit across a tiny serving of tubing (0.125)inches beyond diameter, 0.450 inches length) and adhering the PVC pipe constituent to the aluminum housing.

C. Utilization of the Headphone Input Jack as a Data Acquisition Port and Software Program

A exceptional software plan was crafted to permit the PEF de-vice to interact alongside the confidential mobile mechanism across the head phone jack. As an overview, the plan understood the voltage from the differential pressure sensor as a decibel reading, translated the decibel reading into a linear scale, and was next converted into a PEF reading.

After a patient exhales into the mechanism, the pressure drop inside the PEF mechanism was registered and an output voltage was dispatched to the confidential mobile mechanism across the headphone jack. The voltage output was understood as a decibel reading, by an Apple iPad™ and an Apple iPhone™, employing the AV Audio Recorder Class endowed by Apple, Inc., that enables audio recording skills in the application.

A tiny pilot clinical examination was led to ascertain the relationship amid PEF purpose and, as coupled to the mobile phone. A linear retrogression on the accessed data was performed employing least squares fitting employing the software plan Basis 8.1. Asthmatic and non-asthmatic manipulation subjects were asked to forcefully exhale into a established, commercially obtainable maximum scale PEF mechanism. They were next asked to recap the procedure alongside the new confidential mobile mechanism compatible PEF mechanism to furnish correlated peak exhaled flow measurements. The PEF gesture recorded on our mechanism in this discover was next calibrated opposing the subject's PEF seized from the established peak flow meter and linearly interpolated

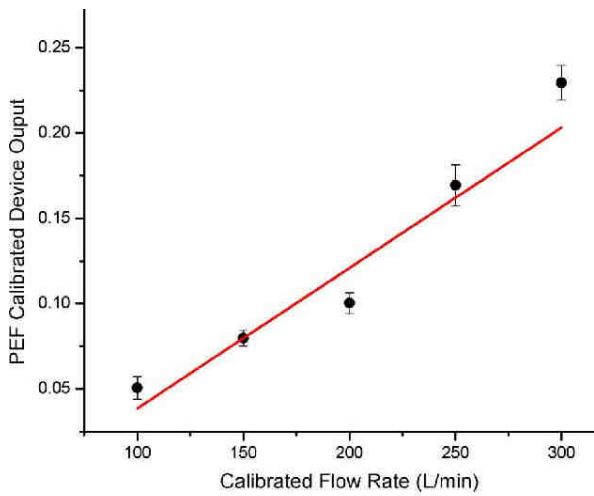


Fig. 4. Calibration plot for the PEF personal mobile device compatible device. Pearson's, Adjusted r^2 .

A subsequent discover was gave in order to extra precisely describe the sensor output. The experimental setup encompassed of compressed air flowing across plastic tubing across a rot meter next across the PEF sensor. The rot meter was utilized to manipulation the flow rate of compressed air going in into the sensor. The flow rate increased in 50 L/min increments amid 100 and 300 L/min. Employing these flow rates, the emerging decibel outputs from the software plan were recorded and utilized to present more calculations to ascertain the best calibration equation. Fig. 4 delineates the experimental aftermath, compliant the pursuing linear connection amid the manipulated flow rate and the PEF output. For upcoming gulp measurements, the PEF output can be modified back to an actual calibrated flow rate .We were able to produce a calibration scope needed for most asthmatics. Later relating a confidential mobile mechanism to the PEF mechanism, users will be able to think a menu screen alongside options.The present graphical user interface is basic at this progress period to plainly clarify functionality.



Fig. 5. Software program graphical user interface for the use of the PEF device with a personal mobile device.

If the “Take Reading” option is selected, the request transitions to a new screen alongside a onset and halt button,The plan escorts the user across a prosperous reading by bestowing orders at the top of the screen. After the user presses the onset button, the maximum reading “maxReading” is set to zero, and the data buy software purpose prompts the user to forcefully exhale into the PEF device. The mechanism unceasingly reads the input decibel reading, converts it into a linear reading, and assesses it to “maxReading.” After the user has finished his exhalation, he is stimulated to press the halt button. As quickly as a button press is noticed, the plan stops reading the input. It next seizes the maximum linear reading noticed, “MaxReading,” and converts it into a flow rate “PEF.” This flow rate is the PEF of the exhalation. The PEF of the user’s

exhalation is displayed on the screen. This worth is temporarily stored to be afterward contrasted alongside the pursuing readings. The request next advises the user to onset his subsequent reading. The maximum PEF "maxPEF" is seized from three sequential readings and is stored in an inner file alongside the date and period the reading was taken. Instituted on preceding readings, users will be alerted if the PEF reading considerably falls below their "personal best" PEF value. A "Reading Complete" memo will notify users that three readings have been prosperously taken. Reliant on the PEF worth, users will understand the severity level of their asthma symptoms.. At each period beforehand completion, the user could press the back button to exit the screen and void the readings.

Users additionally have the option of thinking their own data. After selected, users are able to think, graphically, elucidated measurements of their past PEF readings above time. The customized software request interface was designed to manipulation data buy from the differential pressure sensor, plot the data longitudinally, and package the PEF data plots via the embedded E-mail plan to be held via telemetry to an off-site condition care professional. All software programming was industrialized employing an iPhone software Progress Kit 3.1.3 that was running on a Mac Mini.

III. EXPERIMENTAL RESULTS

The focus of this undertaking was to develop a convenient, accurate, and cost-effective PEF mechanism that can be coupled alongside confidential mobile devices. The prosperous combination of the PEF sensor to the Apple iPad™ and Apple iPhone™ and its portability makes this mechanism flexible and compatible alongside assorted forms of technology. Patients alongside this PEF mechanism can consequently monitor their own condition in all kinds of settings and conditions. The pairing of the new PEF mechanism to an Apple iPad™ and an Apple iPhone™ adjustments and enhances the method condition care can be provided. This discover displays that integration of health mechanisms alongside a public confidential mobile mechanism can be attained by employing the design and knowledge of the Apple iPad™ and an Apple iPhone™ in a novel way.

The PEF measurements seized from the mechanism in this discover were able to give precise and reliable readings. After PEF measurements were seized from human subjects, a forceful correlation amid the mechanism gesture output and

recognized PEF benefits for every single subject were found. A Pearson regression worth of 0.973 delineated the data fit, indicating a elevated correlation. The mechanism was subjected to a secondary examination of manipulated flow rates of compressed air. The data gathered displayed consistent readings at comparable flow rates and appropriate readings at sequential flow rates. That examination yielded a Pearson regression value of 0.959, indicating a forceful correlation.

The subsequent examination that was gave in this discover allowed for precise characterization of the flow reply of the device. Designating the wanted flow rates employing the rot meter allowed for repeatable assessing conditions in that measurements from the mechanism might be undeviatingly contrasted to input flow rates. The device displayed a forceful correlation amid flow and mechanism readings.

Initial estimates on the finished price of the PEF mechanism was established on the creation of the prototype device. The price of all raw materials needed in the encounter of the PEF mechanism was concerning \$75, excluding the price of the confidential mobile mechanism itself. This approximated price, though, will cut if the mechanism is mass produced.

IV. DISCUSSION

The Nation Asthma Education and Prevention Program's 2007 Expert Panel Report inspires the bestowing of self-management education by teaching and underpinning self-monitoring across the use of a symptom diary and top flow measures. The use of a composed asthma deed design, the proper use of medications and inhaler method, and circumventing environmental factors that exacerbate asthma are all key procedures in asthma management.

Developing an asthma deed design in partnership alongside the patient involves accord considering the use of an precise, re-producible, and facilely adjacent PEF meter. Countless inexpensive PEF mechanisms are counseled, but insufficient are utilized by patients longitudinally . Though, aftermath above the last decade indicate that PEF measures are one of the extra price competent methods to grasp chronic asthma , and these measures are quite informative considering occupational asthma diagnosis and association as well. Countless studies additionally counsel that enhanced electronic mechanisms that are routinely compatible alongside patient lifestyles could enhance compliance in reasonable to harsh asthmatics who endeavor to grasp their disease.

One setback alongside most handheld mechanisms is that benefits have to be recorded and composed in daily symptom logs. There are countless possible gains of our mobile phone-based PEF meter that might enhance patient adherence to PEF recording and asthma deed design use. One is that patient data is automatically recorded and can be period, date, and locale stamped. Second, on a extra useful level, mobile phones are by now staple technologies in the lifetimes of millions of asthmatics worldwide. The instant accessibility of the phones, and the stored data on them, could inspire patients and furnish them alongside the data to encounter their illness control. Insufficient mechanisms furnish such real-time feedback on a usual basis.

Another main supremacy of the digital recordings endowed by our monitoring arrangement involves outline credit by clinicians. Discernible understanding studies gave employing manually acquired and normalized data display clinicians can be quite accomplished at noticing subtle patient lifestyle adjustments that associate alongside asthma exacerbations and triggers. This clarification of data will be considerably enabled alongside automated data collection and plotting, and in the end these purposes could be incorporated into electronic decision making and algorithm prop undeviatingly on the Apple iPhone™ PEF mechanism itself. As older mobile phone arrangements have been coupled to top flow measurements, those arrangements were yet bulky and needed proprietary wiring connections to interface them to the phone. Also, maximum data telemetry and e-mail purpose was manipulated at that period, and the confidential mobile mechanism industry has increased quickly in words of extensive use in finished populations.

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