GSM BASED SELF MONITORING SYSTEM FOR ASTHMA PATIENTS

PRABHAVATHI.R
II- M.E. (EMBEDDED SYSTEM TECHNOLOGIES), DEPT OF ECE, VIVEKANANDHA INSTITUTE OF ENGINEERING AND TECHNOLOGY FOR WOMEN, TIRUCHENGODE, NAMAKKAL
prabha25raj@gmail.com

Mr.S.SANKAR M.E.,
ASSISTANT PROFESSOR, DEPT OF ECE, VIVEKANANDHA INSTITUTE OF ENGINEERING AND TECHNOLOGY FOR WOMEN, TIRUCHENGODE, NAMAKKAL
sankar88.ece@gmail.com

Abstract— *To develop the personal lung function monitoring and telemetry devicethat can able to monitor and track asthma symptoms and lung function over time. Asthmatics experience difficulty in breathing and airflow obstruction caused byinflammation and constriction of the airways. Home monitoring of lung functionis the preferred course of action to give physicians and asthma patients a chanceto control the disease jointly. Thus, it is important to develop accurate andefficient asthma monitoring devices that are easy for patients to use. While classicspirometry is currently the best way to capture a complete picture of airflowobstruction and lung function, the machines are bulky and generally requiresupervision. Portable peak flow meters are available but are inconvenient to use.There also exist no portable inexpensive exhaled breath biomarker devicescommercially available to simultaneously measure concentrations of multiplechemical biomarkers. So, the proposed hardware will give the intimation torelatives, as well as doctor and control center, and prescription from doctor alsotransferred to the relatives. If the doctor is not available there means prescriptionfrom control room is also send to the relative. By this, personal monitoring of thepatient is achieved.*

IndexTerms—**Inflammation, Spirometry, Biomarkers,Telemetry device.**

I.INTRODUCTION

Asthma is a chronic pulmonary inflammatory disease that affectsthe airways, and is characterized by an increased sensitivity to various stimuli.Subsequent stimulation may prompt the airways to narrow and induceproduction of mucus causing less air to flow into the lungs. Commonsymptoms of asthma include wheezing, shortness of breath and chesttightness. The intensity of an acute asthma exacerbation, also known as anasthma attack, is unpredictable and has the potential to be life threatening[1].

As of 2004, approximately 300 million people worldwide were afflicted with asthma [2]. In 2010, 25.7 million individuals were estimated to have asthma in the United States [3]. Complications due to asthma accounted for 1.7 million emergency room visits in the United States in 2006 [4], about 14.2 million lost work days in adults in 2008, and annual total cost to society of nearly $56 billion dollars [5]. More than 5 million children have asthma and the prevalence of asthma is greater than 15% for children living in low-income families in the United States [6].

The severity of symptoms, triggers, and responsiveness to treatment medication are often unique to each individual. Thus, a comprehensive guideline for an asthma action plan recommends focusing on monitoring asthma symptoms as a goal for asthma therapy [7]. Spirometry, peak expiratory flow measurement, and a non-invasive marker of airway inflammation known as fractional exhaled nitric oxide (FeNO) are now used by health care professionals for diagnosis and monitoring [8].

A spirometry test is a physiological testnormally performedunder the supervision of trained professionals. It measures thevolume and flow rate of air that can be inhaled and exhaled,and is useful in describing the disease state in the lungs, assessingtherapeutic intervention, and/or monitoring for adversereactions to medication. Two of the most important parametersobtained in a spirometry test are the forced vital capacity(FVC), described as the volume delivered during expirationwhen made as forcefully and completely as possible startingfrom full inspiration, and the forced expiratory volume in onesecond (FEV_1), which is the volume delivered in the first secondof the FVC maneuver [9].

Peak expiratory flow (PEF) has been established as an accurate, repeatable and non-invasive test for monitoring

airflowat home [11,12]. PEF is the maximum flow rate of expiration,which correlates to the degree of obstruction in the airways.Prescribed asthma monitoring plans with PEF monitoringhave been shown to decrease the number of severe asthmaepisodes [13], but are ineffective when not adhered to [14,15].This noncompliance may be due to the time and disciplinerequired to manually assess asthma symptoms over a longtime frame [16]. In addition, biomarkers like nitric oxide (NO)and carbon monoxide (CO) can give health care professionalsanother potential tool to help evaluate and determine asthmatreatment [17].

Portable technology focusing on full-body physiological monitoring using sensors and mobile devices is becoming increasingly prevalent. Recent research in this area has focused on monitoring various physiological functions such as sweat rates [18], cardiac function [19], sleep [20], and biomarkers produced during exercise [21]. These devices provide patients with an inexpensive, portable, and convenient method to noninvasively measure biomarkers of body function to improve healthcare.

The aim of this paper is to report a novel portable approach to asthma monitoring. An asthma monitoring device was developed that combines spirometry (FEV_1, FEV_6, and spirometry graph), PEF, and chemical breath biomarker measurements of nitric oxide (NO), carbon monoxide (CO), and oxygen (O_2) into two breath maneuvers. A software application for Android mobile technology was developed to interpret and display relevant data, record the data to a file on the Android device, and e-mail the data file to a health care professional for personalized care. This paper outlines the development of the instrumentation and software application that enables portable and inexpensive real-time collection of lung function parameters. Future versions of these platforms may be particularly appropriate for pediatric patients who may have greater difficulty documenting their asthma symptoms during the course of a day.

II. PREVIOUS WORK

A. Design and System Construction of the Portable Asthma Monitoring Device

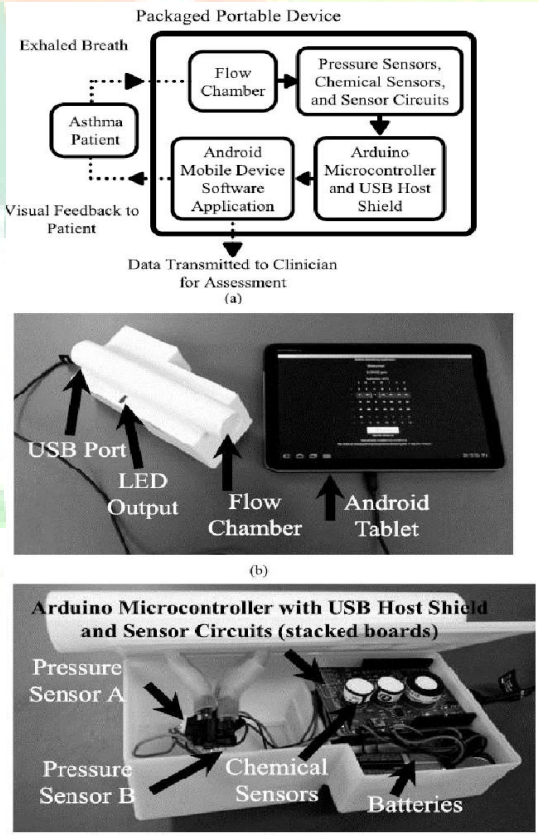

Fig. 1. (a) Schematic overview of the asthma monitoring device and its components.(b) The portable asthma monitoring device

with an Android MotorolaXoom tablet.,(c) The hardware components of the asthma monitoring device.

1) Overview of the Device Layout: A novel portable as thmamonitoring device was created to provide the capability todetect several critical lung function parameters and recordthe data to a mobile device (Fig. 1). Patients exhale intoa flow chamber with embedded sensors that are tetheredto a smart device for data capture. A microcontroller and USB host shield are used to digitize and send the sensor signals to a mobile device through a standard USB connection. A custom software application on the mobile device processes the signal to communicate relevant physiological information back to the patient and allow the processed data to be easily shared via telemetry.

2) Selection of Sensors: PEF values vary depending ongender, age, and height of an individual [26]. In healthyadult women, the maximum flow rate is approximately450–500 L/min while in healthy adult men, the maximum flowrate observed is approximately 600–650 L/min [26]. Low flowrate in this study was considered to be exhaled flow rate that is at or below tidal breathing, which has been reported to bearound 41 ± 11 L/min in healthy adults [27]. Therefore, to fully capture the dynamic range of exhaledbreath, two piezoresistive pressure sensors were selected tomonitor high flows of 50– 900 L/min (pressure sensor A;model #MPX5010; Freescale Semiconductor; San Jose, CA),and low flows of 15–100 L/min (pressure sensor B; model#SSCSNBN002NDAA5; Honeywell; Morristown, NJ).

The dynamic ranges for three of the chemicalbiomarkers found in exhaled breath in asthma patients are0.02–0.13 parts per million (ppm) for NO [28-31], 2–7 ppmfor CO [22, 23], and 14–20 parts per hundred (pph) forO2 [24] whereas in healthy individuals the dynamic ranges are0.005– 0.02 ppm for NO, 1–2.3 ppm for CO, and 14–20 pph for O2 [21, 24]. The chemical sensors were selected todetect the lower end of the biomarker concentration rangefound in exhaled breath in asthma patients (model numbersNO-D4, CO-D4, and O2-G2; AlphaSense Ltd.; Essex,United Kingdom).These three sensors are electrochemical sensors. Theoxygen sensor has a slight humidity dependence while theNO and CO sensors do not have a humidity dependencebut have signal spikes from rapid transient changes inhumidity [25, 23]. The NO and CO sensors are rated for 80%of the original signal after 2 years while the oxygen sensoris rated for 85% of the original signal after 2 years [17-19]. The O2 sensor does not require apotentiostatic circuit and the signal was obtained by using atransimpedence amplifier to convert the current generated bythe sensor into a measureable voltage.Quantification of chemical biomarkers in exhaled breathmust also occur before spirometry maneuvers becausespirometry often causes exhaled NO concentrations toartificially decrease [20].

3) Microcontroller and USB Host Shield: The Arduino UNO and USB host shield systemsends the digital signal in a three byte message from themicrocontroller to the Android mobile device using a USBconnection. During the first breath maneuver, the microcontrollercollects data from the three chemical sensors first ata rate of 100 samples/s for a total of 15s (data from eachchemical sensor is recorded for five seconds in a sequentialmanner). The microcontroller alternates samplingbetween each pressure sensor which occurs for a total of 18 s,allowing ample time for the patient to perform the spirometrymaneuver.

III PROPOSED WORK

This system is a new approach to monitoring lungfunction in asthma patients with a novel portable device that operates using a smart phone or tablet. Initial testing of this asthma monitoring devicein the laboratory setting has demonstrated its capability to measuring major lung function parameters with reasonable accuracy and precision.

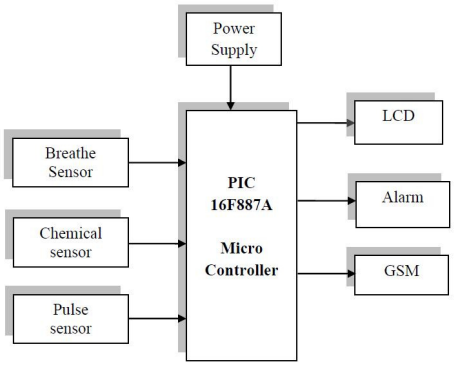

Fig.2Transmitter

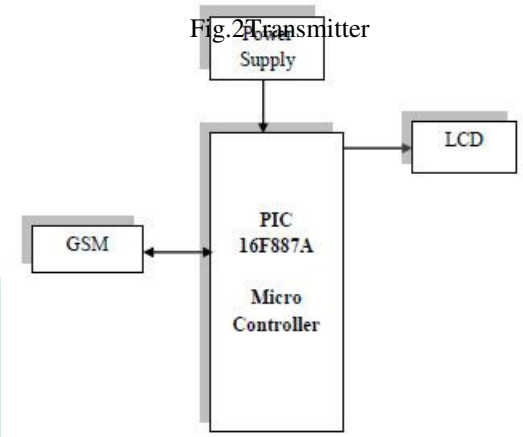

Fig 3(a) Receiver

Fig 3(b) Mobile section

(1) HARDWARE REQUIREMENTS

(A) PIC16F877A

The PIC16F877A CMOS FLASH-based 8-bit microcontroller is upward compatible with the PIC16C5x, PIC12Cxxx and PIC16C7x devices. [13].This feature 200 ns instruction execution, 256 bytes of EEPROM data memory, self - programming, an ICD, 2 Comparators, 8 channels of 10-bit(A/D) converter, 2 capture/compare/PWM functions, a synchronous serial port that can be configured as either 3-wire SPI or 2-wire I2C bus, a USART and a Parallel Slave Port.

(B)BREATHE SENSOR

The sensors contain two in contact with an electrolyte. The electrodesare typically fabricated by fixing a high surface area precious metal on to the porous hydrophobic membrane. The working electrode contacts both the electrolyte and the ambient air to be monitored usually via a porous membrane[15].The electrolyte most commonly used is a mineral acid the electrodes and housing are usually in a plastic housing which contains a gas entry hole for the gas and electrical contacts.

The gas diffuses into the sensor, through the back of the porous membrane to the working electrode where it is oxidized or reduced. This electrochemical reaction results in an electric current that passes through the external circuit. In addition to measuring, amplifying and performing other signal processing functions, the external circuit maintains the voltage across the sensor between the working and counter electrodes for a two electrode sensor or between the working and reference electrodes for a three electrode cell. At the counter electrode an equal and

opposite reaction occurs, such that if the working electrode is an oxidation, then the counter electrode is a reduction.

(C)CHEMICAL SENSORS

The chemical sensor is an inexpensive, portable, foolproof device that responds with perfect and instantaneous selectivity to a particular target chemical substance present in any desired medium in order to produce a measurable signal 22 output at any required concentration[17]. Chemical sensors in actuality are complex devices, generally optimized for a particular application. The features of chemical sensors are

- selectivity
- sentivity
- limit of detection
- response time
- packaging size

The discussion of chemical sensor types is divided into two sections:direct-reading, selective sensors (e.g., electrochemical sensors, optical
fibers); and sensors that use a preliminary chromatographic or electrophoretic sample separation step followed by sensitive, but not necessarily selective, detection.

(C) PULSE SENSOR

Heart rate is a very vital health parameter that is directly related to thesoundness of the human cardiovascular system. This project describes a technique of measuring the heart rate through a fingertip using a PIC microcontroller. While the heart is beating, it is actually pumping blood throughout the body and that makes the blood volume inside the finger artery to change too. This fluctuation of blood can be detected through an optical sensing mechanism placed around the fingertip.

(D) GSM

GSM (Global System for Mobile communications) is a standard developed by the European Telecommunications Standards Institute (ETSI) todescribe the protocols for second-generation (2G) digital cellular networks used Partnership Project (3GPP) developed third-generation (3G) UMTS standardsfollowed by fourth-generation (4G) LTE advanced standards, which do not form part of the ETSI GSM standard. "GSM" is a trademark owned by the GSM association.

(2)SOFTWARE REQUIREMENTS

(A)PROTEUS PROFESSIONAL

PCB layout offering automation of both component placement, track routing, getting the design into the computer can often be the most time consuming element of the exercise. ISIS has been created with this in mind. It has evolved over twelve year's research and development has been proven by thousands of users worldwide. The strength of its architecture is allowed to integrate first conventional graph based simulation.

PROTEUS VSM interactive circuit simulation into the design environment. For the first time ever it is possible to draw a complete circuit for a 24 micro-controller based system and then test it interactively from within the same piece of software[18].ISIS retains a host of features aimed at the PCB designer, so that the same design can be exported for production with ARES or other PCB layout software. It provides total control of drawing appearance in turns of line widths, fill styles, colors and fonts. The General features of proteus software includes

- Runs on Windows 98/Me/2k/XP and later.
- Automatic wire routing and dot placement/removal.
- Powerful tools for selecting objects and assigning their properties.
- Total support for buses including component pins, inter-sheetterminals, module ports and wires.
- Bill of Materials and Electrical Rules Check reports.
- Net list outputs to suit all popular PCB layout tools.
- ISIS provides the development environment for PROTEUS VSM, our interactive system level simulator. This product combines mixed mode circuit simulation, Microprocessor models and interactive component models to allow the simulation of complete micro-controller based designs. ISIS provides the means to enter the design in the first place, the architecture for real time interactive simulation and a system for managing the source and object code associated with each project. In addition, a number of graph objects

can be placed on the schematic to enable conventional time, frequency and swept variable simulation to be performed.

(B) KEIL SOFTWARE

Keil Software is the leading vendor for 8/16-bit development tools (ranked at first position in the 2004 Embedded Market Study of the Embedded25 Systems and EE Times magazine). Keil Software is represented world-wide in more than 40 countries. Since the market introduction in 1988, the Keil C51Compiler is the de facto industry standard and supports more than 500 current 8051 device variants. Now, Keil Software offers development tools for ARM. Keil Software makes C compilers, macrosassemblers, real-time kernels, debuggers, simulators, integrated environments, and evaluation boards for the 8051, 251, ARM, and XC16x/C16x/ST10 microcontroller families. Keil Software is pleased to announce simulation support for the Atmel AT91 ARM family of microcontrollers. The Keil µVision Debugger simulates the complete ARM instruction-set as well as the on-chip peripherals for each device in the AT91 ARM/Thumb microcontroller family[19].

(1)Software Development Cycle

When you use the Keil µVision3, the project development cycle isroughly the same as it is for any other software development project.

1. Create a project, select the target chip from the device database, and configure the tool settings.
2. Create source files in C or assembly.
3. Build your application with the project manager.
4. Correct errors in source files.
5. Test the linked application.

The following block diagram Fig 3.5 illustrates the complete µVision3 software development cycle.

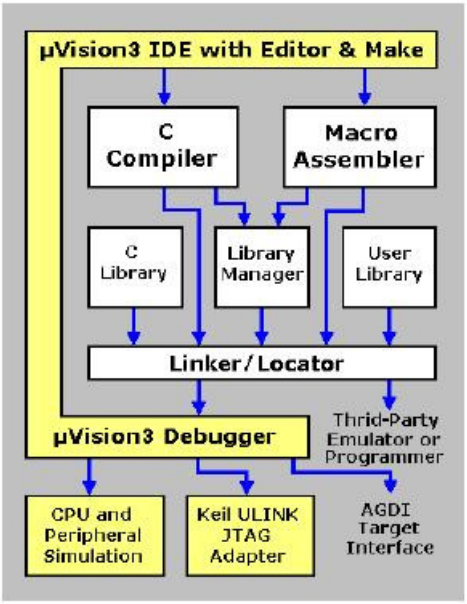

Fig 3.1 software development cycle

IV. EXPERIMENTAL RESULTS

A ten-sample test was conducted in the research setting to determine if the asthma monitoring device can perform a spirometry test comparable to the expiration branch of a clinical spirometer. As noted above, the PEF

values acquired using the asthma monitoring device are not significantly different from the clinical spirometer.

After several forced expiratory maneuvers, patients may experience fatigue and be inclined to stop exhalation before they have completed the maneuver. Spirometry measurements are still considered acceptable if the drop in FEV1 or FEV6 does not exceed 20% if more than three maneuvers are required [9, 41] whichis the case for all measurements of the 10 subjects. Further testing is needed to determine if the asthma monitoring device can accurately detect lung function parameters in those who regularly smoke tobacco.

The significant differences in FEV6values were expected because of the limitations in pressure sensor B, which does not allow the asthma monitoring device to accurately detect flow rates lower than 15 L/min. After several forced expiratory maneuvers, patients may experience fatigue and be inclined to stop exhalation before they have completed the maneuver. Spirometry measurements are still considered acceptable if the drop in FEV1 or FEV6 does not exceed 20% if more than three maneuvers are required [9, 21] which is the case for all measurements of the 10 subjects. Further testing is needed to determine if the asthma monitoring device can accurately detect lung function parameters in those whoregularly smoke tobacco.

The significant differences in FEV6values were expected because of the limitations in pressure sensor B, which does not allow the asthma monitoring device to accurately detect flow rates lower than 15 L/min. Furthermore FEV6 values measured are often dependent on the effort the patient puts into fully completing the spirometry maneuver, which can be inconsistent.

The variability in measured spirometry lung function parameters from the asthma monitoring device and the clinical spirometer were observed to be very similar. For PEF values, the standard deviation of measurements taken on the asthma monitoring device ranged between 5.119–56.102 L/min, while the clinical spirometer had a standard deviation range of 5.574–83.302 L/min. The standard deviation of FEV1 measurements taken on the asthma monitoring device was 0.023–0.333 L, and the clinical spirometer had a standard deviation of FEV1 measurements of 0.015–0.405 L.

The standard deviation of FEV6 measurements from the asthma monitoring device was between 0.071–0.373 L, and the clinical spirometer had standard deviations of FEV6 values between 0.010–0.260 L. Aside from illustrating the inherent variability of spirometry measurements, this data also shows that 9 out of the 10 subjects had their PEF and FEV1 measurements from both devices overlap with one another. This along with the lack of a significant difference indicates that the asthma monitoring device can measure these parameters with an accuracy and precision comparable to that of the clinical spirometer.

Virtual Terminal is a tool which is used to view data coming from Serial Port (DB9) and also used to send the data to the Serial Port. Here the virtual terminal act as transmitter. The data which is to be transmitted is written in the virtual terminal. The result obtain in this phase includes transmission of data collected from the flow chamber is send to relatives, as well as doctor and control center, and prescription from doctor also transferred to the relatives. LCD shows the sensor values.The objective of this project is to analyze and diagnose the asthmausing breathe sensor and monitor the breath rate using PIC microcontroller.

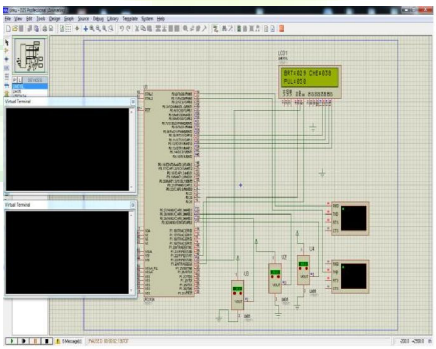

Fig 4.1 Input Data

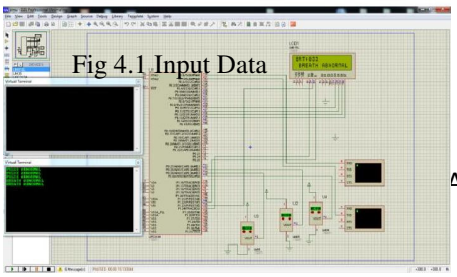

Fig 4.2 output

V. CONCLUSION

This paper presents the architecture of GSM based self monitoring system for asthma patients. The flow chamber that collects spirometry, peak expiratory flow, exhaled nitric oxide, carbon monoxide and oxygen concentration information from patients after two breath maneuvers. In this phase the programming part which have been completed. The microcontroller will get the readings from the flow chamber and it will continuously send the readings to the mobile and at the same time GSM will also send the data to the doctor and the control section.

VI. FUTURE WORK

In the future work a technological advances in miniaturization and nano technology, together with progress in wireless communication allow for the development of miniaturized devices, integrated with clothes or even implanted in the human body. Self-monitoring makes it feasible in almost all situations and locations.

REFERENCES

[1] (2012). *What is Asthma?* [Online]. Available: http://www.nhlbi.nih.gov/health/health topics/asthma.

[2] M. Masoli, D. Fabian, S. Holt, R. Beasley, and Global Initiative for Asthma (GINA) Program, ―The global burden of asthma: Executive summary of the

GINA dissemination committee report,‖ *Allergy*, vol. 59, no. 5, pp. 469–478, May 2004.

[3] L. J. Akinbami *et al.*, ―Trends in asthma prevalence, health care use, and mortality in the United States, 2001-2010,‖ National Center for Health Statistics, Hyattsville, MD, USA, NCHS data brief, no. 94, 2012.

[4] S. R. Pitts, R. W. Niska, J. Xu, and C. W. Burt, ―National hospital ambulatory medical care survey: 2006 emergency department summary,‖ National Health Statistics, Hyattsville, MD, USA, Tech. Rep. 7, Aug. 2008, pp. 1–38.

[5] S. B. L. Barnett and T. A. Nurmagambetov,
―Costs of asthma in the United States: 2002–2007,‖
J. Allergy Clin. Immunol., vol. 127, pp. 145–152, Jan. 2011.

[6] B. Bloom, R. A. Cohen, and G. Freeman,

―Summary health statistics for U.S. children: National health interview survey, 2010,‖ *Nat. Center Health Statist. Vital Health Statist.*, vol 10, no. 250, pp. 1–80, Dec. 2011.

[7] National Asthma Education and Prevention Program, ―Expert panelreport 3 (EPR-3): Guidelines for the diagnosis and management of asthma-summary report 2007,‖ *J. Allergy Clin. Immunol.*, vol. 120, pp. S94–S138, Nov. 2007.

[8] E. D. Bateman *et al.*, ―Global strategy for asthma management and prevention: GINA executive summary,‖ *Eur. Respirat. J.*, vol. 31, no. 21, pp. 143– 178, 2008.

[9] M. R. Miller *et al.*, ―Standardisation of spirometry,‖ *Eur. Respirat. J.*, vol. 26, no. 2, pp. 319–338, Aug. 2005. KWAN *et al.*: PERSONAL LUNG FUNCTION MONITORING DEVICES FOR ASTHMA PATIENTS 2247

[10] M. P. Swanney, R. L. Jensen, D. A. Crichton, L. E. Beckert, L. A. Cardno, and R. O. Crapo, ―FEV6 is an acceptable surrogate for FVC in the spirometric diagnosis of airway obstruction and restriction,‖

Amer. J. Respirat. Critical Care Med., vol. 162, no. 3, pp. 917–919, 2000.

[11] J. M. Ignacio-Garcia and P. Gonzalez-Santos, ―Asthma self-management education program by home monitoring of peak expiratory flow,‖ *Amer.J. Respirat. Critical Care Med.*, vol. 151, no. 2, pp. 353–359, Feb. 1995.

[12] M. R. Miller, O. F. Pedersen, and P. H. Quanjer, ―The rise and dwell time for peak expiratory flow in patients with and without airflow limitation,‖

Amer. J. Respirat. Critical Care Med., vol. 158, no. 1, pp. 23–27, 1998.

[13] P. G. Gibson *et al.*, ―Self-management education and regular practitioner review for adults with asthma,‖ *Cochrane Database Syst. Rev.*, vol. 3, no. 3, p. CD001117, 2003.

[14] P. V. Burkhart, M. K. Rayen, W. R. Revelette, and A. Ohlmann, ―Improved health outcomes with peak flow monitoring for children with asthma,‖ *J. Asthma*, vol. 44, no. 2, pp. 137–142, 2007.

[15] A. W. A. Kamps, R. J. Roorda, and P. L. P.

Brand, ―Peak flow diaries in childhood asthma are unreliable,‖ *Thorax*, vol. 56, pp. 180–182, Mar. 2001.

[16] J. Côté, A. Cartier, J.-L. Malo, M. Rouleau, and L.-P. Boulet, ―Compliance with peak expiratory flow monitoring in home management of asthma,‖ *Chest*, vol. 113, no. 4, pp. 968–972, 1998.

[17] M. Maniscalco and J. O. Lundberg, ―Hand-held nitric oxide sensor NIOX MINO for the monitoring of respiratory disorders,‖ *Expert Rev.Respirat. Med.*, vol. 4, no. 6, pp. 715–721, 2010.

[18] P. Salvo, F. Di Francesco, D. Constano, C. Ferrari, M. G. Trivella, and D. De Rossi, ―A wearable sensor for measuring sweat rate,‖ *IEEESensors J.*, vol. 10, no. 10, pp. 1557–1558, Oct. 2010.

[19] L. Hadžievski *et al.*, ―A novel mobile transtelephonic system with synthesized 12-lead

ECG,‖ *IEEE Trans. Inf. Technol. Biomed.*, vol. 8, no. 4, pp. 428–438, Dec. 2004.

[20] K. Watanabe, Y. Kurihara, T. Nakamura, and H. Tanaka, ―Design of a low-frequency microphone for mobile phones and its application to ubiquitous medical and healthcare monitoring,‖ *IEEE Sensors J.*, vol. 10, no. 5, pp. 934–941, May 2010.

[21] G. W. Hunter *et al.*, ―Smart sensor systems for human health breath monitoring applications,‖ *J. Breath Res.*, vol. 5, no. 3, p. 037111, Sep. 2011.

[22] B. R. Munson, D. F. Young, and T. H. Okiishi,

Fundamentals of Fluid Mechanics, 5th ed. New York, NY, USA: Wiley, 2006.

[23] F. White, *Fluid Mechanics*, 6th ed. New York, NY, USA: McGraw-Hill, 2008.

[24] A. P. Singh, A. R. Paul, and P. Ranjan,

―Investigation of reattachment length for a turbulent flow over a backward facing step for different step angle,‖ *Int. J. Eng., Sci., Technol.*, vol. 3, no. 2, pp. 84–88, 2011.

[25] J. L. Hankinson, J. R. Odencrantz, and K. B. Fedan, ―Spirometric reference values from a sample of the general U.S. population,‖ *Amer.J. Respirat. Critical Care Med.*, vol. 159, no. 1, pp. 179–187, Jan. 1999.