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Arduino based wireless tracking of Sleep Apnea through monitoring of Health parameters

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Abstract - *When breathing repeatedly stops and resumes while slumber, it is referred as sleep apnea. Untreated conditions lead to vigorous snoring during sleep followed with tiredness and can be fatal in future untreated conditions. Obstructive sleep apnea (OSA) is characterized by recurring bouts of partial or total upper airway obstruction brought on by the pharyngeal airway narrowing or collapsing while a person is still trying to breathe. This decrease in airflow, which lasts for at least 10 seconds, causes a drop in blood oxygen saturation and cortical arousals. The long-term effects of Obstructive Sleep Apnea (OSA) eventually lead to heart failure, hypertension, arrhythmia, and cerebrovascular damage. The polysomnography (PSG) nightly sleep study, which is the standard diagnostic method for OSA, is a laborious and time-consuming practice that exacerbates the patient's suffering. Since the introduction of computer-aided diagnosis (CAD), researchers studying sleep disorders have become increasingly interested in the automatic detection of OSA since it affects both therapeutic and diagnostic choices. The present work thrives to develop a wireless system for tracking the various health parameters which fluctuate during apnea connected through the cellular phone module. The device has been tested and various data has been recorded on which clinical remarks can be analyzed for various data sets implemented on different age groups. It has been noticed that people of age 40 years or higher shows a higher chances of developing sleep apnea. The data alteration in Heart rate, saturation of partial pressure of dissolved oxygen in blood (SpO2) and the snoring intensity marks the footprint of Apnea condition in the patient.*

Key Words: Obstructive Sleep Apnea, Arduino, Heart Rate, SpO2, ECG

1. INTRODUCTION

Obstructive sleep apnea (OSA)-related sleep disorders depend on unique disruptions of the upper respiratory system's normal function and are associated to primary hypersomnia, interrupted sleep, and sleep deficiency. Among the most typical sleep disturbances, OSA is characterised by recurrent episodes of partial or full cessation of breathing while asleep. According to the literature, it affects 17% of women and 34% of men in the adult population. The primary symptoms develop with behavioural changes that eventually result in breathing pattern changes, sleeplessness, and may even cause narcolepsy [1]. Depending on the patient's pathophysiology, the length of the involuntary and nocturnal respiratory halt can range from 20 to 40 seconds, but can also be as little as 10 seconds (hypopnea), 2 minutes (apnea), or longer. Disproportionate fat depositions in the muscles of the pharynx tend to narrow the upper airway and are responsible for apneic episodes in OSA patients. The blood oxygen saturation typically falls during the apnea-hypopnea episodes, which then sets off the autonomic neural response and causes micro-arousals with nocturnal gasping for air. 90% of OSA sufferers say they have restless and erratic sleep, weariness, and a lack of vitality. The preponderance of OSA patients are currently underdiagnosed because a bigger percentage of them are asymptomatic. Repeated apnea-hypopnea episodes cause primary events like intermittent hypoxemia, micro arousals, and increased intrathoracic pressure. These primary events then start a cascade of interconnected processes that contribute to the developmental causes of secondary disease manifestations and disease end points, as shown in Figure 1. The main cause of metabolic dysfunction and high blood pressure in OSA patients is sympathetic nervous system (SNS) activation. Sleep apnea is a serious medical condition that can lead to complications such as daytime weariness, diabetes, kidney and liver difficulties, and cardiac issues [2, 3].

The underlying genetic propensity for the disease and intricate interactions between anatomical, neuromuscular, and other variables make up the multifactorial pathophysiology of OSA. Menopause in women, middle age, obesity, snoring, and a number of craniofacial and oropharyngeal characteristics, such as a large neck circumference, retro- or micrognazia, nasal blockage, enlarged tonsils and adenoids, macroglossia, and low-lying soft palate, are risk factors of OSA [5]. The disorder is now better understood and addressed, owing to developments in sleep medicine and the availability of improved diagnostic techniques over the past 20 years. There are numerous therapy options currently accessible, and the management of patients with OSA necessitates a multidisciplinary approach. The most efficient and widely used kind of treatment is positive airway pressure (PAP), which has been around since the early 1980s. Several upper airway surgical techniques, weight loss, and mandibular advancement devices are further choices.

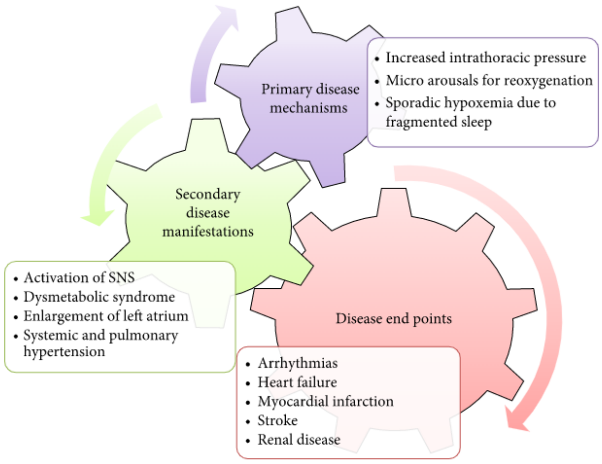

Fig -1: Association of OSA and Cardiovascular disorders [4]

In this article, the wireless technique to monitor OSA is addressed where the tracking system is conjunct with cellular phone through Bluetooth connectivity.

2. MATERIALS & THE PROTOTYPE

For developing the prototype the following electronic components had been utilized. The details of the components are enlisted in Table 1.

Table -1: List of Components

Component	
Ardiuno UNO	Potentiometers (Trim pot)1 MΩ
MAX30102	Capacitors (Polar) 10 μF, 16V
ECG sensor	1N4148 (Diode)
Sound sensor	IC: LM 555
Bluetooth module	IC: LM 358
Pulse sensor	Jumper wires
Breadboard	Single strands wires
Resistors (MFR, 1%, 0.25 W) 10 KΩ	Piezo-buzzer
Thermistor 390 KΩ	A DC voltage source +9V

Three separate layers are merged in this microcontroller-based sleep apnea monitoring device for those with sleeping disorders. A microcontroller unit that connects the input layer and the output layer is the main layer. Four separate sensors are coupled in the input layer to give the Arduino UNO an analogue signal with which to measure various sleep status indices. The Arduino UNO's serial monitor and a mobile application that displays the digital data that the microcontroller has translated are merged into the output layer.

The framework consists of an Arduino UNO microcontroller board, input, and output. The user may see the converted digital data thanks to the Arduino board, which is also connected to the output layer, the serial monitor of the Arduino board, a Bluetooth module connected to a mobile MIT App Inventor programme, and other components. The system's fundamental block diagram is displayed in Figure 2. The sensors simultaneously transmit data to the Arduino UNO, and the Arduino UNO simultaneously transmits the digital data it has converted to the mobile application using the Bluetooth module.

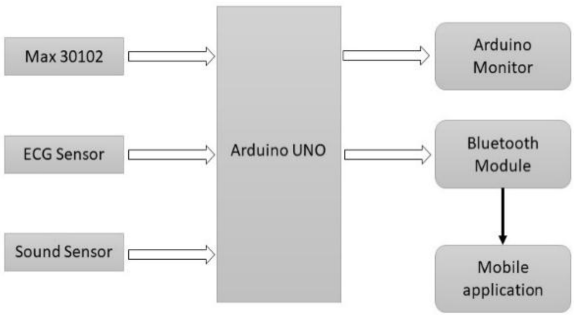

Fig- 2: Block Diagram of the prototype

The sensors simultaneously transmit data to the Arduino UNO, and the Arduino UNO simultaneously transmits the digital data it has converted to the mobile application using the Bluetooth module. The circuit diagram and the prototype has been shown in Figure 3a and b respectively.

The main part of the system is the Arduino UNO, which is based on the VR Microcontroller Atmega328. This programmable microcontroller can be utilised in a variety of projects because of its ability to interface to other sensors or computers. It has 32KB of flash memory and 2KB of static random access memory, of which 13KB is used to store the set of instructions as code. Moreover, it has a 1KB EEPROM (electrically erasable programmable read-only memory).

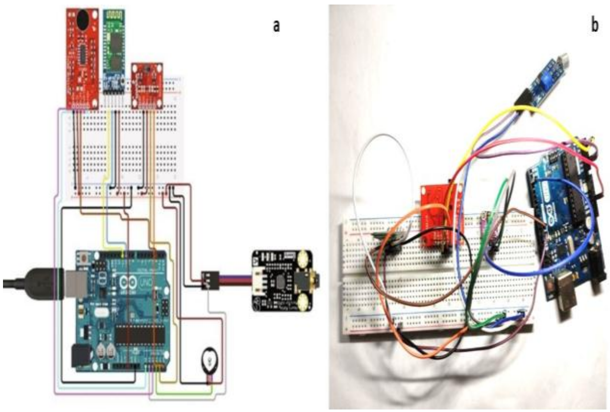

Fig- 3: a. Circuit Diagram b. Design of the prototype

Breathing issues and sleep apnea issues are closely interrelated to the patient's heart rate. To track the patient's heart rate while they are sleeping, the device has a heart rate pulse sensor. One of the main risk factors for sleep apnea is a rapid heart rate. A healthy person's heart beats between 60 and 100 times per minute on average (bpm). Everybody's heart rate is different. Those who are more physically active typically have lower heart rates than those who are less active. A prominent indicator of sleeping difficulties is a higher and unusual fluctuation in heart rate. During sleep apnea, partial pressure of dissolved oxygen falls thus the Max 30102 sensor is integrated in the circuit to monitor real time values. The sound of snoring, a typical symptom of the disorder, also varies from which concluding remarks can be drawn related to the OSA. The system has an analogue sound sensor that measures snoring noise in order to gauge how loudly a person is snoring while they are sleeping. The sound sensor is a small circuit board that converts sound waves into electrical signals using a microphone and some processing circuitry. The analogue pin of the Arduino is used in the system to connect the sensor to the board. For the mobile application, Arduino converts the analogue data from the sensor into digital data. The foundation of this IoT-based research is serial communication. The system includes a Bluetooth module called the HC-05 for serving the purpose. The connector between the Arduino Uno and the Android app is the Bluetooth module. This Bluetooth module functions in two modes: one mode transfers or receives data to another device, while the second mode operates in AT command mode to set the destination device's settings as the default. The user can access the digital data in the mobile application after connection with a Bluetooth device. The devices function at a current of 30mA and a voltage range of 4V to 6V. The Bluetooth module's TX (transmit) and RX (receive) pins handle serial communication. The TX pin functions to send serial data, and the RX pin functions to receive data from the microcontroller. The Arduino's TX pin is linked to the Bluetooth module's RX pin, and vice versa for the Arduino's RX pin and Bluetooth module's TX pin. The mobile application in the system receives digital data from the Arduino after being paired with the Bluetooth module.

3. RESULTS

The results obtained from various subjects of different age groups have been tabulated in Table 1. The corresponding data has been plotted in Figure 4 for better readership and understanding the analysis drawn from the outcome of the research.

Table 2: Variation of various parameters in subjects

Age Group, Years	Heart Rate, bpm	Levels of SpO_2, %	Snoring Intensity, dB
18-30	88	97	28
	82	99	31
	84	99	31
	78	99	27
	91	98	24
31-45	83	96	45
	59	91	62
	97	95	42
	91	86	60
	88	91	32
46-60	98	91	56
	58	88	66
	51	85	62
	54	87	61
	98	96	42
61 >	53	85	67
	56	84	64
	95	92	48
	52	87	65
	48	81	68

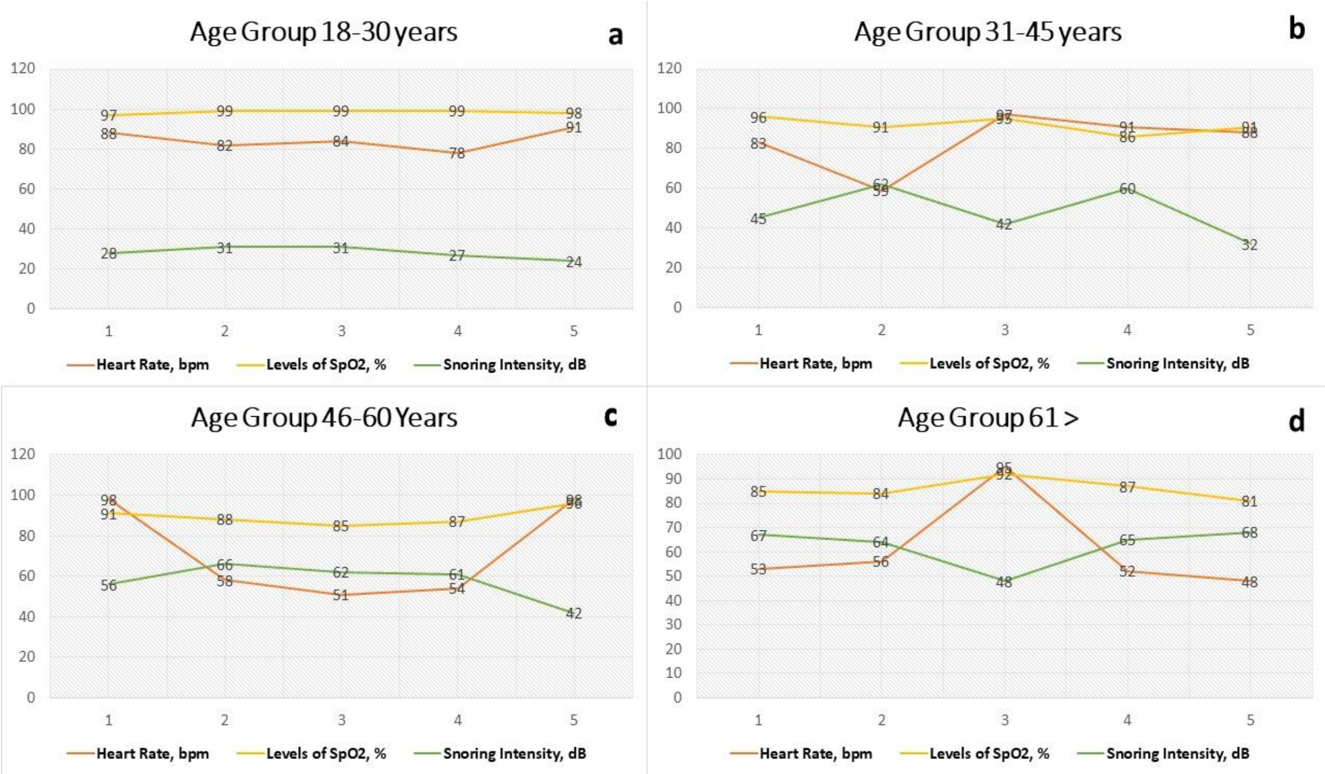

Fig-4: Observation of various health parameters for different subject of various age groups.

4. CONCLUSION

From the results, it has been observed that the tendency of sleep apnea is in subject in upper age group, where commendable fluctuations of SpO2 and Heart rate from normal range has been noticed. Fewer cases of the disorder have been noticed in younger age, which may be due to other pathophysiological issues, likely, obesity, genetic disorder, heart condition or wider neck region (Penzel. 2002). With the aid of portable diagnostic instruments, changes in oxygen saturation and heart rate have been utilised to identify sleep apnea early on (Roose et al. 1993). We found a statistically significant positive connection between the degree of OSA and the volume of snoring. Earlier studies on this association relied on snoring reports from the self or from family members. The current study is the first to evaluate the association between OSA and snoring severity in a large patient population using an objective evaluation of snoring intensity. Due to the widespread incidence of snoring in the general population, snoring is a poor indicator of OSA (Flemons 1994). OSA is intimately linked to a number of major disorders, including arterial hypertension, cardiovascular disease, stroke, and metabolic syndrome, in contrast to non-apneic snoring (Neito 2000, Peppard 2000). Systemic hypertension is thought to be a separate risk factor for sleep apnea (Grote et al, 1999). Simple physical treatment can effectively alleviate sleep apnea. The air pressure inside the upper airways is raised by continuous positive airway pressure (CPAP), which is administered through the nose while wearing a tight mask (Sullivan et al., 1981).

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