Sleep Aid for Obstructive Sleep Apnea

S Malaviga[1], Dhanushya B[2], Jayamithra A[3], Mariya Yeldhos[4]
UG Scholars[1,2,3], Assistant Professor[4].
[1,2,3,4]Department of Biomedical Instrumentation Engineering,
School of Engineering, Avinashilingam Institute for Home Science & Higher Education for Women, Coimbatore
mariya.yeldhos@gmail.com, dhanushyabalamurugan4@gmail.com, mithraudt@gmail.com,
malavigaselva96@gmail.com.

***Abstract*—Obstructive sleep apnea (OSA) is a prevalent disorder giving detailed reports of difficulties and disruptions in breathing at night. This occurs due to breakdown of the upper respiratory tract. The throat muscles constrict and upper airways are blocked and thus the person experiences difficulties in breathing. In order to overcome these difficulties, we have designed a sleep aid which plays a music with prompting tones that helps in emphasizing the breathing of a person during sleep and detect OSA by measuring parameters such as heart rate and blood oxygen saturation level. It also detects the sleep duration and induction time. These are recorded and sent via a Wi-Fi module to a web portal where it is displayed.**

Keywords –Obstructive sleep apnea, sleep aids, heart rate, blood oxygen saturation, sleep duration, sleep induction time.

I. INTRODUCTION

Obstructive sleep apnea (OSA) is a type of disease that is described by pauses in breathing during sleep. The passage through the larynx, pharynx, oesophagus and the trachea slacken and the airways are blocked when the person is sleeping [4]. There may be choking or snorting sounds as breathing begins again. It leads repetitive nocturnal breathing cessations and complications like hypertension, cardiac stroke, and diabetes. This affects the normal sleeping pattern and the person experiences tiredness and irritation during the day [6].

Risk factors include obesity which is a heredity factor, constricted airways, enlarged tonsils, diabetes, strokes, cardiovascular disease and digestive diseases [3].

A. Objective

To emphasize the breathing of a person at night, reduce the risk of cardiovascular diseases in order to make people aware of the effects of undiagnosed sleep apnea and to monitor one's sleep.

B. Mechanism

When a person stops breathing, the blood stream is filled with surplus of carbon dioxide. The brain signals to awaken a patient from sleep and breathe in air. So, as to overcome these drawbacks, "sleep aids", have been brought in to replace the sleeping pills prescribed by doctors for speedy recovery [13].

II. EXISTING TECHNIQUE

Sleep specialists provide remedies for inducing sleep in a person mainly through breathing exercises [12]. 2BREATHE is a device which helps a person to improve the breathing using a device-which is guided breathing tones. During this sleep inducing period, 2BREATHE transforms one's breathing rate into sleep inducing tones. The tones are such that it sedates and gradually guide the person to continued expiration and moderate breathing. Within a certain period, the patient feels relaxed for inducing deep sleep. It's used for a maximum of 10 minutes a day to 40 minutes per week.

The wearable can be taken off after a period of 10 minutes or continue to breathe with the guiding tones until deep sleep is detected.

A. Procedure

Step 1: Breathe

The person wears the device before going to sleep around the waist for inhalation and exhalation. Using Bluetooth enabled smart phone; the breathing movements are being transferred as shown in Fig.1.

Step 2: Breathe in-sync

The 2BREATHE device helps to convert the breathing rate of the patient into tones that will assist in sustained expiration. The person keeps pace with the assisting tones to sleep as shown in Fig.1.

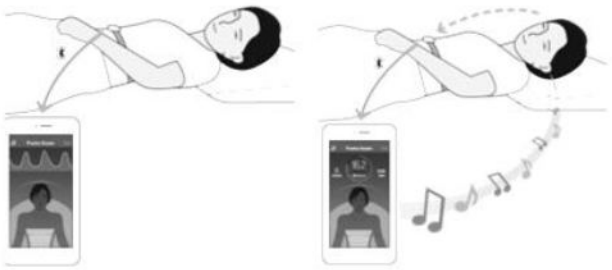

Fig.1. Breathe and breathe in-sync.

Step 3: Remove Sensor or Allow Yourself to Fall Asleep

When the person reaches the 7 minutes goal, the person can terminate the phase manually; remove the wearable and sleep. The person continues to breathe and goes along with the tones until the person reposes.

As the tones continue to guide the person to extend the expiration and moderate breathing, the person begins to doze off. It turns out to be difficult to listen to the tones and thus the person enters a resting state as shown in Fig.2.The patient reaches a relaxed state. Once sleep is detected, 2BREATHE automatically turns off.

Step 4: Track & Review

At the end of each session, 2BREATHE yields the results of the activity as shown in Fig.2.

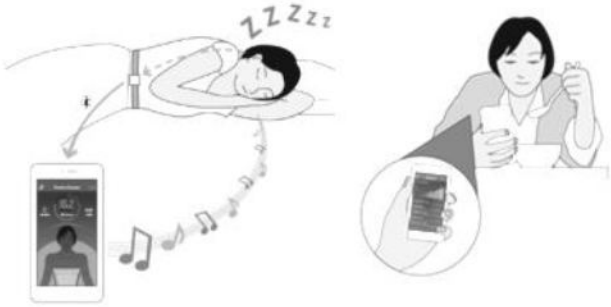

Fig.2. Resting state and track and review.

III. Proposed Method

The proposed method has overcome the existing method with additional features. The proposed sleep aid is SLEEP OFF. In order to induce sleep, a music which is slow, quiet and with minimal modulation is suitable than other music [1]. Thus the guiding tone along with the music helps improve the person's breathing patterns and induces sleep within 5 to 10 minutes.

In order to ensure effective breathing, a mode selector is also incorporated where the person can switch between slow, medium and fast mode according to the patient's requirements.

The parameters measured are SpO_2 level and heart rate. These parameters are useful in determining the level of apnea index in a person as sleep apnea leads to cardiovascular diseases.

A. Block diagram

This block diagram as shown in Fig.3.depicts the hardware and sensor units used in the device. It consists of a NodeMCU which is an open source platform for the IoT (Internet of Things) application and the driver unit for the SLEEPOFF device. All the sensors are connected to this one common unit from where all the data recorded is sent over the Wi-Fi segment to the web application for the patient to view the sleep reports.

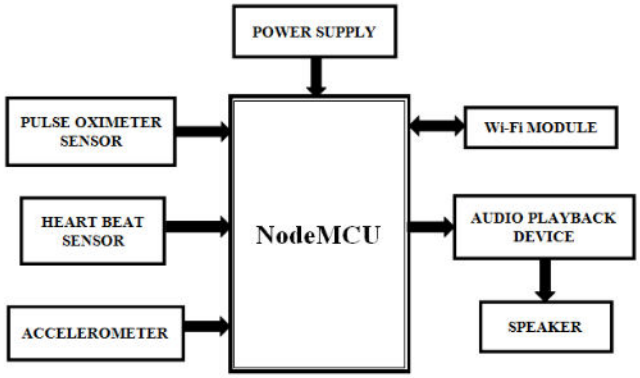

Fig.3. Block diagram of SLEEPOFF.

B. Hardware

Hardware components used for SLEEPOFF is explained. NodeMCU is an open source IoT based platform with a Wi-Fi chip. It has analog and digital pins. The data from all the sensors is acquired in analog from and is converted to digital form. These digital data are transferred to the web application through the Wi-Fi module.

The 3 axis accelerometer has extremely low noise and reduces power consumption. It senses the breathing patterns and tossing movements of the patients. It produces an analog output voltage which is transferred to the NodeMCU for further processing in the web application. SpO_2 sensor is used to measure the oxygen saturation level of blood.

It is based on the principle of the amount of infrared light absorbed by the blood. It is a low cost sensor.

The audio playback device is used for high quality recording with 11 minutes of audio playback. The playback device plays the slow music with the guiding tones based on the output obtained from the accelerometer. The speaker converts electrical signals from the audio playback device to sound waves with further amplification.

C. *Software*

The software architecture is developed in a webpage as shown in Fig.4. for allowing the user to view the sleep history. The user has a unique username and password to login to view the sleep records. Software tools used are PHP and HTML (Hypertext Markup Language).

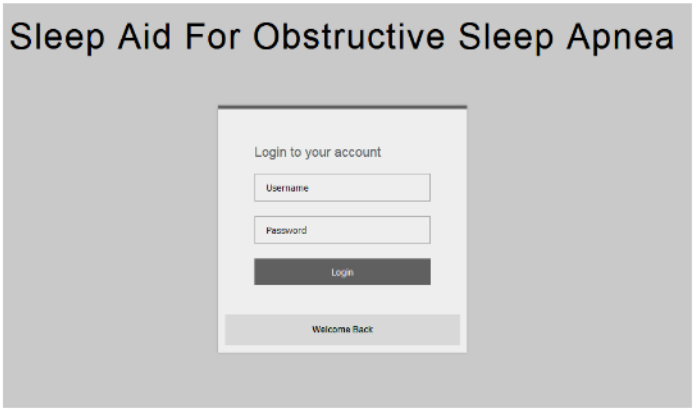

Fig.4. Webpage for user login.

PHP is an open source hypertext pre-processor which is used for web development by embedding it with HTML.

HTML is most widely used markup language for creating web pages and applications. Using an easy-to-use web portal, with a Wi-Fi module for transferring data through an IoT platform is user friendly.

1) *Database*

The database is used to record and store the patient's sleep history as shown in Fig.5. The database consists of the following:

Date and time details: Records the sleep induction time, date and sleep duration

Apnea details: It records and displays the SpO_2 level and heart rate. The data can be retained up to one week and new entries can be made further on.

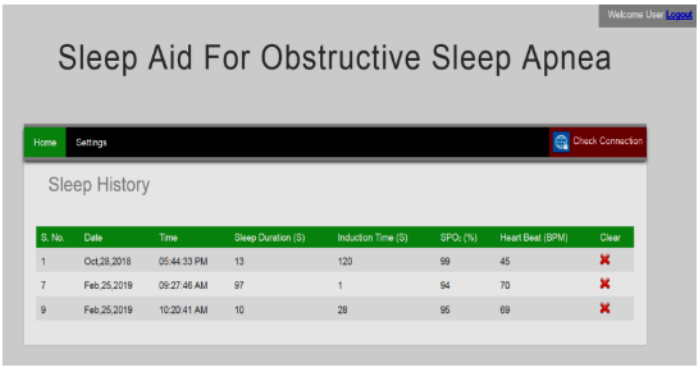

Fig.5. Sleep history

Mode selector:

The mode selector as shown in Fig.6.is used for setting the mode as slow, medium or fast as per the patient's requirements to induce sleep better.
This helps in better breathing patterns according to the mode chosen.

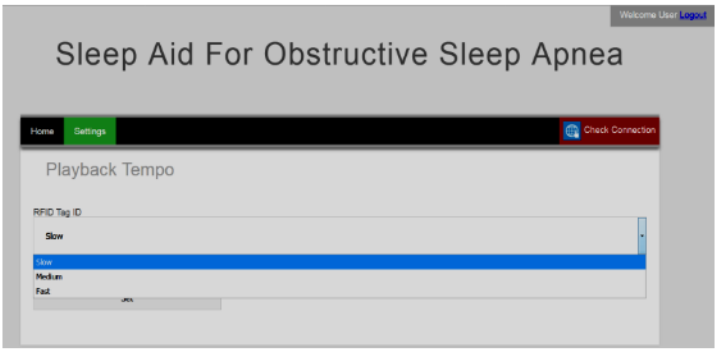

Fig.6. Mode selector

Communication with the server:

The body movements and breathing patterns are recorded and data is transferred to the server. The PHP programming language allows for easy use of web portal to connect to the server through Wi-Fi module across the IoT platform for processing of data. After processing, the results obtained are sent to the server and is simultaneously stored in the database and displayed on the webpage.

IV. Advantages And Limitations

The various advantages of using these devices include:

- In order to lead a healthy lifestyle, adequate sleep is necessary as it benefits heart and mind.
- The proposed sleep aid measures the

parameters such as SpO_2 level and heart rate during sleep.

- These devices are useful especially for women aged, 50 to 75 as their sleep patterns are disturbed due to illness.
- Sleep inducible devices help reduce stress levels and controls cholesterol and blood pressure.

The limitation imposed is that the continuously monitoring heart rate and SpO_2 sensors may yield gross values.

V. Conclusion

Obstructive sleep apnea disrupts an individual's breathing during sleep and it can lead to headaches, frustrations and drowsiness during daytime and also leads to cardiovascular diseases. OSA can be detected, diagnosed and cured eventually using sleep aids as they prove to be more effective than other methods.

The proposed device, SLEEPOFF is designed to ensure comfort and minimize sleep disruption. It captures the breathing patterns, heart rate, blood oxygen saturation level and monitors one's sleep. These additional features incorporated in SLEEPOFF makes it more easier for tracking sleep quality and to detect OSA, as blood oxygen saturation levels drop and heart rate increases when a person temporarily stops breathing during sleep.

a) *Future Scope*

The data recorded can be sent to the physicians and they can prescribe medications in the respective blog for each patient. The music played through the speaker can be modified by fitting earphones.

REFERNCES

[1] Trahan T, Durrant SJ, Müllensiefen D, Williamson VJ (2018) The music that helps people sleep and the reasons they believe it works: A mixed methods analysis of online survey reports. PLoS ONE 13(11): e0206531. https://doi.org/10.1371/journal.pone.0206531

[2] Sumukh S R, Dimpal kumara, Aishwarya M N and Priya S B, "Biomedical Sleep Inducer", *Int. J. Advanced Networking and Applications*, vol. 8, no. 4-2017, 2017.

[3] P. Benotti et al., "The impact of obstructive sleep apnea on nonalcoholic fatty liver disease in patients with severe obesity", Obesity, vol. 24, no. 4, pp. 871-877, 2016

[4] S. Alqassim and M. Ganesh, "Sleep Apnea Patients Monitoring Using Mobile Phone", *International Journal of Science and Research (IJSR)*, vol. 5, no. 1, pp. 1501-1504, 2016. Available: 10.21275/v5i1.nov153101.

[5] Z. Zhang et al., "Reduction in time-to-sleep through EEG based brain state detection and audio stimulation", *2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, 2015. Available: 10.1109/embc.2015.7320261.

[6] "Sleep Apnea Health Center"(2014) WebMD, Archived from the original-05-02.

[7] A. Muaremi, B. Arnrich and G. Tröster, "Towards Measuring Stress with Smartphones and Wearable Devices During Workday and Sleep", *BioNanoScience*, vol. 3, no. 2, pp. 172-183, 2013. Available: 10.1007/s12668-013-0089-2.

[8] De Backer, W "Obstructive sleep apnea/hypopnea syndrome"(June 2013), Panminervamedica.

[9] "Sleep Apnea: What Is Sleep Apnea?"(July 10, 2012), NHLBI: Health Information for the Public. U.S. Department of Health and Human Services.

[10] J. VAN MAANEN et al., "Evaluation of a new simple treatment for positional sleep apnoea patients", *Journal of Sleep Research*, vol. 21, no. 3, pp. 322-329, 2011. Available: 10.1111/j.1365-2869.2011.00974.x.

[11] Diagnosis and Treatment of Obstructive Sleep Apnea in Adults"(8 August 2011),AHRQ Effective Health Care Program.

[12] MacKay, Stuart "Treatments for snoring in adults"(June 2011), Australian Prescriber.

[13] "Sleep complaints: Whenever possible, avoid the use of sleeping pills."(2008),Prescrire Int., 17 (97): 206–12.

[14] Haentjens, P; Van Meerhaeghe, A; Moscariello, A; De Weerdt, S; Poppe, K; Dupont, A; Velkeniers, B "The impact of continuous positive airway pressure on blood pressure in patients with obstructive sleep apnea syndrome: evidence from a meta-analysis of placebo-controlled randomized trials"(23 April 2007),Archives of Internal Medicine.