ORIGINAL RESEARCH PAPER
Volume - 13 | Issue - 06 | June - 2024 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

UNIFORM RESPIRATION AND VARIED RESPIRATION RATE METHODS FOR BETTER BRAIN AND BODY HEALTH

Health Science

Sasipalli V.S. Rao Technical Director, Center for Excellence in Computer Technology, R&D Division of RAMTEJ Technologies Corporation, Hiroshima, Japan

Sasipalli Tejeswarsai Student, Department Mechanical Engineering, University of Memphis, TN, USA

ABSTRACT

Oxygenation to Brain and Body is naturally done by simple breathing, however, there are many situations both in healthy people and patients where oxygenation need to be regulated. Regulation of oxygenation is done in several methods; Pranayama yoga is one of the ancient methods. We propose to introduce a guided application for Uniform Respiration and Varied Respiration Rates making use of pulse width modulation (pmw) technique to regulate oxygenation. Using this application people can practice pranayama yoga or any method for respiration scientifically. Uniform Respiration provides equal respirations, which benefit to control body and mind condition. Varied Respiration Rates provides to increase chest capacity which accommodates more Oxygen supply to brain and body. A mobile application is developed implementing the proposed methods.

KEYWORDS

Oxygenation, Uniform Respiration, Varied Respiration Rate, PWM, Chest Expansion

INTRODUCTION

Our brain has a complex structure just like our other body parts, and it needs to be fed well too. Most and foremost thing to keep our brain healthy and hence body healthy is to get the best circulation of blood and enough quantity of Oxygen (O2) to the brain, but how? This is important because our blood carries Oxygen to our brain, and Oxygen is vital to brain growth and healing. Therefore, oxygenating the brain well is required to improve brain and body health.

About oxygenation:

Brain and Body health is as important as living. Respiration is key to increasing Oxygen in the brain [1]. We know that a good diet and exercise help keep our body fit. But what about our brain health and Oxygenation? How can we get proper quantities of Oxygen, Carbon-dioxide and Nitric-oxide into brain and body? What are the balancing elements that affect brain function and recoveries? Many questions exist about brain and body but less or varying answers reported so far.

Figure 1: Five Vital Signs of Body

Among the five vital signs ((1) Body temperature, (2) Heart rate, (3) Respiration Rate, (4) Blood pressure, and (5) Oxygen saturation), we cannot directly control all the vital signs except Respiration Rate, which in turn controls the other 4 signs. Respiration Rate and Lung capacity define how much Oxygen can be taken in a certain time, say in one minute. Lung Capacity can be increased by Chest Expansion (CE), which can be achieved by controlling Respiration Rate. There is a strong correlation between Lung Capacity and Chest Expansion [2]. Therefore, intake Oxygen can be increased or controlled by controlling Respiration Rate.

But how to control Respiration Rate and intake Oxygen to the fullest need of a human body and brain? Some facts about brain usage of Oxygen:

- Brain uses about three times as much Oxygen as muscles in the body do
- Brain cells are very sensitive to decrease in Oxygen levels and don't survive or function well very long without Oxygen.
- Normal human brain consumes 3.5ml of O2 per 100g of brain tissue per minute, a value which remains constant throughout periods of wakefulness and sleep. The average man weighs 70kg and consumes ~250ml of O2 per minute in the resting state. With the average human brain weighing 1400g (~2% of total body weight), and it consumes ~49ml O2 per minute, or 20% of total body Oxygen consumed while at rest [3].

Oxygen directly fuels 90% of all Brain and Body functions. Average Oxygen level in air is 21%.

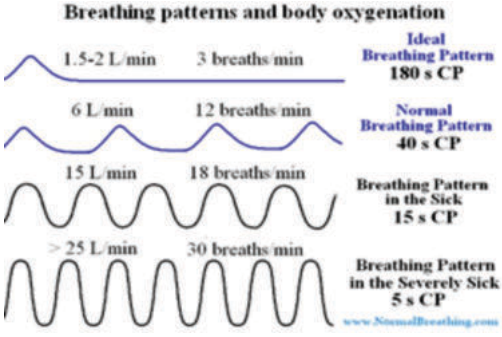

Figure 2: Breathing Patterns and Body Oxygenation
Sources: www.NormalBreathing.com

Respiration provides a dynamic pathway for modulating cerebral oxygenation [4]. More and proper breath /respiration methods can provide uniform and sufficient Oxygen to brain and body. But how to get proper amounts of Oxygen uniformly and how the lung capacities play an important role to quantify oxygenation.

Chest Expansion and Lung Capacity:

Lung volume or respiratory volume refers to the volume of air in the lungs at a given time during the respiratory cycle. Lung capacities are derived from a summation of different lung volumes. The average total lung capacity of an adult human male is about 6 liters of air. Lung volumes measurement is an integral part of pulmonary function test. These volumes tend to vary, depending on the depth of respiration, ethnicity, gender, age, body composition and certain respiratory diseases [5]. Lung volumes can be measured by Spirometry- Tidal volume, Inspiratory reserve volume, and Expiratory reserve volume. Out of all these volume measurements, Tidal Volume (TV) (the amount of air that can be inhaled or exhaled during one respiratory cycle [4]) is our main consideration.

This depicts the functions of the respiratory centers, respiratory muscles and the mechanics of the lung and chest wall [5]. For normal adults, the value is approximately 300-500ml (6.8 ml/kg) [5] but can increase up to 50% on exercise [6]. Intake of Oxygen is done through

natural breathing process without thought, however, regulating Oxygen supply needs a certain practice. Pranayama is one such practice.

Breathing Practice:

All breathing animals including humans, breathe arbitrarily and unknowingly through noses, mouth closed, and with what is called belly breathing, or diaphragmatic breathing. Only the practitioners follow some techniques. Pranayama provides many techniques in breathing practice, however, practicing Uniform Respiration, and Varying Respiration Rates let more flexibility to the practitioners, but need a guided application. According to Hatha Yoga Pradipika, there are nine classical pranayamas, they are: 1) Sitkari Pranayama, 2) Sitali Pranayama, 3) Brahmari Pranayama, 4) Bhastrika Pranayama, 5) Murccha Pranayama, 6) Surya Bhedana Pranayama, 7) Ujjayi Pranayama, 8) Kapala Bhati Pranayama, 9) Nadi Sodhana Pranayama. None of these methods utilize guided devices for uniform respiration or varied respiration rates.

Oxygenating the brain happens naturally through Breathing. Critical balance of correct breathing for proper oxygenation and brain activities or exercises for growth stimulation are required [7]. When we breathe normally through nose and deeply into our belly, we move air and Oxygen down to areas of our lungs where most of the circulation of blood occurs. This is where most Oxygen and carbon-dioxide exchange take place. If we don't learn to breathe naturally with our diaphragm muscle, we do not get the proper amount of Oxygen into our blood to be carried to the brain and body parts. The only way to get more Oxygen to the brain would be to get more blood to the brain by increasing blood flow. Researchers reported that "The oxygenation persisted when neural activity and functional hyperemia (blood flow increases) were blocked, occurred both in the tissue and in arteries feeding the brain, and were tightly correlated with respiration rate and the phase of respiration cycle" [8]. But how to control breathing for balanced gases in-hale and out-hale?

Proposed Techniques And Methods:

Aim of this research is to offer a means to increase oxygenation to brain and body in two methods: (1) Uniform Respiration and (2) Varied Respiration Rates when practicing breath exercises including pranayama, as described the necessity in Introduction part. To realize (1) and (2) we implement PWM technique and control it through software.

PWM Technique

Pulse width modulation (pwm) is a technique used to control the speeds in motors by varying its duty cycles. A duty cycle or power cycle is the fraction of one period in which a signal or system is active. Duty cycle is commonly expressed as a percentage or a ratio. A period is the time it takes for a signal to complete an on-and-off cycle.

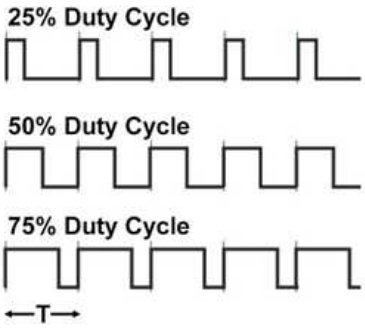

Figure 3: Duty Cycles in PWM

As a formula, a duty cycle (%) may be expressed as:
D = (PW/T) *100%, where D is duty cycle, PW is pulse width (pulse active time), T is total period of signal. Thus a 60% duty cycle means the signal is ON 60% of the time and OFF 40% of the time.

We wrote software to control the duty cycle. This duty cycle ON/Off is mapped with the light glowing on/off and not sudden on/off but smooth fading (fade-in / fade-out) of light, which can be followed: fade-in for inhale and fade-out for exhale. This phenomenon guides practitioners to follow the glowing light during breath practice.

Uniform Respiration (UR)

Uniform Respiration also known as equal breathing (sama vritti in Sanskrit) is a breathing technique in which inhale is equal to exhale. We made the duty-cycles on/off times equal in PWM to achieve uniformity in fade-in and fade-out. When practicing uniform respiration, one can follow this equal inhalation / exhalation following fade-in / fade-out of light to correctly practice uniform respiration.

Varied Respiration Rate (VRR)

Varied Respiration Rate is a technique in which practitioner selects the number of respirations per minute. The glowing light acts at the speed that is matched with the selected respiration rate by the practitioner. The span of respiration changes with this selection, which helps to practice slow or fast respiration. In slow respiration, it takes longer time to complete one cycle of inhalation and exhalation, which in turn helps increase chest expansion and in turn helps to accommodate more Oxygen. This speed selection / control is done in software to manipulate the duty cycle speeds.

General Respiration Rates for healthy humans per minute by age group are shown in below table.

Table – 1 General Respiration Rates

Birth – 1 year	1 – 3 years	3 – 6 years	6 – 12 years	12 – 18 years	After 18 years
30 - 60	24 - 40	22 - 34	18 - 30	12 - 16	12 - 20

Chest Expansion with VRR

Chest expansion (CE) can be practices by breathing naturally. In males and females, Chest Expansion is observed as follows [6], the CE value seems nearly constant for the age group 18-64 [6]. Let us consider the 18-64 age group. A 3.57 – 3.74 cm of chest expansion can be observed.

Table – 2 Chest Expansion Measurements

Age (Years)	Male Mean CE (cm)	Female Mean CE (cm)
18-34	3.72	3.74
35-64	3.66	3.57
65 and above	2.66	2.63

Any lung or pleural disease can give rise to a decrease in overall chest expansion. It is typically low in patients with COPD. Chronic obstructive pulmonary disease, or COPD, refers to a group of diseases that cause airflow blockage and breathing-related problems. These patients have a very high FRC and have limited capability to expand the chest from this position [5]. Functional residual capacity (FRC) is the volume of air left in your lungs after a normal, passive exhalation. Our VRR technique helps practitioners to solve such of these respiration problems slowly by selecting varied respiration rates. VC = Lung Vital Capacity which is referred to as CE. VC is calculated as per the below formula separately for Males and Females [4].

VC (male, in l) = 10^−3 × (27.63 − (0.112 × age)) × height (cm) (1)
VC (female, in l) = 10^−3 × (21.78 − (0.101 × age)) × height (cm) (2)
Example:
Male 60 years, height 174 cm,
VC = 10^−3 × (27.63 − (0.112 × age)) × height (cm)
= 10^−3 × (27.63 − (0.112 × 60)) × 174 = 3.64

Researchers can collect VC / CE data by utilizing our application for further insight. The data collection can be for each VRR and calculate CE values. Reversely, required CE can be set and find the coefficients 27.63, 0.112 for males and 21.78, 0.101 for females from the above equations.

Mobile Application Development

Guiding devices can help in properly doing the exercises. Incorporating Uniform Respiration and Varied Respiration Rates in breathing practice a guiding device is essential. The guiding device / application that we created is used for both Uniform Respiration and Varied Respiration Rates.

While in breathing practice, it is always advantageous to concentrate on or follow something. That something can be our proposed application or device. In the application, light is set emitted in uniform tides, fade-in, and fade-out. The time for fade-in / fade-out is linked to respiration rate per minute can be adjusted based on practitioner

capability by selecting respiration rate. Since most people now-a-days use mobiles, it is highly recommended to have an application as a guiding device.

Features Of The Mobile Application

As shown in Figures 4-8, the application contains (1) Glowing light, (2) Respiration Rate selection, (3) Stop / Reset switches (4) Mantra on/off selection. The application is powered on and off and with a preset mantra selection associated with each respiration rate selection. respiration rate (number of respirations per minute) can be selected, it means Fade-in / Fade-out interval time can be selected. Practitioners can follow the glowing light emission pattern and do breathing exercise accordingly. We have considered the respiration rates between 10 to 20 per minute as recommended the best range for normal individuals [9].

Operation Of The Application

On initiating the mobile application, a startup screen is displayed for a few seconds. Then automatically taken to the next screen where the features of the application are displayed. To start practicing the breath exercise, press "Start" button, which takes to next screen where practitioner can select Mantra audio on/off and Respiration rate. Upon selecting Respiration rate the light starts glowing (fade-in / fade-out) slowly and uniformly. The glowing (fade-in / fade-out) speed is controlled by the VRR selection. Number of minutes practiced is also displayed. To stop the application press "Stop" button. This resets the selection on the screen. The application information is summarized in "i-icon" and option to share the application is provided in "share-icon". The application is offered only in Android phones, similar can be developed for iPhone also, and is under development.

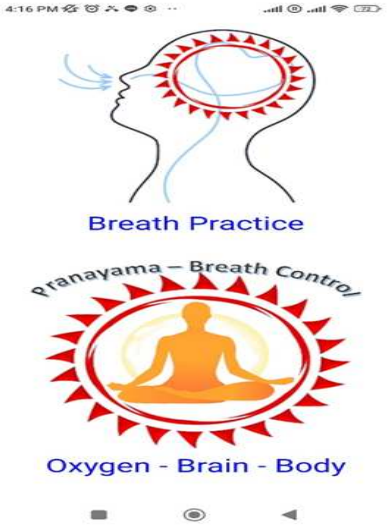

Figure 4: App Startup Screen.

Figure 5: Application Features Screen

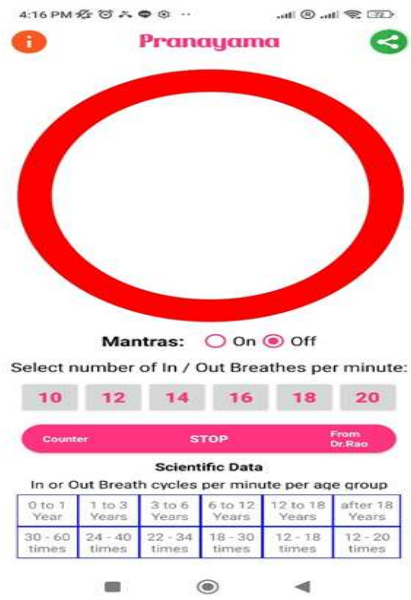

Figure 6: Mantra Audio Selection Screen

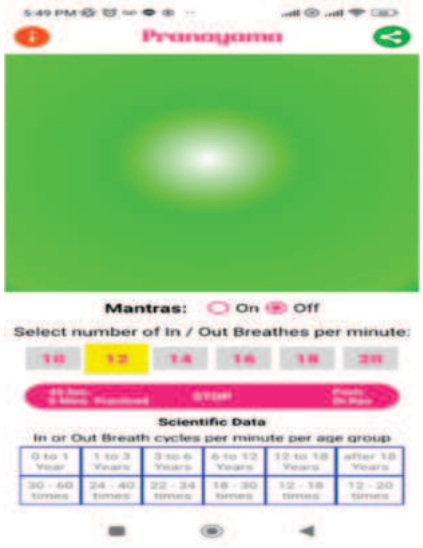

Figure 7: Respiration Rate Selection - Light Fade-In Screen

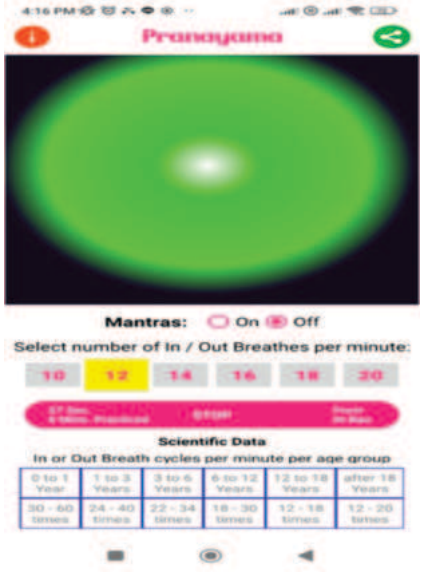

Figure 8: Respiration Rate Selection – Light Fade-Out Screen

Advatages Of This Mobile Application

Practicing "Uniform Respiration" and "Varied Respiration Rate", methods help regulate oxygenation and provide several health benefits, some of which are;

Cognitive function: Both slow and fast kinds of respiration can help improve your cognitive functions. Studies show that fast pranayama in particular can help to improve auditory and sensory-motor skills.

Increase Lung capacity: Practicing varied respiration can help improve lung capacity and function. This includes helping you hold your breath longer and increasing strength in your respiratory muscles.

Mindfulness: Much like the more popular forms of pranayama yoga, longer breathes can increase mindfulness.

Stress and emotional regulation, Anxiety, Reduced hypertension, Psychosomatic disorders, and more are described as Improves Brain Function, Lowers High Blood Pressure, help clear Sinus Congestion, Improves Digestion, Boosts Immune System, Helps in Weight Loss, Helps in Stress Relieving, Helps get Glowing Skin, Promotes Better Sleep, more advantages of Uniform Respiration and Varied Respiration Rates can be listed.

CONCLUSIONS

Uniform Respiration and Varied Respiration Rate the two guided methods are presented and the way to practice them using Mobile application is also presented in this paper. Though breathing is quite natural and thoughtless, practicing it in different ways of Pranayama has been in existence since long, but Uniform Respiration was not quite adequately practiced. Also, chest expansion practice to accommodate more Oxygen for proper oxygenation to brain and body was also not adequately practiced. Our techniques and methods offered in mobile application can solve these problems and help practitioners as a guided device / application in their practice.

Patients can benefit equally by utilizing this application as a guided device and practice breathing to cure their respiration problems. Researchers can further find coefficients in the CE equations for a preset CE value, by collecting data from practitioners.

REFERENCES:

[1] A'ndrea Elyse Messer; December 4, 2019; "Respiration Key to Increase Oxygen in the Brain" https://www.psu.edu/news/research/story/respiration-key-increase-oxygen-brain/; Source: Penn State Neuroscience Institute.
[2] "Correlation between Vital Capacity and Maximum Chest Expansion among Nepalese Young Adults", Journal of Kantipur Dental College, Research Gate Article, Vol. 1 No.1 Issue 1, Jan-Jun 2020;
[3] Cameron Rink and Savita Khanna, Antioxidants & Redox Signaling, 2011 May 15; 14(10): 1889–1903, "Significance of Brain Tissue Oxygenation and the Arachidonic Acid Cascade in Stroke", https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3078506/
[4] National Laboratory of Medicine (National Center for Biotechnology Information), Published online 2014 Dec 9. doi: 10.2147/PPA.S72575, "Lung vital capacity and oxygen saturation in adults with cerebral palsy", https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4267512/
[5] Chest Expansion https://www.meddean.luc.edu/lumen/meded/ medicine/ pulmonar/pd/chest.htm
[6] Ahmed Hasan Reheem et. al., International Journal of Physiology, "Reference Range of Chest Expansion in Healthy Adult Living in al-Muthanna Governorate", https://ijop.net/index.php/mlu/article/download/2062/1822/3961
[7] Brain Needs Oxygen – What Can I Do, Steve Riggs, BS, RRT-NPS, https://www.nacd.org/my-brain-needs-oxygen-what-can-i-do/
[8] "To Get More Oxygen to the Brain, Just Breathe", December 4, 2019, Nature Communications Original story from Penn State University
[9] Sheldon R. Braun, Chapter 43 "Respiratory Rate and Pattern", Clinical Methods: The History, Physical, and Laboratory Examinations. 3rd edition, 1990, https://www.ncbi.nlm.nih.gov/books/NBK365/