International Journal of Engineering Trends and Technology
ISSN: 2231 – 5381 /doi:10.14445/22315381/IJETT-V69I2P215

Volume 69 Issue 2, 107-111, February 2021

A Study On Vocal Breathing To Improve Activity Blood Oxygen Saturation When Wearing A Mask

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Abstract *—At present, because of the COVID-19 epidemic, wearing masks has become routine. People work and live while wearing masks. Masks isolate the virus but also hinder people's breathing. Wearing masks for long-term activities will have negative effects, and the most direct effect is the decrease in oxygen content in the body. These negative effects are common in people who engage in high oxygen consumption activities. Such as workers and medical staff working on the front line. They often suffer from shortness of breath, headaches, and fatigue when wearing masks for a long time. This paper proposes three vocal breathing modes to solve decreased blood oxygen saturation when wearing a mask. Furthermore, sitting, walking, running simulate people's life and work. Namely office work, attendance, and sports. This paper aims to study improving blood oxygen saturation of three vocal breathing patterns under different activity states. A pulse oximeter measures the blood oxygen saturation. The results showed that in the sitting state, the three vocal breathing modes had the same effect on improving blood oxygen. When walking, the "U~" vocal breathing pattern is better. The normal breathing mode and "Voo~" vocal breathing mode are recommended in the running state.*

Keywords — *COVID-19, mask, vocal breathing pattern, hypoxia, blood oxygen saturation, a pulse oximeter.*

I. INTRODUCTION

One year has passed since the COVID-19 outbreak, and it may continue for a long time. Before the widespread vaccination, most people worked and lived under masks. Many people recognize the role of masks in epidemic prevention. Much science has also confirmed this. However, the negative effects of wearing masks for a long time cannot be ignored. The main negative effects are headaches and increased psychological stress caused by hypoxia. This effect is pronounced under high oxygen consumption activities. This is all due to the mask's uncomfortable reaction to the mild hypoxia caused by the respiratory obstruction. Therefore, it is necessary to improve the oxygen content in the body when wearing a mask. It can reduce the negative effects of masks. Although direct improvements to masks can fundamentally solve the problem, the manufacturing cost and time cost are too high. Therefore, from the perspective of masks, changing the breathing pattern can help people get more oxygen and improve the oxygen level in the body. [1]

Sori Sound Lab has proposed three new vocal breathing models. The advantages of the vocal breathing mode are explained in principle. The blood oxygen saturation is used as a physiological parameter to detect the oxygen level in the body. In previous studies [2-4], the effect of these three vocal breathing modes on blood oxygen improvement when wearing a mask has been confirmed.

This paper aims to compare the blood oxygen improvement effects of these three kinds of vocal breathing in different activity states and select the vocal breathing mode with the best improvement effect. Chapter 2 introduces three vocal breathing modes. In chapter 3 explains in detail the principle of vocal breathing mode to improve breathing efficiency. Chapter 4 introduces the detection principle of blood oxygen saturation and pulse oximeter. In chapter 5, the Blood oxygen saturation test and analysis of the results. In chapter 6, Conclusion.

II. VOCAL BREATHING PATTERN

The vocal breathing mode increases the breathing cycle and requires vocalization when exhaling. The normal breathing rate is 16-20 breaths per minute. The frequency of deep breathing is 5-6 times. The vocal breathing rate is 7 to 8 times, which is somewhere in between. Vocal breathing requires 4 seconds to inhale, hold for 1 second, and exhale for 4 seconds. This paper proposes three vocal breathing modes. That is, "Voo~" vocal breathing, "Umm~" vocal breathing, and "U~" vocal breathing. "Umm~" vocal breathing means closing the mouth when exhale, and air flows out of the nasal cavity, causing the nasal cavity to resonate and make an "Umm" sound. "Voo~" vocal breathing is the vibrating vocal cords; slightly close lips, raise tongue, and make a "Voo~" sound. Vibrate the vocal cords and slightly open lips. Air squeezed out of his lips, making a "U~" sound. They all need to vibrate the vocal cords, but they produce different sounds after modulation of mouth shape, tongue position, and nasal cavity. Vocal breathing does not replace normal breathing and improves blood oxygen saturation, so it is recommended to use a mask for three minutes every hour or every half an hour and a minute. When wearing a mask for a long time feels headache and fatigue, people can also use vocal breathing to relieve symptoms. [2-4]

III. VOCAL BREATHING MODE IMPROVES BREATHING EFFICIENCY

The most significant feature of the vocal breathing mode is the vocalization when breathing. Moreover, the breathing cycle is longer than normal. So, it has two advantages. First, the vocal breathing mode requires vocal cords to vibrate, which will cause resonance in the oral cavity, nasal cavity, trachea, lungs, and other organs. The trachea's resonance can remove foreign objects in the trachea, reduce airway resistance, and enhance ventilation. The resonance of the lungs can activate lung function. The resonance of the oral cavity and nasal cavity increases the high-frequency energy of sound waves. Especially in winter, the hot air exhaled from the lungs meets the cold mask's inner wall. It condenses into water droplets attached to the surface, which weakens the gas diffusion ability. However, high-frequency sound waves can cause a certain amount of attached water droplets to slip off, reducing the mask's breathing. resistance. [5]

Second, the vocal breathing pattern has a longer breathing cycle. Longer inhalation cycles can inhale large amounts of oxygen. The pause time in the middle can ensure sufficient gas exchange in the lungs. The vibration and sound during exhalation can also make the air molecules vibrate, the molecular movement is accelerated, and the gas flow rate is accelerated. The permeability of air increases. [6]

IV. PRINCIPLES OF BLOOD OXYGEN SATURATION AND PULSE OXIMETRY

Blood oxygen saturation is an index for detecting oxygen content in the body. It refers to the percentage of the volume of oxygenated hemoglobin (HbO2) bound by oxygen in the blood to the total volume of hemoglobin (Hb) that can be bound, that is, the concentration of blood oxygen in the blood, which is an essential physiological parameter of the respiratory cycle. Therefore, monitoring arterial oxygen saturation (SpO2) can estimate the lungs' oxygenation and the ability of hemoglobin to carry oxygen. The arterial blood oxygen saturation of a normal average body is 95% to 99%. Less than 95% is mean that a state of insufficient oxygen supply.[7]

Pulse oximeters provide a non-invasive way to measure blood oxygen saturation or arterial hemoglobin saturation. It uses the principle of the change in light absorption during arterial pulsation. Two light sources of visible red light (660 ns) and infrared spectrum (940 ns) to illuminate the tested area (fingertips) alternately. The relative light absorption is measured multiple times per second and then processed by the machine to give a new reading every 0.5-1 second to average the last three seconds' readings. The amount of light absorbed by blood oxygen is related to the oxygen content in the blood. Because oxidized hemoglobin absorbs more infrared light and allows more red light to pass through. Deoxyhemoglobin is the opposite. In other words, at high oxygen saturation, infrared light absorption is more than red light absorption. At low oxygen saturation, infrared light absorption is less than red light absorption. So, it is necessary to measure their respective transmittance and calculate the ratio. Then map the ratio value to the blood oxygen saturation. Therefore, the blood oxygen saturation can be obtained by comparing the result with the saturation numerical table. [8] Figure 1 is the absorption spectrum of hemoglobin. [9]

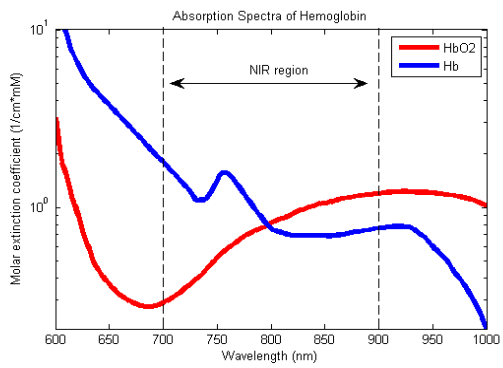

Fig. 1 Absorption spectrum of hemoglobin (license: CC BY-SA 3.0) [9]

The calculation of light transmittance can be obtained by Beer-Lambert law,

$$A = \ln \frac{I_o}{I}$$

Here A is the absorbance. “I” is the intensity of transmitted light. Io is the original intensity of light.

Then use this law to calculate the transmittance of red light A_r and the transmittance of infrared light A_{Ir}, and calculate their ratio R. [10]

$$R = \frac{A_r}{A_{Ir}}$$

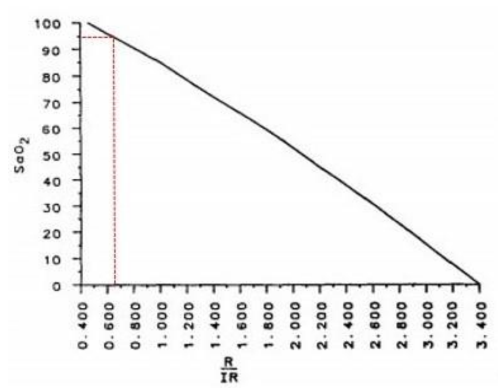

Fig. 2 the relationship between red/infrared ratio and oxygen saturation, as a typical calibration curve of pulse oximeter [11]

Finally, compare the ratio to the experience table to obtain SpO2. An R ratio of 0.5 is about 100% SpO2, 1.0 is about 82% SpO2, and a ratio of 2.0 is 0% SpO2. Therefore, the R ratio of a normal person is between 0.5 and 0.7. Figure 2, A ratio calibration curve of red light and infrared light transmittance. [11]

V. EXPERIMENTS AND RESULTS

Twelve testers participated in the experiment. Most of them are college students in their 20s and have no history of respiratory diseases. The experimental equipment includes a KF94 mask and pulse oximeter. The experiment is divided into three parts: sitting state, walking state, and running state. Measure the blood oxygen saturation of normal breathing mode and vocal breathing mode when wearing a mask under three different activity states. The blood oxygen saturation measurement starts 5 minutes after wearing the mouth in a certain state. The duration of each experiment is 3 minutes, and the interval between experiments is 5 minutes. The experimental sites are sports fields and conference rooms. [12]

Figure 3, Figure 4, and Figure 5 show the blood oxygen saturation curve between the normal breathing mode and the "U~" vocal breathing mode in the three active states. In the sitting state, the normal breathing pattern's blood oxygen saturation is significantly reduced, but the overall level is stable. The blood oxygen saturation of the vocal breathing pattern has been maintained at 98% without fluctuation. When walking, the oxygen consumption is higher than sitting. The blood oxygen saturation of the normal breathing pattern also drops, and the fluctuation is very rapid, and the average is about 96%.

Similarly, the blood oxygen saturation of the vocal breathing pattern remained stable at 98%. Comparing the two breathing modes will find that the blood oxygen saturation curve is almost the same in the running state. The average of the two of them is the same. The saturation curve of normal breathing fluctuates at a high frequency, and the fluctuation deviation is small. On the contrary, the vocal breathing pattern has a low fluctuation frequency, but the fluctuation deviation is large. When people consume much oxygen when running, the body feels a lack of oxygen will quickly and autonomously increase the breathing rate and heart rate to ensure sufficient oxygen. Currently, the breathing efficiency of the normal breathing mode is the same as that of the vocal breathing mode. The high frequency of fluctuations also reflects the advantage of self-regulation. People's breathing patterns can change with the oxygen consumption in the body. However, spontaneous breathing regulation does not seem to occur during sitting and walking, so the vocal breathing mode is more advantageous in sitting and walking.

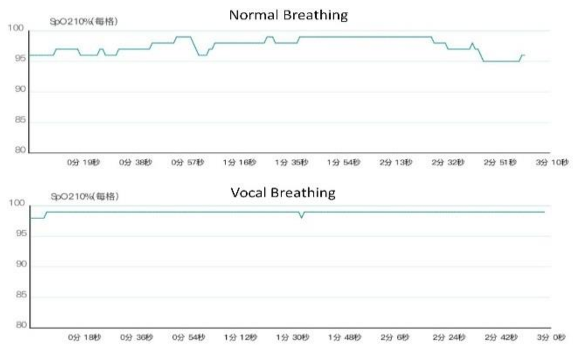

Fig. 3 While sitting with a mask, the blood oxygen saturation curve of a test person's normal breathing and the blood oxygen saturation curve of the "Bu~ vocal breathing mode" (x-axis is time (NN minutes NN seconds), Y-axis is SpO2 (%))

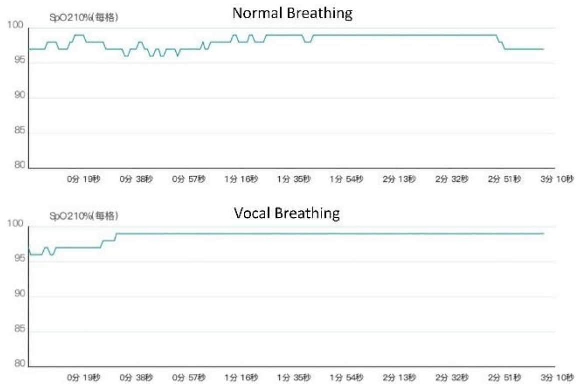

Fig. 4 While walking with a mask, the blood oxygen saturation curve of a tester's normal breathing and the blood oxygen saturation curve of the "Bu~ vocal breathing mode" (x-axis is time (NN minutes NN seconds), Y-axis is SpO2 (%))

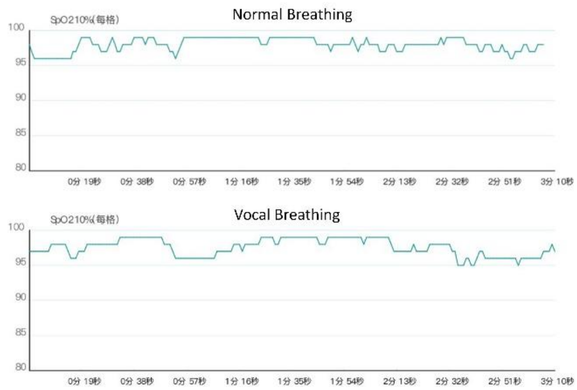

Fig. 5 While running wearing a mask, the blood oxygen saturation curve of a tester's normal breathing and the blood oxygen saturation curve of "Bu~ vocal breathing mode" (x-axis is time (NN minutes NN seconds), Y-axis is SpO2 (%))

Averages 12 testers' data to obtain the average blood oxygen saturation value of different breathing patterns under three active states, as shown in Table 1. In the three active states, the average of normal breathing is about 95%, which means that wearing a mask reduces the blood oxygen saturation to a critical value, but there is no severe oxygen shortage. In sitting and walking activities, the vocal breathing pattern increases blood oxygen by about 2%, and blood oxygen saturation is significantly improved. But in the running state, "Voo~" vocal breathing mode increases blood oxygen and blood oxygen saturation by 1%. The "Umm~" vocal breathing mode reduces blood oxygen saturation by 1% because it exhales through the nose. The vocal breathing pattern does not significantly improve blood oxygen saturation in the running

TABLE I. AVERAGE BLOOD OXYGEN SATURATION MEASUREMENT RESULT

	Normal breathing pattern	Part 1		Part 2		Part 3	
		"Voo~" vocal breathing pattern	$\Delta SpO2$	"U~" vocal breathing pattern	$\Delta SpO2$	"Umm~" vocal breathing pattern	$\Delta SpO2$
Sitting	96	98	2	98	2	98	2
Walking	95	97	2	98	3	97	2
Running	95	96	1	95	0	94	-1

Conducted a respiratory comfort survey on all testers. The comfort level is divided into 5. Levels 1 to 5 are: terrible, uncomfortable, general, comfortable, and great. Table Ⅱ is the results of the mos-test of breathing comfort.

It can be found from the table that all breathing patterns are very uncomfortable when running, so it is not recommended to wear a mask to exercise. For meditation and meditation, the normal breathing pattern is uncomfortable. The comfort of vocal breathing is one level higher than normal breathing mode, which is normal.

TABLE II. MOS-TEST OF BREATHING COMFORT

	Sitting	Walking	Running
Normal breathing pattern	2	2	1
"Voo~" vocal breathing pattern	3	3	2
"U~" vocal breathing pattern	3	3	2
"Umm~" vocal breathing pattern	3	2	1

Combining the results of the blood oxygen saturation test and respiratory comfort mos-test results, a recommendation table for the effect of breathing patterns on improving blood oxygen saturation under different activity states is summarized. "○" means a recommendation. For the sitting state, the three vocal breathing patterns have the same improvement effect. For walking, the "U~" vocal breathing mode is better. For the running state, normal spontaneous breathing regulation can maintain normal blood oxygen saturation.

TABLE III. RECOMMENDED BREATHING PATTERNS FOR DIFFERENT ACTIVITY STATES

	Sitting	Walking	Running
Normal breathing pattern			○
"Voo~" vocal breathing pattern	○		○
"U~" vocal breathing pattern	○	○	
"Umm~" vocal breathing pattern	○		

VI. CONCLUSION

It has been proven that wearing a mask can effectively block the spread of the virus. However, most people ignore the negative effects of masks. To reduce the impact of wearing masks on people's health. The sori sound laboratory has proposed three vocal breathing modes to improve the mild hypoxia caused by wearing a mask [2-4]. In this paper, three vocal breathing patterns are applied to three different activity states to compare the improvement effects of their blood oxygen saturation.

The experiment results show that the three vocal breathing modes can significantly improve blood oxygen saturation in the sitting and walking states. They can increase by about 2%. However, the effect of improving blood oxygen saturation in a running state is insufficient. In the sitting state, the three vocal breathing modes have the same effect. When walking, the "U~" vocal breathing pattern is better. The normal breathing mode and "Voo~" vocal breathing mode are recommended in the running state. Respiratory comfort Mos-test results show that the comfort of vocal breathing mode is higher than normal breathing in most cases. Therefore, it is recommended that using a one-minute vocal breathing pattern every half an hour to improve people's body's blood oxygen levels. Try to avoid strenuous exercise when wearing a mask.

REFERENCES

[1] Katharina Buchholz, (2020) Asians Still Most Likely to Wear Face Masks Due to COVID-19. [Online]. Available: https://www.statista.com/chart/21452/share-of-people-wearing-face-masks-per-country-covid-19

[2] Zhixing Tian, Myung-Jin Bae, "On a long breathing method to improve blood oxygen saturation when wearing a mask," SSRG International Journal of Engineering Trends and Technology, Volume 68, Issue 12, December 2020, Pages 87-90.

[3] Zhixing Tian, Myung-Jin Bae, "'Bu' vocal breathing method to improve blood oxygen saturation when wearing a mask," SSRG International Journal of Engineering Trends and Technology, Volume 68, Issue 10, 1 October 2020, Pages 33-36

[4] Zhixing Tian, Bong-Young Kim, and Myung-Jin Bae, "A study on healthy breathing pattern when wearing a mask," International Journal of Engineering Research and Technology, Volume 13, Issue 7, 2020, Pages 1562-1566

[5] IK-Soc and Myung-Jin. "study on a new sound necklace for a body fitness," International Information Institute Ltd (Japan), v.19, no.9A, pp.3737 – 3743(2018)

[6] Bong-Young Kim, Ik-Soo Ahn, and Myung-Jin Bae. “A Study on Lung Function Activation of Sound Necklace,” Journal of Engineering and Applied Sciences, Volume 13, Issue 3, 2018.

[7] Kirkby, J.; et al. (2010). "Reference equations for specific airway resistance in children: The Asthma UK initiative." European Respiratory Journal. 36 (3): 622–629.

[8] (2020) Oxygen saturation. Wikipedia. [Online]. Available: https://en.wikipedia.org/wiki/Oxygen_saturation_(medicine)#cite_note-9

[9] (2004) Principles of pulse oximetry. Anaesthesia UK. [Online]. Available: https://web.archive.org/web/20150224221820/http://www.frca.co.uk/article.aspx?articleid=332

[10] (2021) Pulse oximetry. Wikipedia. Adrian Curtin. [Online]. Available: https://en.wikipedia.org/wiki/Pulse_oximetry#Indication

[11] (2002) Pulse Oximetry. Oximetry.org. [Online]. Available: https://web.archive.org/web/20150318054934/http://www.oximetry.org/pulseox/principles.htm

[12] James E Sinex, Pulse oximetry: Principles and limitations, “The American Journal of Emergency Medicine,” Volume 17, Issue 1, 1999, Pages 59-66.

[13] Zhixing Tian, Seong-Geon Bae, and Myung-Jin Bae,” On the Effect of Everyday Stress by Repeated Vocalization of ‘voo~,’” Seventh Sense Research Group, IJETT, Vol.68, Issue9, No.1, pp.162-166, Sept. 2020.