

"Bu~" vocal breathing method to improve blood oxygen saturation when wearing a mask

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Abstract — Recently, the hypoxia problem caused by wearing a mask has received more attention. This paper proposes a new solution to solve this problem. That is, changing the breathing pattern. This paper proves that the new breathing mode can increase air intake and activate lung function so that it can exchange air to a greater extent and obtain more oxygen. Then use blood oxygen saturation as an evaluation index of the level of oxygen content in the body to prove its effectiveness. The photoelectric pulse oximeter, which was developed based on the principle of different light absorption by blood, was used to test blood oxygen saturation. The experimental results not only confirm that wearing a mask under high oxygen consumption will cause certain hypoxia but also demonstrate that the new breathing mode can increase the blood oxygen saturation in the body and improve the hypoxia in the body. "Bu" vocal breathing method is a simple and effective breathing method.

Keywords — Blood Oxygen Saturation, Mask, Pulse Oximeter, "Bu~" Vocal Breathing Method, lung, COVID-19.

I. INTRODUCTION

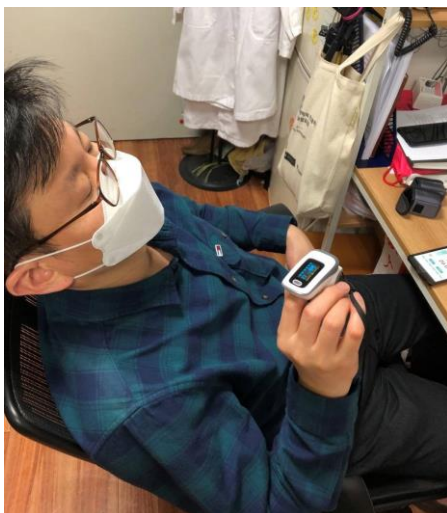


Fig. 1 Sitting quietly oxygen saturation test with a mask

Blood Oxygen Saturation refers to the percentage of a person's oxygen-loaded red blood cells to the total hemoglobin. It indicates the ratio of reduced oxygen hemoglobin combined with oxygen to form oxygenated

hemoglobin. Red blood oxygen is transported by red blood cells to body organs such as the brain and heart. The proper functioning of the body's organs requires adequate oxygen as a prerequisite. The calculation function of blood oxygen saturation is $SpO_2 = \frac{HbO_2}{HbO_2 + Hb}$. where HbO_2 is oxygenated haemoglobin (oxyhemoglobin) and Hb is deoxygenated haemoglobin. Hypoxemia is hypoxia. There are some common symptoms. Such as dizziness and sleepiness, cannot lift the energy when doing things, and easy to get angry. Long-term lack of oxygen in the blood will cause the cerebral cortex to suffer the most direct damage. It will occur that A series of terrible consequences such as cardiac arrest, myocardial failure, and blood circulation failure. Below is the effect of oxygen saturation reduction. [3] [4].

TABLE I. THE EFFECT OF REDUCED OXYGEN SATURATION [5]

SPO2	EFFECT
95%~100%	Normal
< 95%	It is defined as hypoxia
< 80%	Impaired mental function
< 75%	Loss of consciousness

This paper will explore the effect of the "Bu" vocal breathing method on improving blood oxygen saturation when wearing a mask. This is to solve the problem of insufficient blood oxygen saturation caused by wearing a mask by changing people's normal breathing. In the first chapter, the research purpose of this thesis and blood oxygen saturation has been introduced. In chapter 2, explains the function of the lungs, and the third chapter explains the influence of the "Bu" vocal breathing method on the lung function. In chapter 4 introduces the detection principle of a pulse oximeter and the calculation of blood oxygen saturation. In chapter 5, the experiment and results of blood oxygen saturation detection. Chapter 6, Conclusion.

II. LUNG FUNCTION

The main function of the lungs is gas exchange. It is divided into air circulation function, gas exchange function, and pulmonary circulation function. Air circulation function refers to the process of gas exchange between the lungs and the outside world. The human chest and abdomen have intercostal muscles and diaphragm muscles. When they relax, the volume of the lungs expands, causing the air pressure in the lungs to be lower than the external



atmospheric pressure, which presses air into the lungs. When the intercostal and diaphragm muscles contract, the lungs shrink. The gas pressure inside the lungs increases and is greater than the outside atmospheric pressure, expelling the gas. This cycle completes the process of breathing. [6]

Gas exchange function refers to the process of gas exchange between the alveoli and the blood of the pulmonary capillaries. After the outside air enters the lungs, the oxygen concentration in the air is high, and the capillary carbon dioxide concentration is high, forming a partial pressure difference, so oxygen diffuses into the capillaries, but carbon dioxide diffuses to the alveoli. The completes the gas exchange function.

The function of the pulmonary circulation is to maintain respiratory function, venous blood ejected from the right ventricle enters the pulmonary artery, passes through the pulmonary artery to arrive at the branches of the pulmonary artery in the lungs, and flows to the capillary network around the alveoli. At that time, gas exchange is performing. The reduced hemoglobin in the capillaries combines with oxygen, and with the blood circulation, oxygen is carried to the cells throughout the body, and the carbon dioxide produced in the cells is taken away from the lungs. [7]

III. THE EFFECT OF "BU" BREATHING ON LUNG FUNCTION

The method of "Bu" breathing is to inhale by the nose and exhale by mouth. The breathing rate is 5-7 times per minute, deep inhale for 4 seconds, hold your breath for 2 seconds, and then the exhaled air vibrates the vocal cords and emits "Bu~" The sound lasts for 5 seconds. It is like deep breathing. Deep breathing has longer inhalation and breathing time than ordinary breathing, which is to strengthen the air circulation function of the lungs and allow more air to enter the lungs. because of hold on several seconds between inhalation and ventilation. The residence time of seconds can ensure that more gas participates in the exchange, which also strengthens the gas exchange function of the lungs. [8]

Moreover, "Bu" breathing must be vocalized. Sounding is produced by the air in the lungs passing through the glottis. Due to the squeezing of the air by the vocal cords, the vocal cord is vibrated. The sound from the vocal tract is finally radiated through the resonance of the oral cavity, nasal cavity, airway, lungs, and other organs. That is to say, the vibration of the vocal cords can drive the resonance of other organs. The resonance produced by the lungs can stimulate the lungs and stimulate the function of the lungs, and the resonance of the trachea can remove foreign bodies in the trachea to reduce airway resistance and to enhance ventilation. [9] [10]

IV. THE DETECTION PRINCIPLE OF PULSE OXIMETER

The principle of the pulse oximeter is to detect changes in blood absorption of light. Oxyhemoglobin (HbO_2) and deoxyhemoglobin (Hb) in the blood have different absorption rates for incident light of different wavelengths.

Usually a set of monochromatic red light (600-750 nm) and infrared light (850-1000 nm) LED lights are used as light emitters, which through a reasonable translucent part with good blood flow, such as fingers, toes, earlobes, and more.

Oxidized hemoglobin absorbs more infrared light and allows more red light to pass through. Deoxyhemoglobin allows more infrared light to pass through and absorb more red light. Using this principle, the blood oxygen saturation can be calculated by measuring the transmissivity of two kinds of light. High oxygen saturation: infrared absorption > red light absorption. Low oxygen saturation: infrared absorption < red light absorption. [11]

The most used measurement method is the transmission method, which detects transmitted light. There is a photodetector at the other end of the LED, which collects the light that is absorbed by the capillary and transmitted through. The following is the formula for calculating transmittance according to Beer-Lambert law. [12]

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

Where A is absorbance-how much light is absorbed when passing through the filter. I is the intensity of transmitted light. I_o is the original intensity of the light before passing through the filter

Use Beer-Lambert law to calculate the transmittance of red light and infrared light, and then calculate their ratio.

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

Where A_r refer to the transmittance of red light, and A_{Ir} refer to the transmittance of infrared light. R represents the ratio between them, and then this ratio is obtained by looking up the empirical table formula to get SpO₂. Generally, the R ratio of 0.5 is equal to about 100% SpO₂, the ratio of 1.0 to about 82% SpO₂, and the ratio of 2.0 is equal to 0 %SpO₂. [13]

V. EXPERIMENT AND RESULTS

The experimental site is the staircase of the Engineering Hall of Soongsil University. The subjects of the study were healthy college students aged 20-30 years, including six males and six females, a total of 12 people. All research subjects are required to wear pulse oximeters and climb stairs. Record blood oxygen saturation data onto three different conditions. They are breathing normally without a mask, breathing normally with a mask, and " Bu " breathing with a mask. The duration of the test of each case is 5 minutes. The subject rested for 15 minutes after each trial. During the experiment, the pulse oximeter should be fixed, because it can prevent the measurement data error caused by excessive vibration of the pulse oximeter from being too large. Table 2 shows the results of the blood oxygen saturation test. [2] [14]



Fig. 2 A machine of pulse oximeter

TABLE II. RESULTS OF THE BLOOD OXYGEN SATURATION TEST

	No Mask	Keep Mask On		Bias $\Delta SpO_2(\%)$
	Normal Breathing Pattern $SpO_2(\%)$	Normal Breathing Pattern $SpO_2(\%)$	"Bu" Vocal Breathing Pattern $SpO_2(\%)$	
1	96	95	97	2
2	97	96	97	1
3	96	94	98	4
4	98	95	95	0
5	97	92	96	4
6	97	93	96	3
7	96	94	98	4
8	98	96	97	1
9	97	93	98	5
10	95	95	97	2
11	98	96	98	2
12	96	93	96	3

The experimental results in the table are the average of all blood oxygen saturation values measured in 5 minutes. Although climbing stairs requires a large amount of oxygen, the blood oxygen saturation is still within the normal range without wearing a mask. After wearing a mask, the oxygen saturation of blood decreased significantly due to the increased resistance of air inhaled by the mask, and six people were below 95%, that is, mild hypoxia. Others are also near the critical value. When using the "Bu" vocal breathing method when wearing a mask, there is no case below the critical value. Compared with normal breathing when wearing a mask, blood oxygen saturation has a significant increase.

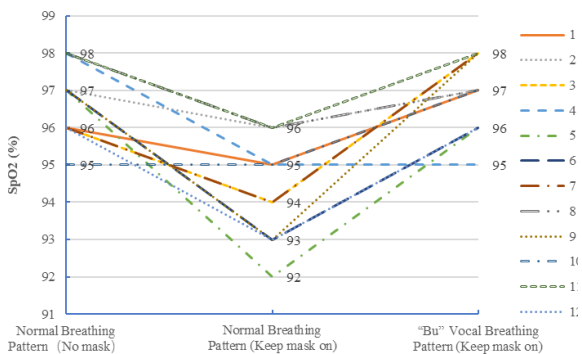


Fig. 3 Comparison of blood oxygen saturation in three cases

Figure 3 is obtained by further analyzing the data in the above table. It can see the changing trend of SpO2 from normal breathing without a mask, normal breathing with a mask to a mask "Bu" Vocal Breathing. In Figure 3, the results of most test subjects resemble the letter V. This also shows that after wearing a mask, continuing to maintain the previous breathing pattern does not ensure enough blood oxygen content. However, if people switch to a new breathing mode, people can improve the lack of blood oxygen.

VI. CONCLUSION

It has been confirmed that wearing a mask for a long time may cause poor breathing and hypoxia, and this may become more serious as exercise or thinking increases the oxygen consumption of muscles and brain. To improve this problem, a new breathing model is proposed. It is the "Bu" vocal breathing method. To demonstrate the effectiveness of this method, this paper papered theoretically analyses the effect of the new method and uses the measurement data onto the pulse oximeter to illustrate the effect of the new breathing mode on blood oxygen saturation. It can be seen from the experimental results that high-oxygen-consuming exercise is very dangerous for people wearing masks, which can easily cause hypoxia and harm people's health. The new breathing method can improve this problem. In the experiment, all subjects below the critical value (95%), after using the "Bu" vocal breathing method, the value of blood oxygen saturation was higher than the critical value and within the normal range. Experimental results prove that the use of the "Bu" vocal breathing method is effective in improving hypoxia caused by wearing a mask and can improve its blood oxygen saturation.

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