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# On A Long Breathing Method To Improve Blood Oxygen Saturation When Wearing A Mask

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***Abstract*** *— With the spread of COVID-19 around the world. Wearing a mask has caused some controversy. The mask will increase breathing resistance and cause hypoxia. This is the reason that many people oppose wearing masks. However, the anti-epidemic effect of masks has been scientifically proven. To make more people accept wearing masks, this article proposes a new solution. Namely, the long breath mode. It does not require any changes to the mask's structure, only that we need to change the original breathing pattern. This article demonstrates that a new breathing program can increase air intake, activate lung function, and obtain more oxygen. We then tried to use blood oxygen saturation as an indicator of the human oxygen level to prove its effectiveness. A photoelectric pulse oximeter developed according to different light absorption principles in the blood is used to test blood oxygen saturation. Experimental results show that wearing a mask under high oxygen consumption can cause a period of hypoxia. It has been confirmed that the recommended long breathing method increases the oxygen saturation in the body's blood and relieves the lack of oxygen in the body.*

**Keywords —** *Long Breathing Method, COVID-19, Mask, Pulse Oximeter, Lung Function, Health.*

## I. INTRODUCTION

**Fig. 1 Side view of the author wearing a mask**

At present, COVID19 has broken out worldwide, and many countries have turned into serious epidemic areas. Home quarantine, hand sanitizer, and masks have become epidemic prevention measures to prevent infectious diseases. However, people do not like to wear a mask, as if it would hinder breathing freedom. It has been confirmed that wearing a mask for a long time may cause hypoxia. This is a reason that people don not like it. In previous studies, even in a quiet sitting experiment with a mask, blood oxygen saturation was significantly reduced. If people perform physical or mental activities, they will increase the brain and muscles' oxygen consumption. These high oxygen consumption life activities will make the blood oxygen saturation in the blood reach the threshold. Further, due to the obstructive effect of the mask on breathing, blood oxygen Saturation may continue to be below the threshold, and hypoxia's risk will greatly increase. [1], [2]

Hypoxia can cause serious consequences. Short-term mild hypoxia can make people breathe faster, dizziness and sleepiness, concentration and reaction, and irritability. Long-term severe hypoxia can cause cardiac arrest, myocardial failure, and blood circulation failure. Because chronic hypoxia can cause cell death, sometimes the damage caused by hypoxia is irreversible. Therefore, maintaining normal blood oxygen saturation is beneficial to health. [3].

This article aims to explore the relieving effect of long-term breathing after wearing a mask on alleviating hypoxia. And use blood oxygen saturation as an indicator of human body oxygen level. The first chapter introduces the research background and purpose of this article. Chapter 2 explains the lungs' function, and Chapter 3 explains the effect of long breathing on lung function. Chapter 4 introduces the detection principle of blood oxygen saturation and pulse oximeter. The fifth chapter, blood oxygen saturation detection experiment and results. Chapter VI Conclusion.

## II. LUNG FUNCTION

The main function of the lungs is gas exchange. It has an air circulation function, gas exchange function, and closed circulation function. The air circulation function refers to the process of gas exchange between the lungs and the outside world. On the one hand, when inhaling, when the inter-abdominal and diaphragm muscles relax, the volume of the lungs expands, causing the air pressure in the lungs to be lower than the external atmospheric pressure, and the air is pushed into the lungs. On the other hand, when exhaling, blood oxygen saturation, and lung contraction. The lungs' air pressure increases and is higher than the external atmospheric pressure, and air in the lungs is expelled. This is the complete process of lung relaxation and contraction during breathing. [4], [5]

The gas exchange function refers to the process of gas exchange between alveoli and capillaries. As shown in Figure 2 [6], the lung comprises many alveoli, and many

capillaries surround the alveoli. Outside air enters the lungs to reach each alveolus. The oxygen concentration in the alveoli is high, and the capillary carbon dioxide concentration is high. Due to the osmotic pressure, oxygen permeates into the capillaries. On the contrary, carbon dioxide permeates from the capillaries to the alveoli. This is because the gas will penetrate from the high concentration area to the low concentration area.

The function of the pulmonary circulation is carried out along with blood circulation. Venous blood is discharged from the right ventricle and enters the pulmonary artery, passes through the pulmonary artery, reaches the pulmonary artery branch, and flows into the surrounding capillary network. As described above, the alveoli and capillaries carry out the gas exchange. Oxygenated protein with oxygen circulates in the blood, bringing oxygen to the cells of the body. And the carbon dioxide produced by the cells is discharged to the alveoli. [7]

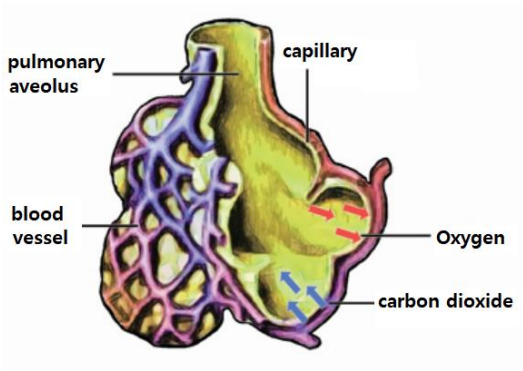


**Fig. 2 The composition of the lungs. [6]**

## III. THE EFFECTS OF LONG BREATHING ON THE HUMAN BODY

The method of long breathing is not much different from ordinary breathing, so people can quickly grasp it. It requires the nose to inhale and the mouth to exhale, and the breathing lasts longer. The number of breaths is 5-15 times per minute. Usually, a deep exhale for 3 seconds, hold your breath for 3 seconds, and then slowly exhale for 3 seconds. This is like taking a deep breath. Therefore, the lungs inhale a large amount of air and maintain it for a period, which facilitates the permeation of oxygen and enhances gas exchange efficiency. Figure 3 visually demonstrates this breathing pattern through changes in lung relaxation and contraction over time. [7]

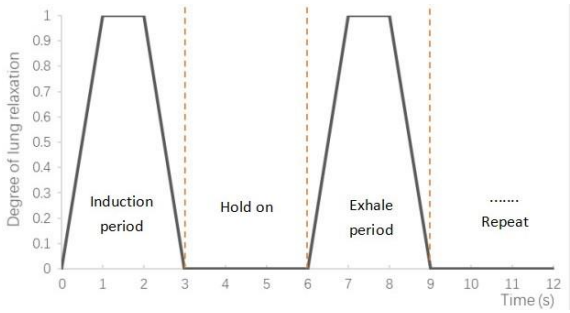


**Fig. 3 Changes in lung relaxation and contraction over time**

Breathing rhythm is also closely related to heart rate. Deep breathing can enhance the inhibition and regulation of autonomic nerves, thereby achieving calming and relaxing effects. On the one hand, when air is inhaled to expand the lungs, it activates stretch receptors in the lung organs, transmits signals to the brain, and inhibits sympathetic nerves. At this time, the effect of nerve excitement inhibition is strengthened, and the body relaxes and calms down. In other words, the lungs expand after inhaling air, suppressing the sympathetic effect. On the other hand, when exhaling, blood from the lungs flows back to the heart, enhancing the parasympathetic effect. The two mechanisms of suppressing sympathetic nerves and strengthening parasympathetic nerves produce the same inhibitory effect. Therefore, the body will relax. This process is equivalent to when the driver turns off the accelerator and depresses the brake, the vehicle speed will be reduced. Long and deep breathing takes longer than the normal breathing process. The relaxation effect is more obvious, and the relaxed cells consume less oxygen, which is beneficial to increase blood oxygen saturation. [8] [9]

Long breathing will increase the contraction of lung muscles to reduce airway resistance and increase gas circulation efficiency. The lung muscles' contraction increases the pressure in the lungs, resulting in a smaller pressure difference between the lung and the outside. Long breathing can accelerate the airflow speed, so the product of the velocity and the cross-sectional area will also increase, thereby reducing airway resistance, making breathing easier, and reducing psychological stress. In addition, oxygen inhalation and exhaust gas consumption are accelerated, and the oxygen concentration in the lungs increases, which solves hypoxia. [10. [9] [10]

## IV. PRINCIPLES OF BLOOD OXYGEN SATURATION AND PULSE OXIMETRY DETECTION

Blood oxygen saturation (SPO2) is an indicator of the human body's oxygen content level. It is defined as the percentage of the number of oxygen-loaded red blood cells to the total hemoglobin level. It indicates the ratio of reduced oxygen hemoglobin combined with oxygen to form oxygenated hemoglobin. Oxygen is not simply integrated into the serum but combined with Deoxyhemoglobin to produce oxygenated hemoglobin. Hemoglobin acts as an oxygen carrier to move oxygen throughout the body with the blood circulation. Therefore, by calculating the binding rate of oxygen and hemoglobin, you can know the level of human oxygen. 98%-99% are normal blood oxygen levels. Less than 95% is defined as hypoxia. [11], [12]

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 absorbed by the capillary and transmitted through. The following is the formula for calculating transmittance according to Beer-Lambert's law. [12] The calculation formula of blood oxygen saturation is

$$SpO_2 = \frac{HbO_2}{HbO_2 + Hb}$$

where $HbO_2$ is oxygenated hemoglobin (oxyhemoglobin), and Hb is deoxygenated hemoglobin.

The principle of a pulse oximeter is to detect changes in blood absorption of light. Oxyhemoglobin (HbO2) and Deoxyhemoglobin (Hb) in the blood have different absorption rates for different light wavelengths. Using this principle can detect oxyhemoglobin (HbO2) and deoxyhemoglobin (Hb) content. A set of monochromatic red light (600-750nm) and infrared light (850-1000nm) are often used as the detection light source.

Because oxidized hemoglobin absorbs more infrared light and allows more red light to pass through, Deoxyhemoglobin allows more infrared light to pass through and absorbs more red light. In other words, high oxygen saturation: infrared light absorption > red light absorption. Low oxygen saturation: infrared light absorption < red light absorption. [13]

The following is the formula for calculating light transmittance according to Beer-Lambert law:

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

Here A is the absorbance. I am the intensity of transmitted light. Io is the original intensity of light. Then use the Beer-Lambert law to calculate the red-light transmittance () and infrared light transmittance (), and then calculate the ratio.

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

Here. R represents the ratio of light transmission between them, and then SpO2 is obtained by looking up the experience table. An R ratio of 0.5 is about 100% SpO2, a ratio of 1.0 to about 82% SpO2, and a ratio of 2.0 is 0% SpO2. Therefore, the R ratio of a normal person lies between 0.5 and 1. [14]

## V. EXPERIMENT AND RESULTS

The 12 subjects were healthy men and women in their 20s. The measurement environment was tested in a quiet office. The equipment includes a KF94 mask and pulse oximeter. Although running and other exercises can create high oxygen consumption conditions, this may move the pulse oximeter. Therefore, it is better to use meditation to solve problems because the intense mental activity will consume a lot of oxygen. First, when wearing a mask, the tester must calculate complex math problems during normal breathing and measure the blood oxygen saturation heart rate for 10 minutes. After another 15 minutes of rest, while wearing the mask, use the long breathing mode and repeat the same measurement operation. In another case, blood oxygen saturation during normal breathing without a mask should also be measured as a reference. During the experiment, the pulse oximeter should be kept still to reduce measurement errors. [15], [16]

Figure 4 is the curve of blood oxygen saturation overtime when a tester wears a mask and breathes normally. The blood oxygen saturation continued at 99% in the first three minutes and suddenly dropped from the third minute, and the curve went up and down. From the third minute and 50 seconds, the blood oxygen saturation returns to 99%. This is because it takes a certain time for the previous oxygen to be consumed, so the blood oxygen saturation does not decrease until three minutes later. When the human body perceives the drop in blood oxygen, it regulates breathing autonomously, and the blood oxygen saturation value is restored in the fourth minute. However, the change in spontaneous breathing cannot be sustained and will increase oxygen consumption. Increasing oxygen consumption lower than changing the breathing oxygen intake will cause a greater decrease in blood oxygen saturation. So, it drops to the lowest value in the 5th minute. The regulation of spontaneous breathing is limited, and the oxygen saturation cannot be kept stable. In Figure 5, the sudden increase in heart rate in the third minute also illustrates the lack of oxygen. [15]

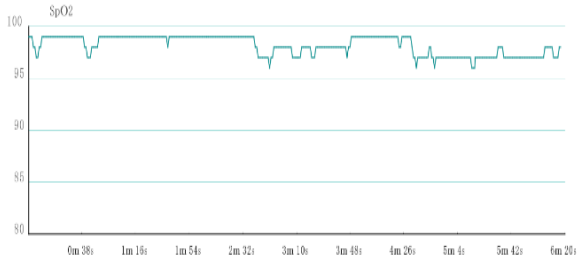


**Fig. 4 The curve of blood oxygen saturation over time**


**Fig. 5 The curve of heart rate**

Table 1 records the average value of all blood oxygen saturation values measured over 10 minutes. The blood oxygen saturation of the 12 subjects who breathed normally without a mask were all within the normal range, which shows that the 12 subjects are all healthy. When wearing a mask to breathe normally, the blood oxygen saturation is significantly reduced due to increased breathing resistance. Two-thirds of the subject has mild hypoxia, which is less than 95%. Others are also near the critical value. This is not a healthy state.

On the other hand, when breathing with a long-term mask, the oxygen saturation in most subjects' blood increased significantly. In other words, it shows that the long breathing method of wearing a mask can relieve the decrease of blood oxygen saturation to a certain extent. The line chart in Figure 6 can more intuitively see this change. The red line (long breathing mode) is always above the blue line (normal breathing mode) and not less than 95%. Test results show that the long breathing method can increase blood oxygen saturation by 2%.

**TABLE 1. RESULTS OF THE BLOOD OXYGEN SATURATION TEST**

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

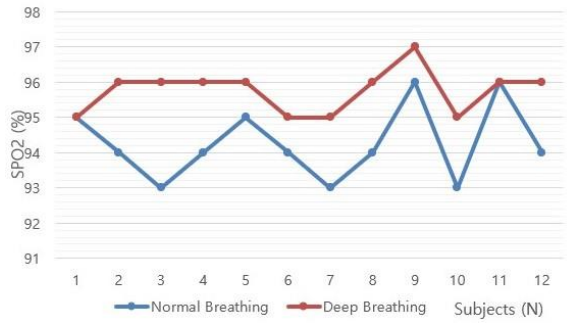


**Fig. 6 Comparing blood oxygen saturation of normal breathing and long-breathing blood oxygen saturation of 12 subjects wearing masks.**

## VI. CONCLUSION

If you wear a mask for a long time, you may have trouble breathing and hypoxia. This is a clear fact and has been proven in experiments. Many physical activities and mental activities will increase the oxygen consumption of muscles and brain, and accidents caused by hypoxia due to the resistance of wearing a mask may become more serious. A long new breathing method is proposed to improve this problem. In this paper, the effect of this method is analyzed theoretically to explain its principle and function. Using pulse oximeter data, the long breathing method's effect on reducing blood oxygen saturation is compared and reviewed.

Experimental results show that high oxygen consumption activities are very harmful to people who wear masks and may cause hypoxia and endanger human health. Even if the human body can sense hypoxia and adjust the breathing pattern on its own in time, the effect is not obvious and unstable. The proposed long breathing method requires people to adjust the breathing mode to maximize breathing efficiency passively, so the blood oxygen improvement effect is obvious. It increases blood oxygen saturation by 2%. Therefore, experiments have proved that using the long breathing method can effectively improve the hypoxia caused by wearing a mask. Still, it is expected that new methods that can significantly improve blood oxygen saturation reduction will be studied in the future.

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