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On An "Umm~" Vocal Breathing Pattern To Improve Blood Oxygen Saturation When Wearing A Mask

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Abstract — *With the spread of COVID-19 around the world. Many governments will obligate and enforce mask-wearing. This caused a lot of dissatisfaction. This is mainly because wearing a mask can cause respiratory discomfort and hypoxia. This is considered harmful to health. However, the anti-epidemic effect of masks is remarkable, and there is no other better anti-epidemic plan. Wearing masks is still the mainstream. Therefore, reducing the side effects of masks has become particularly important. This article proposes a new solution. That is, "Umm~" speaks and breathes. This is an active-controlled breathing mode. It can increase respiratory efficiency, thereby increasing the oxygen content in the body. In experiments to evaluate the body's oxygen content, we use blood oxygen saturation as an indicator. Experimental results show that the normal breathing mode cannot meet the human body's blood oxygen demand under the condition of wearing a mask. The "Umm~" vocal breathing can significantly alleviate the decline in blood oxygen saturation. After using this method, blood oxygen saturation increased by approximately 2.5%.*

Keywords — *"Umm~" Vocal Breathing Pattern, COVID-19, Mask, Blood Oxygen Saturation, Pulse Oximeter, Hypoxia, Breathing.*

I. INTRODUCTION

Masks are not a common sight until 2020. It is often seen in specific places, such as hospitals, mines, dusty factories, and some severe air pollution cities. After the COVID-19 outbreak, the demand for masks has increased significantly. According to data from the survey company, the daily output of masks has reached 200 billion, and more than half of the world's population has tried to wear masks. Therefore, respiratory discomfort and hypoxia-induced by masks have attracted more attention. Wearing a mask generally causes mild hypoxia, making people breathe faster, dizziness and sleepiness, concentration and reaction, and irritability. If this hypoxic state continues for a long time, it will further cause cell death and weaken the respiratory system's function. Often the damage caused by hypoxia is irreversible. Therefore, maintaining the normal oxygen content in the human body is beneficial to health. Hypoxia and respiratory discomfort were also the main reasons why most people opposed wearing masks.[1] [2]

On the one hand, wearing masks has a significant anti-epidemic effect and can protect people from viruses. On the other hand, wearing masks for a long time may chronically damage people's health, which seems contradictory. Therefore, it is important to find ways to reduce the harm of wearing masks. Optimizing the structure of masks and comprehensively promoting them requires many costs, and it cannot be achieved quickly. So, this paper proposes an "Umm~" vocal breathing method. This is a universally applicable method that anyone can easily master, even without training. It requires people to breathe in with their mouth and nose and exhale through their nose. The breathing rate is 8-10 times per minute, deep inhale for 2 seconds, hold the breath for 1 second, then shut up, vibrate the vocal cords, and make the nasal cavity resonate. The "Umm" sound lasted for 6 seconds in total.

This paper aims to explore the effect of "Umm~" vocal breathing mode on improving blood oxygen saturation. And use the pulse oximetry measurement results to explain in detail. Chapter 2 explains the effect of wearing a mask on breathing. Chapter 3. Explains the effect of "Umm~" breathing on breathing efficiency. Chapter 4 introduces the detection principle of blood oxygen saturation and pulse oximeter. Chapter 5, blood oxygen saturation detection experiment and result analysis. Chapter VI Conclusion.

II. THE EFFECT OF WEARING A MASK ON BREATHING

Wearing a mask will hinder the exhalation and inhalation process of the nose and mouth, reducing gas exchange efficiency. After wearing the mask, the inspiratory and expiratory flow resistance increased by an average of 126% and 122%, respectively. A lower intake will mean that the wearer may need to inhale harder to get the required amount of fresh air. Therefore, people will replace the original breathing with a higher breathing rate. That is, breathing becomes rapid. Although this can obtain short-term high oxygen, it will not last.

High-speed breathing will increase oxygen consumption and cause respiratory discomfort. In severe cases, it can cause hypoxia. From the airway resistance formula (.), airway resistance is inversely proportional to flow velocity and cross-sectional area and proportional to pressure difference. Think of the airway simply as a tube connected to the nose and mouth, and the other end connected to the lungs. When wearing a mask, the mask covers the mouth and nose, which is equivalent to reducing the cross-sectional area of the mouth and nose while reducing the airflow rate, so the breathing resistance increases, which will cause discomfort and induce hypoxia. Figure 1 shows the breathing air circulation in the human lungs.[3] [4]

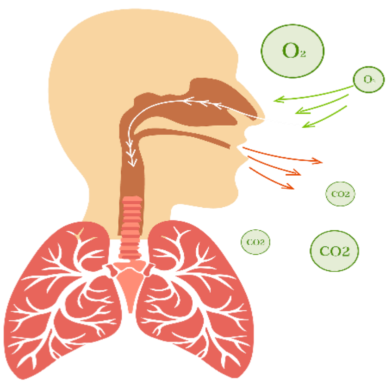

Figure 1. Human lungs breathing air circulation [3]

According to research results, the amount of air exchange reduced by an average of 37% after wearing a mask. Another reason is the geometric dead space in the mask. There is a free space between the mask and the face. Because the mask hinders gas diffusion, some carbon dioxide remains in this space and cannot be discharged. This part of the carbon dioxide will be inhaled again during the next inhalation. Then, the concentration of carbon dioxide in the inhaled air is higher. That is, the concentration of oxygen decreases. A decrease in the amount of oxygen the human body obtains per unit of time may cause mild hypoxia, especially when a large amount of brain activity and exercise consume a lot of oxygen. It will cause severe hypoxia. [5]

III. THE EFFECT OF “UMM~” BREATHING ON BREATHING EFFICIENCY

“Umm~” vocal breathing method is different from normal breathing, especially it requires nasal resonance to make a sound. The “Umm~” breathing method must be vocalized. Sounding is caused by the air in the lungs passing through the glottis. Due to the squeezing of the air by the vocal cords, the sound is vibrated. The vocal tract's sound is finally radiated through the oral cavity's resonance, nasal cavity, airway, lungs, and other organs. In other words, the vibration of the vocal cords can drive the resonance of other organs. In the “Umm~” vocal breathing method, the nasal cavity is required to resonate, which also makes the air molecules vibrate, the molecular movement speeds up, and the gas flow rate increases. The permeability of air increases. In addition, the trachea's resonance can remove foreign objects in the trachea, reduce airway resistance, and enhance ventilation.[6]

On the other hand, the “Umm~” vocal breathing method increases the lung muscles' contraction, increasing the pressure in the lungs and reducing the pressure difference between the lungs and the outside world. And deep breathing can speed up the airflow. As a result, the airway resistance is reduced, breathing becomes easier, and the inhaled oxygen increases, thereby increasing blood oxygen saturation.[7]

IV. PRINCIPLES OF BLOOD OXYGEN SATURATION AND PULSE OXIMETRY

Blood oxygen saturation (SpO2) is the percentage of the volume of oxygen-bound oxyhemoglobin (HbO2) in the blood to the total volume of hemoglobin (Hb) that can be combined, that is, the concentration of blood oxygen in the blood, which is the respiratory cycle Important physiological parameters. The functional oxygen saturation is the ratio of HbO2 concentration to HbO2+Hb concentration, which is different from the percentage of oxygenated hemoglobin. 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 human body is 98% to 99%. Less than 95% is defined as hypoxia.[8][9]

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 (660nm) and infrared spectrum (940nm) are used to illuminate the tested area (fingertips) alternately. The amount of light absorbed during these pulses 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 calculate their respective transmittance and calculate the ratio. The result is compared with the saturation value table stored in the memory to obtain the blood oxygen saturation.[10]

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

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

Where A is the absorbance. *I* prefer 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 their ratio.

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

R refers to the ratio of light transmission between them, and then SpO2 is obtained by looking up the experience table. Usually, the ratio (R) of 0.5 is about 100% SpO2, the ratio (R) of 1.0 to about 82% SpO2, and the ratio (R) of 2.0 is 0% SpO2. Therefore, the ratio (R) of a normal person lies between 0.5 and 1. [11]

V. EXPERIMENT AND RESULTS

Twelve subjects participated in the experiment. Most of them are college students in their 20s. Experimental equipment includes a KF94 mask and pulse oximeter. To create high oxygen consumption conditions without affecting the experimental data's accuracy, the method of sitting and solving math problems is used as the test condition.

Because intense mental activity consumes a lot of oxygen, resting can reduce the pulse oximeter's experimental error.

The experiment is divided into three parts. The first part is that the blood oxygen saturation during normal breathing should also be measured as a reference. The last two parts are the blood oxygen saturation during normal breathing when wearing the mouth and breathing with “Umm~.” The experimental site is a quiet meeting room.[12]

Figure 2, Figure 3, and Figure 4 are the blood oxygen saturation changes with time when a tester breathes normally without a mask, breathes normally when wearing a mask, and when using the “Umm~” vocal breathing method when wearing a mask. It can be found that when breathing normally without wearing a mask, the blood oxygen saturation has been steadily maintained at 98%, showing a straight line. However, after wearing a mask, if you still breathe normally, the blood oxygen saturation curve will fluctuate and become uneven. Because the obstructive effect of the mask first reduces the blood oxygen saturation. Then, when the human body perceives the drop in blood oxygen, it adjusts its breathing, and the blood oxygen saturation is restored. However, normal spontaneous breathing changes cannot be sustained and will increase oxygen consumption and decrease saturation. So, the blood oxygen saturation curve fluctuates up and down. The human body is also trying to maintain blood oxygen saturation at a normal value. But with the increase in oxygen consumption. The self-regulating effect of normal breathing is limited. Blood oxygen saturation may be below the threshold, increasing the risk of hypoxia. It can be seen from Figure 5. In the first 20 seconds of using the “Umm~” vocal breathing method, the blood oxygen saturation is still below 98%. This is because the blood oxygen saturation has a certain delay to the inhaled oxygen indication. Still, after continuous “Umm~” vocal breathing, the blood oxygen saturation returns to the normal value from 30 seconds and has been steadily maintained at 98%.

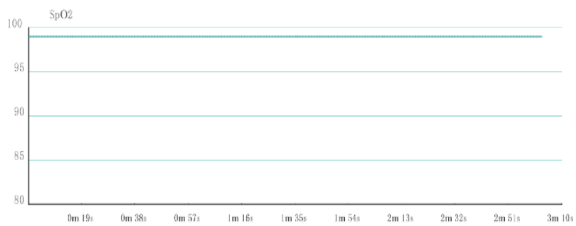

Fig. 2 Normal breathing without a mask, the curve of blood oxygen saturation with time

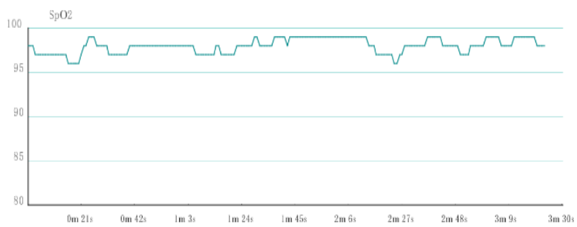

Fig. 3 Wearing a mask to breathe normally, blood oxygen saturation change curve with time

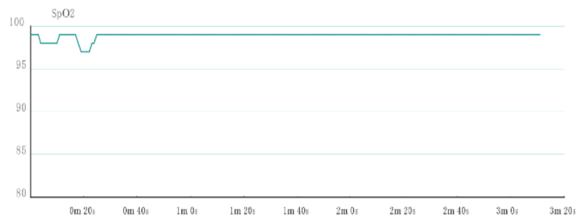

Fig. 4 Wearing a mask “Umm~” to breathe, blood oxygen saturation change curve with time

Table 1 records the average value of the blood oxygen saturation values measured under various conditions. For normal breathing without a mask, the saturation of the 12 testers was within the normal range. When wearing a mask, due to the increased breathing resistance, if you keep breathing normally, the blood oxygen saturation will also be significantly reduced, and the blood oxygen saturation of more than 40% of the testers is less than 95%. Except for one person, the blood oxygen saturation of the other subjects was 95%. It can be inferred that more than 90% of people are mildly hypoxic or at risk of hypoxia. Although hypoxia is not serious, blood oxygen saturation remains at a low value for a long time, which will harm people's health. However, when using “Umm~” to breathe, all subjects' blood oxygen saturation was improved. And they are all above the threshold. It can also be seen from Figure 3 that the blood oxygen saturation increases and remains stable.

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 (%)	ΔSpO_2 (%)
1	98	95	96	1
2	99	95	97	2
3	97	95	97	2
4	98	94	95	0
5	98	92	96	4
6	98	93	97	4
7	97	94	98	4
8	98	96	98	2
9	99	95	98	3
10	96	95	96	1
11	98	94	98	4
12	97	93	96	3

Figure 5 is a statistical histogram of blood oxygen saturation of two breathing methods when 12 subjects wear masks. Compared with Table 1, it can more intuitively reflect the influence of normal breathing mode and "Umm~" acoustic breathing mode on blood oxygen saturation. It can be found that almost all blue rectangles are lower than 95%. And the orange rectangle on the right is higher than the blue rectangle on the left. This means that the "Umm~" acoustic breathing mode can improve blood oxygen saturation and make blood oxygen saturation higher than the threshold. It can restore blood oxygen saturation to above the critical value and increase blood oxygen saturation by about 2.5%.

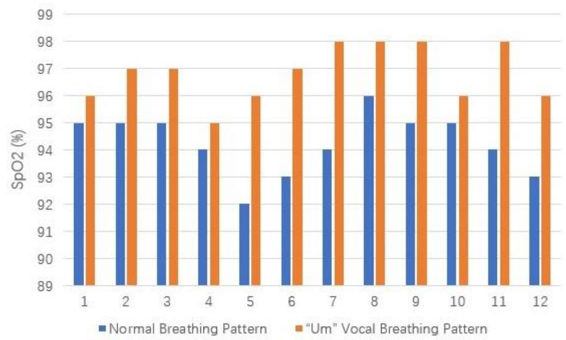

Fig. 6 Histogram of blood oxygen saturation statistics for 12 subjects wearing masks

VI. CONCLUSION

The obstructive effect of wearing a mask on breathing causes many studies have proved hypoxia. But in the era of the COVID-19 pandemic, wearing masks has gradually become an obligation. To reduce the impact of wearing masks on our health. This paper proposes a new "Umm~" vocal breathing method to improve this problem. This is different from the previously proposed long breathing method, which requires the vocal cords to vibrate and the nasal cavity to resonate to produce sound. Then, using the blood oxygen saturation as an indicator, the pulse oximeter measurement experiment was used to illustrate this method's blood oxygen improvement effect.

The experimental results show that for the normal breathing mode of wearing a mask, even if the breathing mode's autonomous adjustment can increase the blood oxygen saturation to a certain extent, the average blood oxygen saturation is still significantly decreased due to instability. For "Umm~" vocal breathing mode, people subjectively increase the breathing volume to compensate for the lack of oxygen wearing a mask so that the blood oxygen saturation is stably maintained at a normal value. Compared with the normal breathing mode, it can improve the low blood oxygen saturation. It increases blood oxygen saturation by 2.5%. "Umm~" vocal breathing mode is a simple and effective method to improve blood oxygen saturation.

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