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# Effects of wearing masks on human health and comfort during the COVID-19 pandemic

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**Abstract.** To explore the influence of wearing different types of masks on people's health and comfort, an experimental study was conducted through a subjective questionnaire survey, physiological response test, and thermal imaging test. The results showed that, in a warm environment, wearing masks for a long time significantly affected the subjective feelings and physiological reactions of people. After wearing the mask, the personnel feels more hot and humid, the discomfort is significantly increased. At the same time, the mean skin temperature increases, the heart rate increases, and the blood oxygen saturation level decreases, which ultimately leads to a decline in health and comfort levels. Different types of masks have different effects on people. The effects of wearing KN95 masks, gauze masks, medical surgical masks, disposable civilian masks, disposable medical masks, and sponge masks on people's health and comfort levels are sequentially reduced.

## 1. Introduction

In recent years, with the increasing incidence of infectious diseases<sup>[1-2]</sup>, especially the frequent occurrence of respiratory infectious diseases<sup>[3-4]</sup>, people are prone to become high-risk groups of respiratory infectious diseases. Especially in the current outbreak of COVID-19, the main transmission route is droplet transmission, so wearing a mask is the main way to block new coronaviruses.

After wearing a mask, people will feel suffocated and feel uncomfortable even sitting silently. And people wearing masks will directly reduce the amount of oxygen inhaled by the body, leading to lack of oxygen in the brain, and even harm the health of the body. Especially with the advent of summer, wearing masks makes people more uncomfortable, but the COVID-19 epidemic is not over, people still need to continue wearing masks. Due to the shortage of mask resources, people wear masks of various materials. However, different types of masks have diverse impacts on people's health and comfort<sup>[5]</sup>. Therefore, how to scientifically and rationally choose suitable masks has become a hot topic of current research. Based on this, from three perspectives of subjective evaluation, physiological test, and thermal imaging test, this paper conducted an experimental study on the effects of wearing different masks on human comfort and health in a warm environment and hopes to provide people with a precise basis for selecting masks during the COVID-19 epidemic.

## 2. Methods

### 2.1. Laboratory introduction and participants

The experiment was completed in a university laboratory in May 2020. The laboratory layout and field test photos are shown in figure 1. The environmental parameters of the laboratory (with an area of 48m<sup>2</sup>)



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are controlled by intelligent air conditioning. Indoor environmental factors were controlled within the effective range before each experiment, that is, the air temperature was 28 °C, the relative humidity was kept at 60%. Twelve college students were recruited to participate in the experiment voluntarily in this experiment. They were in good health without any adverse symptoms. This experiment adopts the design of the subjects, and all subjects repeat the test under all conditions.



Figure 1. Laboratory layout and field test photos.

### 2.2. Experimental conditions and procedures

In this experiment, a total of seven conditions were set. They are no mask, disposable medical mask, medical surgical mask, medical protective mask (KN95 mask), non-disposable mask (sponge mask), disposable civilian mask, gauze mask. The experimental process is shown in figure 2. The subject should sit or read for about 100 min. Then conduct a thermal imaging test for about 5 min. After completing the test, the subject took 10 min to fill in the subjective questionnaire according to their own feelings. Finally, the physiological parameters are measured for about 5 min.

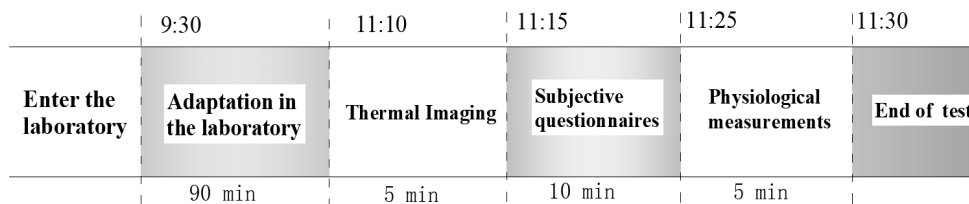


Figure 2. Experimental process.

### 2.3. Measurements

Subjective sensation voting mainly includes: thermal sensation vote (TSV) is evaluated using the ASHRAE standard 7-level scale. Wetness and air freshness evaluations also use a 7-level scale. The discomfort evaluation uses a 5-level scale. The content of health and comfort evaluation includes headache, dry mouth, eye irritation, listlessness, dry skin, dizziness, hard to think, Nasal congestion, difficult to concentrate, poor breathing, unpleasant smell in the air, etc.<sup>[6]</sup>, using a 5-level scale, 0~4 means none, a little bit, some, quite, and extraordinary. The measured physiological parameters include skin temperature, core temperature, blood pressure, heart rate, and blood oxygen saturation. Measuring instruments mainly include DB12 oximeter, CH602B digital sphygmomanometer, Raytek ST60 infrared thermometer. Thermal imaging of the human body is measured using the FLIR E8 handheld infrared camera.

### 2.4. Statistical analysis

The experimental data were analyzed using statistical software SPSS 25.0. First, check the data and eliminate extreme outliers; then use the Shapiro-Wilk test to determine whether the experimental data conform to the normal distribution; finally, the data adopt the method of single-factor repeated measurement analysis of variance for significance Difference test, significance level  $p < 0.05$  is considered statistically significant.

### 3. Results

#### 3.1. Subjective evaluation results

The average value of the voting values of all subjects in each working condition is regarded as the voting value under the working condition. As is shown in figure 3(a). Wearing a mask had a significant effect on the TSV of the subjects ( $p=0.028$ ). The impact of wearing KN95 mask medical surgical masks, disposable medical masks, sponge masks, and gauze masks on TSV decreased in turn. Figure 3(b) shows that participants wearing masks also felt more humid, with a statistically significant difference ( $p<0.001$ ).

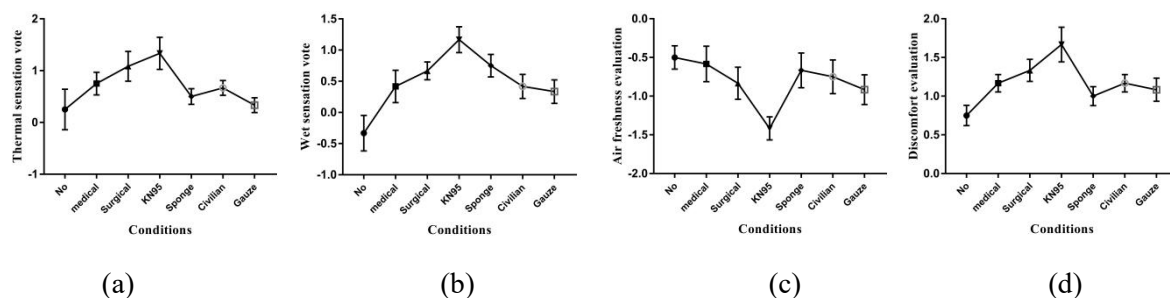


Figure 3. Subjective evaluation of subjects under different conditions

Figure 3(c) shows the changes of the air freshness evaluation of the subjects under different conditions. The smaller the evaluation value, the worse the air quality. It can be found that after wearing the mask, the subjects felt that the air quality decreased significantly ( $p=0.017$ ). It can be seen from figure 3(d) that wearing a mask has a significant difference in personnel comfort ( $p=0.001$ ), wearing a sponge mask is more comfortable, wearing KN95 masks has the lowest level of comfort, and wearing other masks has a lower level of comfort.

Table 1. Effects of wearing masks on human health and comfort feeling.

	Degree of symptoms (mean (standard deviation)) at different conditions							p
	No mask	Disposable medical mask	Medical surgical mask	KN95 mask	Sponge mask	Disposable civilian masks	Gauze mask	
Headache	0.25±0.45a	0.35±0.49	0.58±0.79	0.75±0.87	0.5±0.52	0.33±0.49	0.5±0.67	0.427
Dry mouth	0.58±0.51	0.75±0.45	1.08±1.08	1.58±1.51	0.75±0.97	0.83±0.72	1.42±1.16	0.034
Eye irritation	0.0±0.0	0.0±0.0	0.08±0.29	0.17±0.39	0.0±0.0	0.0±0.0	0.17±0.39	0.195
Listlessness	0.75±0.45	1.08±0.67	1.17±1.03	1.33±1.07	0.92±0.67	1.17±0.39	1.33±0.49	0.038
Dry skin	0.5±0.52	0.58±0.51	0.67±0.49	0.92±0.9	0.5±0.52	0.83±0.72	1.08±0.9	0.047
Dizziness	0.5±0.52	1.33±0.98	1.25±0.97	1.92±0.67	1.08±0.79	1.0±0.6	1.42±0.67	0.025
Hard to think	0.75±0.45	0.92±0.79	1.33±0.98	1.75±0.87	0.83±0.83	1.17±0.39	1.5±0.9	0.026
Nasal congestion	0.08±0.29	0.0±0.0	0.08±0.29	0.17±0.39	0.17±0.39	0.0±0.0	0.17±0.39	0.503
Difficult to concentrate	1.0±0.74	1.08±0.67	1.42±0.67	1.83±0.83	1.25±0.45	1.08±0.29	1.58±0.67	0.018
Poor breathing	0.5±0.52	0.83±0.39	0.92±0.79	1.83±0.94	0.92±0.29	0.83±0.39	0.75±0.45	0.002
unpleasant smell in the air	0.33±0.49	0.5±0.52	0.67±0.65	0.58±0.51	0.58±0.51	0.42±0.51	0.75±0.45	0.183

<sup>a</sup>The lightest symptoms are underlined, The most severe are bold.

It can be seen from table 1 that most of the symptoms related to health and comfort after wearing the mask are significantly increased. When wearing a KN95 mask, symptoms such as dizziness, difficulty concentrating, and difficulty breathing are more severe; The total health and comfort assessment can be calculated. The specific algorithm is: the sub-item indicators are corrected by subtracting the sub-item score from 4, and then the corrected sub-item scores are added. Therefore, the higher the total score, the higher the health and comfort level. As is shown in figure 4. The wearing of masks has a significant impact on the health and comfort level of personnel ( $p < 0.005$ ). The health and comfort levels of sponge masks, disposable medical masks, and disposable civilian masks are relatively close.

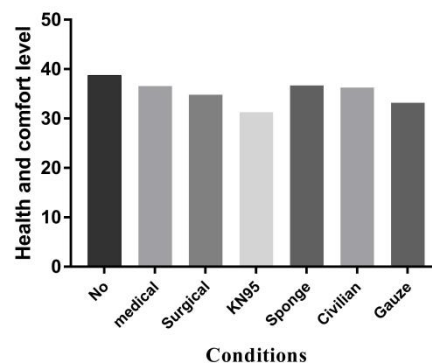


Figure 4. The effect of wearing masks on the subjects' health and comfort level.

### 3.2. Physiological test results

As shown in figure 5(a), The mean skin temperature also changes with the wearing of different types of masks ( $p < 0.001$ ). Figure 5(b) shows that the systolic blood pressure changes less than 4% ( $p = 0.915$ ), while diastolic blood pressure changes less than 3% ( $p = 0.529$ ), No statistically significant differences were observed. As shown in figure 5(c), The subject's heart rate increases after wearing the mask ( $p = 0.04$ ). It can be seen from figure 5(d) that the effect of wearing a mask on blood oxygen saturation is more obvious ( $p = 0.048$ ).

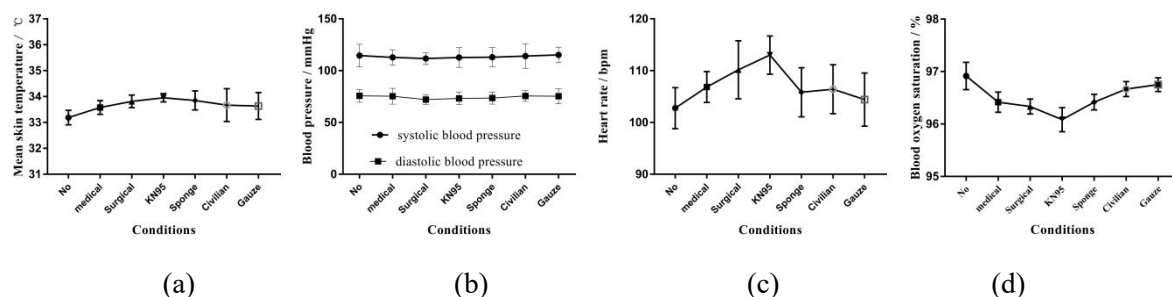


Figure 5. Changes of the physiological parameters of the subjects under different conditions

It can be seen from table 2 that headaches, dry skin, bad smells in the air, and other symptoms are less related to the mean skin temperature, heart rate, and blood oxygen saturation concentration, while other symptoms are more related to these physiological parameters. The increase in mean skin temperature and heart rate, dry mouth, difficulty concentrating, and other symptoms intensified. As the blood oxygen saturation level decreases, symptoms such as listlessness, dizziness or wanting to sleep, and a decline in mental thinking ability increase.

Table 2. The relationship between physiological parameters and comfort and health.

Headache	Dry mouth	Listlessness	Dry skin	Dizziness	Hard to think	Difficult to concentrate	Poor breathing	unpleasant smell in the air
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Mean skin temperature	0.022	0.317**a	0.068	0.167	0.175	0.172	0.205*	0.365**	0.082
Heart rate	0.026	0.269**	0.043	0.043	0.122	0.210*	0.353**	0.,256	-0.014
Blood oxygen saturation	-0.014	-0.414**	-0.437**	0.057	-0.225**	-0.315**	-0.102	-0.338**	-0.142

<sup>a</sup> \* indicates significance ( $p < 0.05$ ), \*\* indicates significance ( $p < 0.01$ ).

### 3.3. Thermal imaging test results

The thermal imaging results of the subjects under different conditions are shown in figure 6. It can be found that the maximum temperature on the surface of KN95 masks, disposable medical masks, medical surgical masks, disposable civilian masks, sponge masks, and gauze masks increases sequentially.

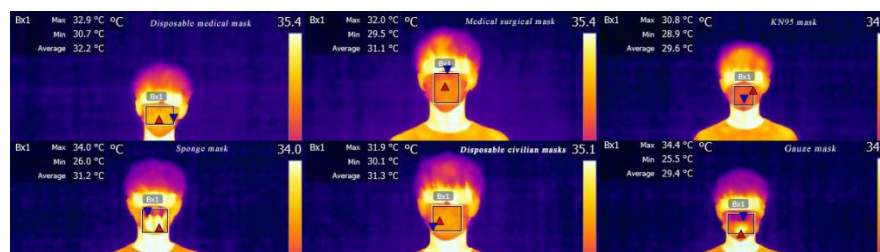


Figure 6. Results of thermal imaging test under different conditions.

## 4. Discussion

The experimental results show that wearing a mask significantly reduces the person's thermal comfort level and air quality perception, leads to a decline in health comfort level. As can be seen from figure 3, the voting value of the thermal and wet sensation increases after wearing the mask. This is mainly because of the space behind the mask is blocked, and nasal airflow will become hot on the sides of the cheek, and makes people feel more hot and humid. Figure 4 shows that wearing a KN95 mask has the most significant impact on the health and comfort level of the personnel. This is because the structure of the KN95 mask and the face are well-adhesive, which seriously affects the flow of breathing air.

Physiological test results show that certain parameters are more potential physiological parameters in the study of personnel health and comfort. Figure 5 shows that after wearing the mask for a while, the skin temperature of the person has increased, the heart rate has increased. The effect of wearing a mask on the blood pressure of the personnel was not obvious, and no statistical significance was observed, indicating that the effect of wearing a mask on the blood pressure of the personnel was small. The results of changes in heart rate and blood oxygen saturation are consistent with the results of the subjective evaluation. When the blood oxygen saturation level is low, that is, the oxygen supply is insufficient, the human body will feel fatigue, and the cognitive ability of the brain will decline<sup>[7]</sup>, which will eventually lead to a decline in the level of health and comfort.

The thermal imaging test results are consistent with the subjective evaluation results and physiological test results. As can be seen from figure 6, the temperature on the surface of the KN95 mask is the lowest, because it has the highest breathing resistance<sup>[8]</sup>, and the breathing airflow is difficult to form a connection with the external environment. The surface temperature of the gauze mask and sponge mask is high, because of the poor adhesion between the structure and the human face, resulting in a large loss of breathing heat. The surface temperature of disposable medical masks, medical surgical masks, and disposable civilian masks is relatively close, but the surface temperature is lower than that of sponge masks and gauze masks. This is because these three types of masks contain melt-sprayed fabric, which is not breathable.

## 5. Conclusion

This article uses a combination of subjective evaluation, physiological testing, and thermal imaging testing to study the impact of wearing different types of masks on human health and comfort in a warm environment. The following conclusions were obtained:

1. In a warm environment, wearing a mask for a long time will increase the person's hot and humid feeling, reduce the perceived air quality, and increase the discomfort significantly, which will eventually lead to a decline in the level of health and comfort.
2. Wearing a mask significantly affects people's physiological responses. The mean skin temperature increases, heart rate increases, and blood oxygen saturation decrease, resulting in more severe symptoms such as listlessness, poor breathing, and dizziness.
3. The effects of wearing KN95 masks, gauze masks, medical-surgical masks, disposable civilian masks, disposable medical masks, and sponge masks on the health and comfort level of personnel were successively reduced.

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