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EFFECT OF SURGICAL MASK USE ON BREATHING AIR QUALITY AND OXYGEN SATURATION: A QUASI-EXPERIMENTAL MODEL

Ertan Kara*, Burak Mete, Hakan Demirhindi, Ceren Kanat, Esra Mete

Çukurova University, Faculty of Medicine. Department of Public Health Adana/Turkey

ABSTRACT

This study aimed to investigate the effect of surgical masks (SM), which are widely used in the community in the fight against COVID-19, on breathing air quality and blood oxygen saturation among healthy people.

This study included 45 healthy individuals. At rest and indoor conditions; blood oxygen concentrations and heart rates were recorded, while simultaneous oxygen (O_2), carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen oxides (NOx), VOC (volatile organic compounds) concentrations, and humidity and temperature were measured both in the mouth-nose area (MNA) in the indoor area before the mask was worn, and in MNA inside the mask (in-mask) after the mask was worn.

The mean age of 45 healthy participants was 36.06 with a male to female ratio of 53.3% to 46.7%. When the indoor room air values in MNA without SM were compared with in-mask MNA values; in-mask O_2 saturation was observed to decrease, CO to increase in smokers, and VOC, humidity and temperature to significantly increase in all participants. SM wearing was observed not to significantly alter simultaneously measured peripheral blood O_2 saturation and resting heart rate. The (measured) effect of SM wearing on O_2 saturation and heart rate was found to be very small.

Wearing a surgical mask was found not to impair blood O_2 saturation in healthy individuals at rest. Further studies can be recommended to support the results in this study.

KEYWORDS:
COVID-19, pandemic, surgical mask, oxygen saturation, heart rate

INTRODUCTION

Effective methods in combating the epidemic can be grouped into the two main categories of pharmacological and non-pharmacological methods. There is currently no effective pharmacological method -drug or vaccine- to control the coronavirus (COVID-19) epidemic and to reduce its spread. Non-pharmacological methods such as wearing masks, maintaining physical distance and ensuring hand hygiene prevail in combating and supressing the epidemic. Wearing a mask is considered to be an inexpensive and effective method for the control of the epidemic. The combination of wearing a mask and physical distance measures was observed to suppress the epidemic curve [1-4]. In the initial period of the epidemic (spring of 2020), symptomatic patients were recommended to wear a mask to prevent the spread of respiratory droplets. However, new evidence in the following period (summer and autumn of 2020) led to expanding the use of masks to the whole population in order to reduce or prevent the spread of the infection originating from asymptomatic individuals. Despite the legal requirements, some individuals still resist wearing a facemask [5]. Recently, various worries have been raised regarding mask wearing, like masks being harmful to health and disrupting oxygen saturation. Such confusing claims lead to resistance to mask usage, which is currently one of the most effective, non-pharmacological methods to combat COVID-19. Therefore, this study aimed to investigate the effect of surgical masks (SM), which are widely used in the community, on breathing air quality and blood oxygen saturation among healthy people.

MATERIALS AND METHODS

Sampling and type of the study. This study is a quasi-experimental research conducted in the Department of Public Health, Faculty of Medicine, Çukurova University, Adana, Turkey in October 2020. The minimum sampling size was calculated to include 30 participants following a pilot study, based on 80% of power and 95% of confidence interval. A larger number of participants, i.e. 45 healthy individuals, were included in the study.

Data collection forms. The data collection forms included sociodemographic information like age, sex, height, weight, accompanying chronic diseases, smoking habits, beard presence and physical

characteristics, indoor room air quality measurements, no-mask room air quality measurements in the mouth-nose area (MNA) before the mask was worn, and in-mask MNA air quality measurements after the mask was worn.

Measurement instruments. An iBRID MX 6 multi-gas monitoring device was used for air quality and pollution measurements. This device can measure approximately 120 types of different substances and warns of high and hazardous concentrations. The warning time of the device was recorded during in-mask measurements (Figure 1).

A VRN501. Veron fingertip pulse oximeter was used to perform simultaneous measurements before and after wearing the mask (Figure 2).

A humidiometer and thermometer were used to perform indoor ambient air quality measurements, no-mask ambient air quality measurements and in-mask air quality measurements (Figure 3).

All the instruments were calibrated before starting the experiments.

Measurements. Measurements were performed in three stages, indoor (in a closed room) and while the individual was resting (in rest). The first step consisted of room air measurement recordings. In the second stage, measurements of air quality parameters in MNA were recorded. The third stage included in-mask MNA measurements after the mask was worn. A new, unused, standard, three-layer SM was used during in-mask measurements.

First stage measurements: Room air quality and pollution measurements consisting of Oxygen (O_2), carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen oxides (NO_x), VOC (volatile organic compounds) concentrations, and humidity and temperature.

Second stage measurements: Before wearing the mask, MNA room air quality and pollution measurements consisting of O_2, CO, SO_2, NO_x, VOC concentrations, and humidity and temperature with simultaneous blood O_2 saturation and heart rate measurements. Mean values at the fifteenth minute were recorded. Air quality measurements were performed by using disposable single-use soft medical cannulas for each participant. Probes attached to the humidiometers and thermometers were changed for each participant in humidity and temperature measurements.

Third stage measurements: The same measurements as the second stage were repeated, but this time after wearing the mask (in-mask). Again, mean values at the fifteenth minute were recorded. In-mask air quality measurements were performed by using disposable, single-use, soft, medical cannulas inserted inside the mask. Probes attached to the humidiometers and thermometers were changed after each participant in humidity and temperature measurements.

Statistical analyses. Data were analyzed by using SPSS 22 ® software. Normal distribution was tested with the Kolmogorov- Smirnov test. Mean values were compared using the t test and the paired t test. Statistical significance was accepted as $p<0.05$. In effect size analyses Cohen's d values of $d\geq1$ were interpreted as "very large", with 0.8 as "large", 0.5 as "medium" and 0.2 as "small" effect sizes.



FIGURE 1
MX6 iBrid air quality measurement instrument



FIGURE 2
VRN501 Veron fingertip pulse oximeter



FIGURE 3
Humidiometer and thermometer

RESULTS

The average age of 45 healthy people included in the study was calculated as 36.06. The male participants consisted 53.3% of the study population and 46.7% were smokers. The sociodemographic characteristics of the participants were presented in Table 1.

In air quality measurements performed after wearing a mask, the average warning time of the device was found to be 14.43 seconds (min: 10-max: 30). When no-mask room air MNA values were compared with in-mask values, it was found that in-mask O_2 had decreased, CO had increased especially in smokers, while VOC, humidity and temperature values increased statistically significantly in all participants wearing a mask. Any statistically significant change in the peripheral blood O_2 saturations and resting heart rates was not observed in simultaneous measurements performed after wearing the mask. The measured effect size of the mask wearing on blood oxygen saturation and heart rate was found to be very small (Table 2).

Mean values of air quality parameters (with confidence intervals) at fifteenth minute of measurements in MNA, before and after wearing the mask, were presented in Figure 4.

TABLE 1
Sociodemographic characteristics of the participants

Parameters	Values
Sex Male/Female (n/%)	24 (53.3) / 21 (46.7)
Age (Min-Max, X±S.S.)	26-60, 36.06±11.62
Body Mass Index (Min-Max, X±S.S.)	17.58-37.58 (24.77±4.14)
Smoker Yes/No (n/%)	21 (46.7) / 24 (53.3)
Beard Yes/No (n/%)	10 (41.7) / 24 (58.3)
Total (n/%)	45 (100.0)

TABLE 2
Indoor room air, no-mask and in-mask nose-mouth area air quality parameters, SpO_2 and Pulse values

Parameters	Indoor room air	No-mask (15th minute)	In-mask (15th minute)	p	Cohen's d
O_2 (%)	20.89±0.11	20.09±0.60	17.47±0.76	**<0.001***	3.82
CO (ppm)	0±0	3.15±4.59	10.17±10.67	**<0.001***	0.85
SO_2 (ppm)	0±0	0±0	0±0	1.000	0
NO_X (ppm)	0±0	0±0	0±0	1.000	0
VOC (ppm)	5.79±2.42	27.04±12.11	52.36±36.92	**<0.001***	0.92
Humidity (%)	54.46±10.07	68.44±13.63	88.75±11.26	**<0.001***	1.62
Temp. (^oC)	28.00±1.85	30.10±5.50	33.03±10.14	**<0.001***	0.35
SpO_2 (%)		96.97±1.21	96.82±1.23	0.415	0.12
Pulse (per minute)		78.55±12.72	78.82±10.80	0.740	0.02

Values are mean±standard deviations, oxygen (O_2), carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen oxides (NO_x), VOC (volatile organic compounds), ppm (parts per million), SpO_2 (peripheral capillary oxygen saturations), temperature (temp), Celsius degrees (^0C), standard deviation (SD). *Statistically significant values

TABLE 3
In-mask VOC and CO values according to sex, smoking habit and beard presence

Sex	VOC	p	CO	p
Male	46.35±24.84	0.864	15.20±4.42	**<0.001***
Female	59.22±46.86		4.42±6.65	
Smoker				
Yes	43.39±23.56	0.357	17.04±11.85	**<0.001***
No	60,20±44,57		4.16±3.89	
Beard				
Yes	45.90±21.22	0.989	16.90±13.70	0.841
No	54.20±40.36		14.00±9.16	

Values are mean±standard deviations, carbon monoxide (CO), VOC (volatile organic compounds)
*Statistically significant values

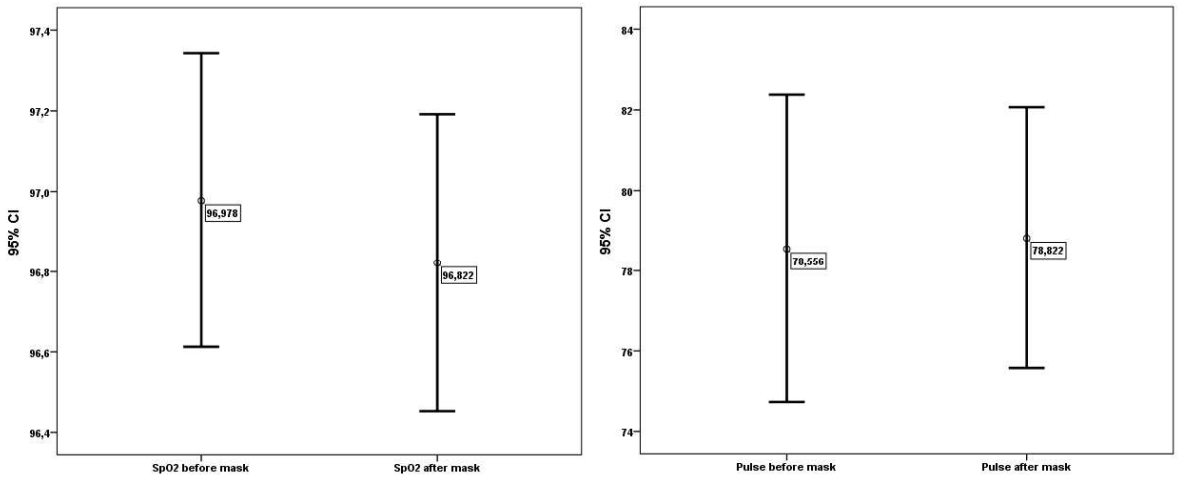


FIGURE 4
Pulse and SpO_2 values before and after wearing the mask

When in-mask VOC and CO measurements were compared according to sex, smoking and facial beard presence, it was found that CO concentration was found to significantly increase in smokers (smoker male = 23.87, female = 0.4 packs year). It was found that the presence of a beard had no significant effect on VOC and CO values (Table 3).

DISCUSSION

Maintaining physical distance and using a mask are important factors in minimizing COVID-19 virus exposure in public and closed areas. In some countries, it has been made mandatory to wear a facemask in public and closed work areas. Mask wearing rules may be ignored when driving alone or in uncrowded open areas provided that physical distance is observed. However, wearing a mask is useful in preventing the spread caused by symptomatic or asymptomatic people, only if every individual uses a mask [1]. More supporting evidence is needed to reduce the resistance of individuals regarding the use of facemasks. This study aimed to compare in-mask air quality with that of the room air and at MNA before wearing the mask. VOC, CO, humidity and temperature values were found to increase, while the O_2 concentration to decrease at in-mask measurements. It was found that mask use did not significantly alter peripheral blood O_2 saturation or heart rates at rest, measured simultaneously with in-mask measurements. The concentration of gases and substances already present in the breathing air before the mask was worn were observed to increase inside the mask. This increase and the irritation caused in the respiratory tract may explain the discomfort expressed shortly after wearing the mask. In addition, the increase in temperature and humidity may be causing difficulty in breathing, as a result of the increase in the resistance inside the respiratory tract. The discomfort felt when using SM has been attributed to neurological reactions or psychological conditions such as anxiety, claustrophobia, and perceived sensory difficulty in breathing. The neurological reactions are caused by increased afferent stimuli originating from the sensitive area of the face (highly sensitive to heat) when covered with the mask or by the increased temperature of the inhaled air [6]. In a study investigating the effect of humidity and temperature on the acceptance or tolerance of the mask in exercising people, Nielsen et al. found that the acceptance of wearing a mask was highest, when the temperature inside the mask is 27 ^{0}C degrees and below, and the increase in the amount of moisture inside the mask increased the resistance to wearing a mask [7]. In a study by Samannan et al., in which the effect of SM on gas exchange in healthy individuals and patients with chronic obstructive pulmonary disease (COPD) was investigated, it was found that the gas exchange was not impaired not only in healthy people, but also in severe COPD patients [8]. Roberge et al. reported that the use of a N95 mask by healthcare workers did not have any negative physiological effects after one hour of use [9]. In a study investigating the effect of using simultaneously both N95 and a SM on air quality, a significant difference was observed between the use of an N95 mask together with a surgical mask and with the use of an N95 mask alone, in terms of gas concentrations, inhalation and expiration pressures. The N95 mask type, especially those with expiration valves, has an important positive impact on mean O_2 and CO_2 concentrations in the inhaled air and respiratory pressures. It has been stated that placing the surgical mask on a N95 mask will worsen gas concentrations in the inhaled air [10]. It is important to inform the public based on evidence, in terms of worries about mask use, which is an important, effective and inexpensive method in the control of the epidemic.

The question is how individuals can best benefit from this intervention? Firstly, public health pro-

fessionals and leaders must ensure a clear public understanding about when and how to wear face masks properly and continue to provide evidence for their effectiveness. Secondly, although face masks are generally well tolerated for short periods of time, prolonged use can make it difficult for some people to breathe, especially in hot or humid environments. Masks need to be developed to increase their physical comfort and ease of use. Thirdly, there is a need for consistent and clear messages that normalize the use of masks in the community. At the current critical point of time, when COVID-19 is on the rise again, the widespread adoption of face mask use is a highly effective low-tech solution that can help positively impact the tide in national and global efforts against COVID-19 [1, 11].

Among the limitations of the study are that the study was conducted on healthy individuals, a single type of surgical face mask was examined, measurements were made at rest and indoors, in a closed area only.

CONCLUSIONS

It has been determined that the use of masks does not impair peripheral blood oxygen saturations in healthy individuals at rest. Although this study fills a gap, in order to eliminate the concerns about the negative effects of mask use on health, more evidence-based studies are needed.

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CORRESPONDING AUTHOR

Ertan Kara
Çukurova University, Faculty of Medicine.
Department of Public Health
Adana/Turkey

e-mail: ekara@cu.edu.tr