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Research Article

Measurement of Lung Function Indices and Oxygen Saturation of Subjects Who Wear Surgical Face Masks Compared with Those Who Wear Cloth Masks

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Abstract

Background/Aim

Facemasks are physical barriers to respiratory droplets that may enter through the nose and/or mouth and to the expulsion of muco-salivary droplets from infected individuals. The present study aimed at measuring lung function indices and oxygen saturation in subjects who wear surgical masks compared with cloth masks. Following the outbreak of the COVID-19 pandemic, the use of face masks is now widely recommended by international, national, and local authorities as a key strategy to reduce the spread of severe acute respiratory syndrome 2 (SARS-2) coronavirus.

Methods

Fifty (50) male and female healthy adult volunteers (ages between 25-35 years) without any pulmonary or cardiac disease, and non-smokers were recruited and grouped into three (3)

Group 1 – (Control) - Subjects who did not wear any type of face masks;

Group 2 – Subjects who wore surgical face masks;

Group 3 – Subjects who wore cloth face masks Oxygen saturation and lung function indices were measured before the use of facemasks and immediately after facemasks were removed. The subjects wore the facemasks for two (2) hours. In a standing position, the subjects' oxygen saturation was recorded using a pulse oximeter on the subjects' index fingers of their right hands, while the lung function indices (FVC1, FEV1, and PEFR) were measured three times using a spirometer, with the highest value chosen. Data were analyzed statistically using Graph Prism 8.1 version. Results were presented as mean + SEM, ANOVA, and Tukey's Multiple Comparison Test were used to compare the means obtained, and P-values less than 0.05 ($p < 0.05$) were considered statistically significant.

Results

The results showed that oxygen saturation was significantly decreased by both surgical and cloth masks compared with control, while ventilatory functions were significantly decreased by cloth masks but not by surgical masks compared with control. The decrease in oxygen saturation and ventilatory functions were however not clinically important since their decrease was minimal and not sufficient to induce hypoxia and breathing-related problems.

Conclusion

Thus, the use of facemasks is safe, especially surgical facemasks. Consequently, the use of facemasks is advised and recommended during an outbreak of airborne disease, but the duration of use, condition of use, and choice of mask may be important factors that should be put into consideration since masks are associated with discomfort. However, the life-saving benefits of wearing masks seem to outweigh the discomfort.

Keywords: COVID-19 pandemic; Oxygen saturation; Lung function indices; Surgical facemask; Cloth facemask

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Introduction

During the coronavirus disease 2019 (COVID-19) pandemic, most countries and health organizations like the World Health Organization (WHO) propagated wearing face masks by early 2020 as a key strategy to reduce the spread of the severe acute respiratory syndrome 2 (SARS 2) coronavirus. Wearing face masks is recommended in many scenarios, mostly in clinical contexts, when infected by certain respiratory diseases or in times of epidemics where the risk of potential transmission through air passages has to be reduced [1]. Face masks are defined as physical barrier to respiratory droplets that may enter through the nose and mouth and to the expulsion of muco-salivary droplets from infected individuals [2,3]. There are different types of face masks and respirators offering different levels of protection to users [4-6]. They include medical-grade masks, such as surgical masks, N95 respirator masks and non-medical cloth masks. The different types of face masks serve the general purpose of providing some form of protection against contaminants in the air, ranging from pollen to chemical fumes to pathogens. The filtering capacity, and hence the level of protection against pollutants and pathogens, depends on the materials used and the engineering design [4-6]. Facemasks are recommended to reduce the chances that the wearer spreads SARS-CoV-2, and may provide some protection for the person wearing the mask as well [7,8]. Their role may be particularly important in COVID-19, where infected individuals may be shedding virus while asymptomatic or presymptomatic [7,9,10]. However, widespread usage of face masks is limited largely by the feeling that they are uncomfortable and concerns about inadequate gas exchange [11]. Masks are visible indicators of crisis mode, which can prompt behavioral changes such as social distancing and frequent hand washing [12]. Mask-wearing can be effective in the containment of communicable diseases [3] and has thus become a new normal in many societies during the COVID-19 pandemic. The surge in demand for surgical masks and respirators has led to a global shortage of supply and raw materials. As a result, many people have resorted to making their masks, recycling used masks, or settling for masks offering less protection than needed. Face masks not only have a direct positive medical impact in terms of preventing the virus from spreading to those who are most vulnerable [13], but they also have positive societal effects as wearing masks allows for the relaxing of other preventive measures such as strict isolation and quarantining [14]. However, face masks also cover, a major part of the human face, which can crucially affect social interaction. Our faces provide the key information of personal identity; additional socially important information such as trustworthiness, attractiveness, age, and sex, information that supports the understanding of speech by enabling facial speech analysis, as well as fine-grained information that allows for reading the other's emotional state *via* expression analysis [15].

Oxygen is tightly regulated within the body because hypoxemia can lead to many acute adverse effects on individual organ systems. Oxygen saturation is a measure of how much hemoglobin is currently bound to oxygen compared to how much hemoglobin remains unbound. Normal blood O2 saturation is usually defined as a fractional saturation of 90 to 97.5%, which corresponds to an arterial oxygen partial pressure of 13.3 to 13.7 kPa, if there are no other hemoglobin species, apart from oxy and reduced hemoglobin. In a fit healthy individual, this is usually above 95%, although it varies with degree of fitness and current altitude. Due to the critical nature of tissue oxygen consumption in the body, it is essential to be able to monitor current oxygen saturation. Pulse oximetry is a simple and non-invasive method used to examine oxygen saturation (SpO_2) in various parts of the body [16]. Pulse oximeter is used to measure oxygen saturation which is a non-invasive device that is placed over a person's finger or ear lobe. The pulse oximeter was invented in 1972 by Takuo Aoyagi, an electrical engineer at the Nihon Kohden Company in Tokyo [17].
Ventilation is the volume of air that can be taken in or out of the lungs over one minute. In humans, the average ventilation rate is 6 liters/minute. Ventilation and cardiac output increase simultaneously at the onset of exercise. The types of ventilation include pulmonary and alveolar ventilation. Anatomical dead space is the sum of two separate components of lung volume; the first is the nose, pharynx, and conduction airways which do not contribute to gas exchange. Physiological dead space consists of alveoli that are either well-ventilated but poorly perfused (e.g. apex of the lung in upright individuals) or well-perfused but poorly ventilated [18,19].

Physiological effects of the se of masks

Discomforts

Prolonged use of facemasks has been associated with complaints of headaches, and light-headedness, as well as an increase in perceived exertion and perceived shortness of breath (Rebmann *et al*., 2013). Headaches are also a prominent symptom reported by healthcare workers wearing masks during the COVID-19 pandemic [20].

Effect on oxygen saturation

An observational study of 52 surgeons wearing surgical masks revealed a slight decrease in arterial O2 saturation from approximately 98% before surgery to 96% after surgery, which ranged from 1-4 hours in length. Additionally, an increase in heart rate from approximately 85 bpm before surgery to 90 bpm after surgery was also noted [21].

Effect of CO_2

In 2013, Rebmann and colleagues [19] examined the impact of N95 respirators alone compared to N95 respirators with a surgical mask overlay in nurses during a 12-hour shift. Transcutaneous CO_2 became elevated during the 12-hour shift, both in nurses wearing an N95 respirator and N95 respirator with a surgical mask overlay [19]. However, while Co_2 elevations were statistically significant after the 12-hour shift, like the O_2 saturation data discussed above, the changes are likely not clinically important, as Co_2 remained within healthy normal ranges (< 45 mmHg) [19]. These studies [21,19] support that wearing a medical-grade mask does not appear to impact blood oxygen or carbon dioxide concentrations.

Effects on ventilation

Spirometry showed reduced FVC, FEV_1, and PEF with the surgical mask and even greater impairments with the FFP2/N95 mask. Wearing the FFP2/N95 mask resulted in a reduction of *V*O2max by 13% and of ventilation by 23%. These changes are consistent with an increased airway resistance [22,23].

Effect on cardiac function

Increase in breathing resistance may augment and prolong inspiratory activity leading to more negative intrathoracic pressure (ITP) for longer durations. Prolonged and more negative ITP increases the cardiac preload and may lead to higher stroke volume on the one hand which is consistent with our results showing a statistical trend towards higher stroke volume while wearing FFP2/N95 mask or surgical mask [24]. (Convertino *et al*., 2005). In addition, cardiac afterload increases because of an increased transmural left-ventricular pressure resulting in enhanced myocardial oxygen consumption [25].

Effects in relation to performance

Surgical masks, and to a greater extent FFP2/N95 masks, reduce the maximum power (*P*max Watt). Maximum power depends on energy consumption and the maximum oxygen uptake (Vo_2max). The effect of the masks was most pronounced on Vo_2max. Since the cardiac output was similar between the conditions, the reduction of *P*max was primarily driven by the observed reduction of the arterio-venous oxygen content. Therefore, the primary effect of face masks on physical performance in healthy individuals is driven by the reduction of pulmonary function. In addition, the auxiliary breathing muscles have been described to induce an additional afferent drive which can contribute to an increase in the fatigue effect [26,27].

Effects on rate of breathing

Most studies demonstrate increased dyspnea with facemasks compared with controls [28-30], although this is not a universal finding [31].

Effects of facemask in relation to exercise

The World Health Organization does not currently recommend wearing a mask while exercising [32], and the CDC recognizes that it may be difficult to wear a mask during high intensity physical activities. Research examining military grade respirators suggests that there may be alterations to ventilation during high exercise intensities above 85% of maximum oxygen consumption [33].

Effects of face mask in relation to pregnancy

In pregnant women, a recent systematic review demonstrated that N95 masks worn for a short period of time do not impact maternal heart rate, fetal heart rate, respiratory rate, or blood oxygen concentration levels [34]. While prolonged use of cloth masks in pregnant women has not yet been studied, short term use of masks in pregnant women does not appear to create any physiological aberrations.

Mask microclimate and face skin temperatures

Micro-climate (temperature, humidity), subjective ratings and heart rate are significantly influenced by the wearing of different kinds of facemasks. Previous study had observed that delivery of air with different temperatures into a facemask corresponded to the application of a local thermal stimulus to the skin surface around the mouth, nose and cheek. This local thermal stimulus also affected the heat exchange from the respiratory tract. In our investigation, microclimate temperature, humidity and skin temperature inside the facemask increased with the start of step exercise, which led to the different perceptions of humidity, heat and high breathing resistance among the subjects wearing the facemasks. High breathing resistance made it difficult for the subject to breathe and take in sufficient oxygen. Another study had reported that the increases in heart rate, skin temperature and subjective ratings may pose substantial additional stress to the wearer and might reduce work tolerance. This could be the reason why Farquharson reported that working 12hours shifts while wearing an N95 mask had indeed been a challenge to their staff. The surface temperature outside the facemask was lower, and the temperature in the facemask microclimate was significantly higher, for the N95 masks than for the surgical masks indicating that the heat loss from the respiratory tract is more difficult to endure in N95 masks, inducing higher heat stress and perception of discomfort [35,36].

Psychological effects of facemasks

The widespread usage of facemasks is limited largely by feeling they are uncomfortable and concerns of inadequate gas exchange [11]. Specifically, reactance often occurs when people perceive a threat to their freedom of choice, which in turn, leads to efforts to restore that freedom, such as non-compliance [37], anger [38], and derogation of the source. The recommendations for wearing masks in public, and in some cases mandates, may impact perceptions of autonomy if people feel like they do not have a choice over whether or not to wear them.

Oxygen saturation

Oxygen is essential for ATP generation through oxidative phosphorylation, and therefore must be reliably delivered to all metabolically active cells in the body [39,40]. Oxygen is tightly regulated within the body because hypoxemia can lead to many acute adverse effects on individual organ systems. Oxygen saturation is a measure of how much hemoglobin is currently bound to oxygen compared to how much hemoglobin remains unbound. Normal blood O_2 saturation" is usually defined as a fractional saturation of 90 to 97.5%, which corresponds to an arterial oxygen partial pressure of 13.3 to 13.7 kPa, if there are no other hemoglobin species, apart from oxy and reduced hemoglobin. Hemoglobin (Hgb or Hb) is the primary carrier of oxygen in humans. Approximately 98% of oxygen transported in blood is bound to hemoglobin, while only 2% is dissolved directly in plasma [41]. Hemoglobin is a metallo-protein with four subunits, each composed of an iron-containing heme group attached to a globin polypeptide chain [42]. One molecule of oxygen can bind to the iron atom of a heme group, giving each hemoglobin the ability to transport four molecules of oxygen. Various defects in the synthesis or structure of erythrocytes, hemoglobin, or the globin polypeptide chain can impair the oxygen-carrying capacity of blood, leading to hypoxia. Hypoxia can be the result of an impaired oxygen carrying capacity of the blood (e.g. Anemia), impaired unloading of oxygen from hemoglobin in target tissues (e.g. Carbon monoxide toxicity) or from a restriction of blood supply.

Measurement of oxygen saturation

Pulse oximetry is a simple and non-invasive method used to examine oxygen saturation (SpO_2) in various parts of the body [16]. Pulse oximeter is the device used in measuring oxygen saturation which is a non-invasive device that is placed over a person's finger or ear lobe.

Oxy- Haemoglobin curve

Oxygen-hemoglobin dissociation curve is the curve that demonstrates the relationship between partial pressure of oxygen and the percentage saturation of hemoglobin with oxygen. It explains hemoglobin's affinity for oxygen [43]. Normally, in the blood hemoglobin is saturated with oxygen only up to 95%. Saturation of hemoglobin with oxygen depends upon the partial pressure of oxygen. When the partial pressure of oxygen is more, hemoglobin accepts oxygen and when the partial pressure of oxygen is less, hemoglobin releases oxygen. The oxygen-hemoglobin dissociation curve has a sigmoidal shape due to the binding nature of hemoglobin. The sigmoid shape of the oxy-haemoglobin dissociation curve is due to cooperativity between the component globin chains. This means that the affinity of haemoglobin for oxygen is the lowest when the first oxygen molecule binds to the tense, deoxy-haemoglobin molecule, so at a very low partial pressure of oxygen (PO_2), the gradient of the curve is almost flat.

Shift in oxy-haemoglobin curve

A right shift of the oxygen saturation curve indicates decreased oxygen affinity of hemoglobin which will allow more oxygen to be available to tissues. Oxygen-hemoglobin dissociation curve is shifted to right in the following conditions: Decrease in partial pressure of oxygen, increase in partial pressure of carbon dioxide (Bohr effect), increase in hydrogen ion concentration and decrease in pH (acidity), increased body temperature, excess of 2,3-diphosphoglycerate (DPG) in red blood cell [43].

A left shift of the oxygen saturation curve indicates an increase in oxygen affinity of hemoglobin which reduces oxygen availability to the tissues. Factors that cause a left shift in the oxygen-hemoglobin dissociation curve include decreases in temperature, PCO2, acidity, and 2,3-bisphosphoglyceric acid, formerly named 2,3-diphosphoglycerate, decrease in hydrogen ion concentration and increase in pH (alkalinity) (Figure 1).

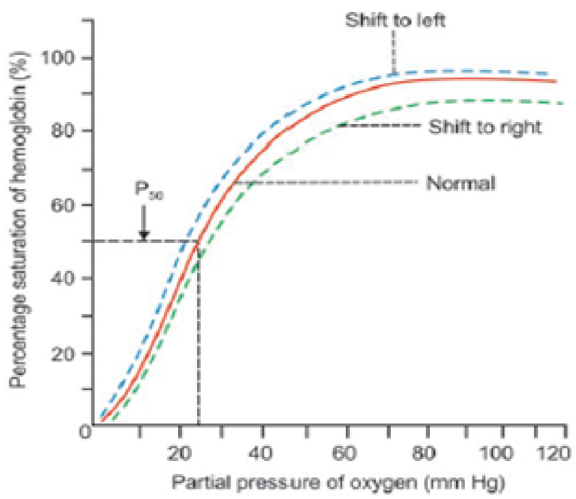

Figure 1: Oxygen-hemoglobin dissociation curve [43].

Ventilation

Ventilation is defined as the rate at which air enters or leaves the lungs.

Types of Ventilation

- Pulmonary ventilation
- Alveolar ventilation

Pulmonary ventilation

Pulmonary ventilation is the inflow and outflow of air between the atmosphere and the lung alveoli [44]. Pulmonary ventilation (Respiratory minute volume) is the volume of air moving in and out of the lungs per minute in quite breathing. It I s a cyclic process by which fresh air enters the lungs and equal volume of air leaves the lungs [43].

Value and calculation of pulmonary ventilation

The normal value of pulmonary ventilation is 6000ml (6litres) per minute Pulmonary ventilation is Tidal volume (TV) Respiratory rate 500ml 12/minutes = 6,000ml (6L) /minute [43].

Importance of pulmonary ventilation

The ultimate importance of pulmonary ventilation is to continually renew the air in the gas exchange areas (alveoli, alveoli sac, alveoli duct and respiratory bronchioles) of the lung, where air is in proximity to the pulmonary blood [44].

Alveolar ventilation

Alveolar ventilation is the rate at which new air reaches the gas exchange areas of the lungs [44]. Alveolar ventilation is the amount of air utilized for gaseous exchange every minute. Alveolar ventilation is the major factor that determines the concentration of oxygen and carbon (iv) oxide in the alveolar [43].

Value and calculation of alveolar ventilation

The normal value of alveolar ventilation is 4200ml (4.2litres) per minute Alveolar ventilation is (Tidal volume-Dead space volume) Respiratory rate (500 - 150) 12/min = 4,200ml (4.2litres) / minute [43].

Dead space ventilation

Dead space represents the volume of ventilated air that does not participate in gas exchange.

Types of dead space

- Anatomical dead space
- Physiological dead space

Anatomical dead space

Anatomical dead space is represented by the volume of air that fills the conducting zone of respiration made up by the nose, trachea, and bronchi. This volume is considered to be 30% of normal tidal volume (500 ml) therefore, the value of anatomic dead space is 150 ml. It is typically 2.2 ml (kg body weight), but is not fixed; varying with posture, breath holding, and lung volume[18].

Physiological dead space

Physiological dead space consists of

1. Anatomical dead space
2. Alveolar dead space

Physiological or total dead space is anatomical dead space plus alveolar dead space which is the volume of air in the respiratory zone that does not take part in gas exchange and consists of alveoli that are either well-ventilated but poorly perfused (e.g. apex of the lung in upright individuals) or well perfused but poorly ventilated (e.g. as in small airway disease) [18]. This can vary with body size and other more subtle factors. The respiratory zone is comprised of respiratory bronchioles, alveolar duct, alveolar sac, and alveoli. In a healthy adult, alveolar dead space can be considered negligible. Therefore, physiologic dead space is equivalent to anatomical dead space [18].

Materials and Methods

Materials

Subject

The study was conducted in the laboratory of the Department of Physiology, University of Benin. 50 active and healthy volunteers of both sexes and within the age range of 25-35 years were recruited from the university. The study was carried out between 9-2 pm after informed consent was granted by the subjects. Subjects with cardiac, pulmonary or inflammatory diseases and smokers were exempted.

Study design

Participants' bio-data were collected using a questionnaire. In this study, participants oxygen saturation (SpO2) and lung function indices were recorded twice, before and after the removal of facemasks after it applied for 2 hours using a pulse oximeter and spirometer respectively. Each subject performed three tests, one with no mask (nm) (control), one with a surgical mask (sm), and one with a cloth mask (cm). Tests were performed at the same time of day within a minimum of 48 hours between two tests and subjects wore the facemask for 2 hours. Subjects were encouraged to speak and behave in their usual manner throughout mask application and mask position did not vary during the procedures (never below the nose) to ensure adequate nose and mouth coverage. Subjects' oxygen saturation and lung function indices were recorded twice, just before the use of mask (baseline) and immediately after the removal of the mask after it was applied for 2 hours. For the spirometry measurements, each subject in a standing position was instructed on the need to put maximum effort into blowing into the digital spirometer [45]. Subjects were asked to hold the mouthpiece around the opening of the mouth in such a way that the mouth completely goes tightly around the opening of the mouthpiece to prevent leakage of air. Subjects were then asked to inspire maximally and then expire forcibly at once through the mouthpiece into the spirometer. Each subject had three attempts and values for each subject were recorded from the screen and the highest of the three values was taken. For pulse oximetry measurement, pulse oximeter with a reusable clip-type finger probe was used and a finger probe was applied to the second finger of the right hand and values for baseline were recorded. Following 2hours of wearing the mask without varying the position of the masks during the procedures (never below the nose), oxygen saturation and spirometry measurements were recorded. For each subject, we calculated the mean of the two SpO_2 and spirometry readings for each period (before and after the use of the mask).

Masks

Disposable sterile one-way surgical paper masks and cloth masks were provided for the subjects and the mask position did not vary during the procedures (never below the nose).

Measurement

Pulse oximeter with a reusable clip-type finger probe was used to measure the blood O_2 saturation during the study. For all measurements, finger probe was applied to the second finger of the right hand. Spirometry measurements were recorded using a digital spirometer. For each modality (nm, sm, cm), data of three expiratory manoeuvres with 5mins intervals were recorded using the best values obtained for forced vital capacity (FVC), forced expiratory volume in 1st second (FEV_1), and peak expiratory flow rate (PEFR).

Ethical clearance

Ethical clearance was obtained for the research.

Results

Data was expressed as means ± standard error of mean (SEM). Statistical analysis was carried out using GraphPad Prism 8.1 software. ANOVA and Tukey's multiple comparisons test were performed to test for comparisons between test and control and P < 0.05 was considered statistically significant (Figures 2-5) (Table 1).

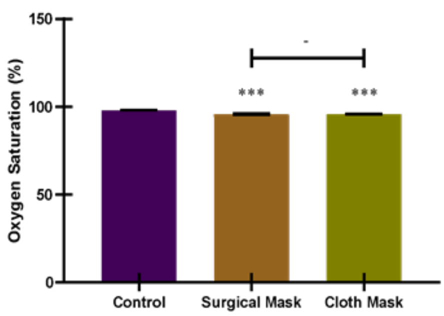

Figure 2: Effects of face masks on oxygen saturation in humans.

Result shows a statistically significant decrease in oxygen saturation in subjects who wore surgical and cloth masks compared with control (p<0.05). There was no significant difference between those who wore cloth masks and those who wore surgical masks (p>0.05).

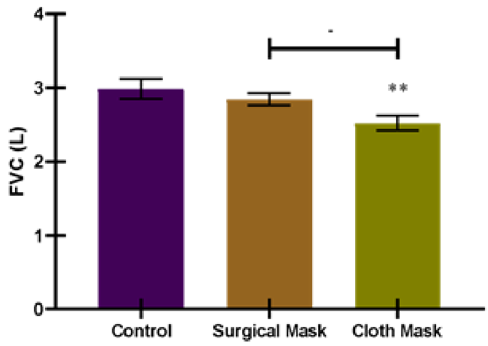

Figure 3: Effects of face masks on Forced vital capacity in humans.

Results show a statistically significant decrease in FVC in subjects who wore cloth masks but none in subjects who wore surgical masks compared with control (p<0.05). There was also no significant difference between those who wore cloth masks and those who wore surgical masks (p>0.05).

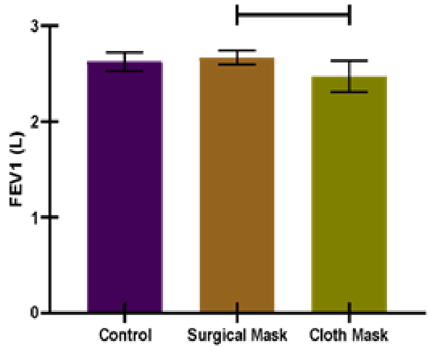

Figure 4: Effects of face masks on forced expiratory volume in one second in humans.

Results show a statistically significance decrease in FEV1 in subjects who wore cloth masks but not in subjects who wore surgical masks compared with control. There was also no significant difference between those who wore cloth masks and those who wore surgical masks (p>0.05).

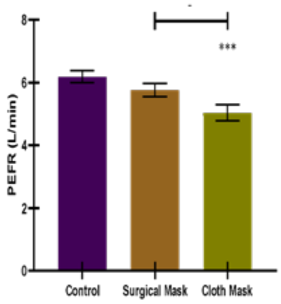

Figure 5: Effects of face masks on peak expiratory flow rate in humans.

Result shows a statistically significant decrease in PEFR in subjects who wore cloth masks but none in subjects who wore surgical masks compared with control (p<0.05). There was also no significance difference between those who wore cloth mask compared to subjects who wore surgical masks (p>0.05) (Table 1).

	Control	Surgical Mask	Cloth Mask
Pulse Rate	82.86±1.516	88.14±2.016	88.34±1.732
Oxygen Saturation	98.14±0.1512	95.94±0.5955***	95.8±0.3692***
FVC	2.986±0.1356	2.843±0.08337	2.521±0.09929**
FEV1	2.628±0.09757	2.669±0.07255	2.472±0.1635
PEFR	6.195±0.1876	5.765±0.2062	5.038±0.2562***

Table 1: It shows the mean for all indices taken plus standard error of mean. The level of significance is also indicated.

Discussion

This present study was carried out to examine the effects of the use of facemasks on oxygen saturation and lung function indices. From the results of this study, oxygen saturation level was significantly decreased by the use of both surgical mask and cloth mask compared with control. This finding is consistent with that of [21] which reported a decrease in oxygen saturation levels in surgeons with surgical masks during surgery but contrary to that of [23,46]. The decrease in oxygen saturation might have resulted from the increased CO_2 content of the inspired air(re-breathing) due to the exhaled CO_2 getting trapped beneath the surgical face mask [47]. While the changes in O_2 saturation in both masks were statistically significant, they are not clinically important given that, the oxygen saturation of subjects with both masks remained within the normal range (90–98%) [21]. Also, the decrease in oxygen saturation may not be sufficient to induce hypoxia (value less than 60%) since the oxygen saturation of the subjects immediately after the removal of both masks after application for 2 hours remained at 95% which is still within the normal clinical range in healthy individuals. It is thought that after a very short time, the barrier function of face mask is gone [48]. Thus, it is hard to believe that these masks serve as a reducer of oxygen uptake, but they may be acting as a psychological restriction over spontaneous breathing.

The result of this study also showed a significant decrease in FVC, FEV_1 and PEFR in subjects who wore cloth masks but no significant difference in subjects who wore surgical masks compared with control. This indicates a decrease in ventilatory function with the use of a cloth mask but not with a surgical mask. With cloth masks, this finding is consistent with that of [23,49,50] which reported that surgical masks showed no statistically significant or clinically significant effects on ventilation. With cloth masks, this finding is contrary to that of [23] which reported that cloth masks do not affect ventilation. The reduction in ventilatory function could have resulted from the increase in inhalation and exhalation resistance and a lower breathing frequency [50-52]. The increase in inhalation and exhalation (breathing) resistance, was likely caused by exhaled moisture that was retained by the mask. The increased breathing resistance means that greater air force would be needed for the air to pass through the mask, which in humans, could mean an increase in respiratory muscle use. This study demonstrated that there may be a small increase in breathing resistance while wearing a mask which is in agreement with [49]. Although these changes were relatively minor, the individual wearing the mask can perceive these changes in breathing. Therefore, the observed changes in ventilatory function are small enough to have minimal clinical implications.

This study also showed that both surgical and cloth masks were associated with some degree of discomfort and suffocation with a higher degree in cloth masks than in surgical masks. It would appear that, the degree of discomfort associated with face masks greatly depends on the duration of use, how tight or loose fitted it is, type of materials and design used, and the number of layers of the mask.

Conclusion

In conclusion, face masks have slight effects on oxygen saturation and ventilatory function which is clinically negligible since the observed effects are minimal and not sufficient to induce hypoxia and breathing-related problems. Thus, the use of facemasks is safe, especially the surgical mask. Consequently, the use of masks during pandemics of airborne diseases becomes a necessity but the duration of use, condition of use and the choice of mask may be an important factor of consideration since mask is associated with discomforts. Above all, the reduction of virus transmission and the potentially life-saving benefits of wearing face masks seem to outweigh the discomforts.

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