TITLE PAGE

ORIGINAL ARTICLE

Title:

Two Hours Of Uninterrupted Masking: The Tolerability Of Face Masks Amidst A Pandemic

Running title:

Comparison of different face masks in COVİD19 pandemic

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AUTHOR'S CONTRIBUTIONS

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- Conception and design of the study.
- Collection, analysis and interpretation of the data.
- Drafting the manuscript and revising it critically for important intellectual content.
- Given final approval of the version to be published.

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All authors declare that they:

1. Have made substantial contributions to design, or acquisition of data, or analysis and interpretation of data;

2. Been involved in drafting the manuscript or revising it critically for important intellectual content; and

3. Given final approval of the version to be published.

4. Agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Title

TWO HOURS OF UNINTERRUPTED MASKING: THE TOLERABILITY OF FACE MASKS AMIDST A PANDEMIC

Abstract

Background/Aim: There is insufficient data on physiological and psychological alterations that may occur among health-care workers wearing various face masks during novel coronavirus-2019 (COVID-19) pandemic. In this study, we aimed to investigate the physiological effects of various types of face masking and associated discomfort among health-care workers.

Methods: This prospective study included 33 healthy health-care workers. Each participant was asked to wear a single surgical mask, double mask, N95 type mask, and surgical mask on N95 type mask for an uninterrupted period of 2 hours. Oxygen saturation, heart pulse, blood pressure, respiratory rate, and step counts were recorded at baseline and every 30 min of 2 hours with a total of five times for each mask type. Self-assessment of fatigue, exhaustion, and headache were also graded. Intra- and inter-group analyses were performed.

Results: There was no significant difference in the oxygen saturation, pulse and respiratory rates among the participants including intra- and inter-groups ($p>0.05$) Although no significant difference was seen in diastolic blood pressure, systolic blood pressures gradually and significantly increased with a double surgical mask ($p<0.05$).

Headache and exhaustion scores increased gradually and significantly over time at every measurement time-point with every mask type ($p<0.05$) Fatigue scores also increased in intra-group comparison of mask types without any difference in-between.

Conclusion: Our study results show that, during 2 hours of period, face mask types affect only subjective parameters such as headache, exhaustion, and fatigue without any change in the objective parameters such as oxygen saturation, and pulse and respiratory rates among health-care workers.

Keywords: COVID-19, face masking, personal protective equipment, surgical mask, N95 mask, hypo-oxygenation.

What's already known about this topic?

- Various masking types have been individually searched for their physiologic effects, particularity for oxygenation in the literature.
- Existing data are limited and, to the best of our knowledge, there is no study comparing four types of masking among health-care workers.

What does this article add?

- Two hours of uninterrupted face masking with various mask types does not affect objective physiological parameters.
- Subjective parameters such as headache, fatigue and exhaustion may be altered by using two hours of uninterrupted masking with differences between various mask types.

MAIN TEXT

INTRODUCTION

Novel coronavirus-2019 (COVID-19) infection, which was first reported in Wuhan City, Hubei, China in late December 2019, was declared global pandemic in March 2020 by the World Health Organization (WHO) after the virus spread to all around the world and its consequences led to devastating results with an ongoing high number of deaths (1-5). At the time of writing this report (October 2020), there has been more than 43 million cases of COVID-19 reported in accordance with the case definitions and testing strategies in the affected countries, including 1. 355,963 deaths (6). Highly contagious severe acute respiratory syndrome-coronavirus 2 (SARS-CoV-2) virus causing acute respiratory syndrome is known to be transmitted by direct contact and droplet spread (7).

Health-care workers (HCWs) fighting at the front line during COVID-19 pandemic have been through tough times due to the use of personal protective equipment (PPE) that may have a detrimental effect on their health. During the pandemic, studies investigating the difficult working conditions to which HCWs are exposed are of utmost importance. However, there is a very limited number of studies showing the impact of PPE on vital parameters of HCWs in the literature. The evaluation of physiological impact of mask wearing seems to be helpful for planning working periods of medical staff and for preventing these detrimental effects.

Uninterrupted masking is important at indoor areas such as hospitals which carry a high risk of viral load, as the half-life of the aerosolized virus is between 1.1 and 1.2 hours and the air may contain virus for a long time (7). Face masks have been scientifically proven to decrease this droplet transmission (8). Although uninterrupted use of PPE such as face masks is necessary for prevention as they are recommended by many public health authorities internationally with the aim of preventing new infections, it is almost certain that to comply with this requirement is not so practical due to the suffocative nature of masking. Regular pauses for face masking can be an important issue in these hard times for front-line HCWs. Long-term use of N95 type masks may cause hypo-oxygenation and increased blood carbon dioxide (CO_2) concentrations, leading to complaints including headache and fatigue and complicating long working hours with masks (9). This discomfort causes the workers to wear off the mask for some periods; however, this unprotected period without proper masking increases the risk of contagion. This is also the case for surgical masks by decreasing oxygen saturation as evidenced by a study conducted among surgeons in the operating rooms (10).

In the present study, we aimed to investigate the effects of a single surgical mask, double surgical mask, N95 type mask, and N95 type with a surgical mask on vital parameters such as oxygen saturation, heart pulse, blood pressure, and respiratory rate among HCWs. In the light of the results of this study, our objective was to identify the optimal uninterrupted masking time with proper break times and working schedules in front-line HCWs.

MATERIALS AND METHODS

Study design and study population

This prospective study was conducted at the polyclinics of a tertiary care hospital between July and September,2020. All participants were informed about the nature of the study and a written informed consent was obtained. The study protocol was approved by the Acibadem Mehmet Ali Aydınlar University, Medical School, Board of Ethics (Date: 26/06/2020; No: 2020-13/8). The study was conducted in accordance with the principles of the Declaration of Helsinki.

A total of 33 HCWs including physicians, nurses, administration officers, front desk staff, receptionists, and cleaning staff were included. The presence of acute or chronic systemic diseases such as diabetes (type I or II), heart diseases (congenital or acquired), lung diseases (asthma, chronic obstructive pulmonary disease, bronchitis) for any continuous medication for any medical reason or known vitamin deficiency, cigarette smoking, pregnancy, and any history of infection for the past two weeks were excluded from the study. Complete blood count analysis was performed for every participant to rule out anemia. Those having chronic headaches were also excluded.

Each participant was asked to wear the same type of a single surgical mask (triple-layered surgical mask, certified by the International Organization for Standardization (ISO; 13485; EN-10993-1,5,10, and EN-14683 approved), double mask (same surgical mask used in the single mask), N95 type mask (3M Corp., St. Paul, MN, USA), and surgical mask on N95 type mask for an uninterrupted period of 2 hours in the same time period during working hours between 08:00 AM and 13:00 PM. Completion of the study for each participant lasted for four days, as only one type of masking was tested during one day at the same duration of the day.

Data collection and instruments

Body height and weight of the were noted. Data including oxygen saturation, heart pulse, blood pressure, respiratory rate, and step counts were recorded using a follow-up sheet at baseline and every 30 min of 2 hours with a total of five times for each mask type. Pulse oximetry measurement was performed by an experienced nurse who was unblinded to the study, and a standardized measurement was done using a PC-66B hand-held pulse oximeter (Shenzhen Creative Industry Co. Ltd., Shenzhen P.R. of China) device. Temperature of the hospital environment was always set at 22 to 24ºC through a constant running air-conditioning system of the facility. None of the female participants had nail polishes due to the institutional rules, which may interfere with the pulse oximetry measurements.

Self-assessment of fatigue and exhaustion were also graded with Fatigue Numeric Rating Scale (NRS). The score ranges from 0 to 10 (0-Energetic, no fatigue, 10-worst possible fatigue or exhaustion at all, and 5- completely exhausted) Headache was assessed using the Visual Analog Scale (VAS). The scores are ranked on a 10-cm line from no pain to the worst pain (11).

For step counts, the participants were asked to download a validated Runtastic Pedometer© (Adidas, Germany) application on their Android or IOS mobile phones and record the step counts obtained from this program for standardization. They were also told to carry their phones in their pants' pocket during face masking. Each participant was followed by an auditing staff every 15 min to ensure the proper use of masks and compliance with the study protocol.

Statistical Analysis

Statistical analysis was performed using the SPSS version 26.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency. Distribution of the variables was analyzed using the Kolmogorov-Smirnov test. Regression analysis of dependent variables was carried out using the Friedman and Wilcoxon tests. Intra- and inter-group analyses were performed using the Friedman test (Wilcoxon test).at which a p value of <0.05 was considered statistically significant.

RESULTS

Baseline demographic characteristics of the participants are shown in Table 1. Of the study population,24 were females and 8 were males with a mean age of 28±4.3 (range, 23 to 35) years. The mean BMI was 22.2±2.7 (range, 18.7 to 30.5) kg/m^2.

There was no significant difference in the oxygen saturation in the intra- and inter-group comparisons according to the time-points (0, 30, 60, 90, and 120 min) (Table 2, Figure 1). There was a gradual decrease in the pulse rates with the double surgical mask over time, indicating statistical significance ($p<0.05$). However, the pulse rates were not significantly different between the measurement time-points and between the groups ($p>0.05$), with an exception that pulse rates with the single surgical mask were significantly lower than the other types of masking at only 60 min (Table 3, Figure 2). The increase in the step counts was comparable in the intra- and inter-group analyses ($p>0.05$) (Figure 3). Also, respiratory rates did not significantly change during all types of masks, and the type of mask did not affect the rates significantly ($p>0.05$) (Figure 4). Diastolic blood pressure values were not statistically different in the intra- and inter-group analyses ($p>0.05$), while systolic blood pressure values gradually and significantly increased with double surgical masks ($p<0.05$), indicating no statistically significant difference among the other groups ($p>0.05$) (Table 4, Figures 5, 6).

Furthermore, we observed no intra- or inter-group difference in the subjective scores of headache, fatigue, and exhaustion at the measurement time-points. However, headache and exhaustion scores gradually increased over time at every measurement within every mask type, indicating a statistically significant difference among the mask types ($p<0.05$). Fatigue scores did only significantly differ from headache and exhaustion scores at 30 min of measurement in which there was no significant difference of scores among the mask types ($p>0.05$); however, a gradual and statistically significant increase was observed in the intra-group analysis ($p<0.05$) (Tables 5, 6, 7).

DISCUSSION

COVID-19 infection declared by the WHO as pandemic in March 2020 has caused a high number of deaths globally since the start of the pandemic (1-5). This highly contagious and deadly virus is known to spread by droplets in the air and direct contact (7). Face masking is offered strongly and mandatory in many countries especially at public places during the pandemic.(12,13) The reason for this extensive social obligation is related to the high viral contagion and uncertainty of infection clinics caused by the virus. A total of 44% of the COVID-19 infections can be transmitted from human to human, before the symptoms of the illness appear and, moreover, some patients may have a positive test for COVID-19 with no sign of the infection ever (14,15). Recently, the United States, one of the most affected countries of the pandemics, Centers for Disease Control and Prevention (CDC) declared that the main transmission way is through respiratory droplets produced when an infected person coughs, sneezes, or talks while direct contact is thought to be inferior to the former (16). In addition, the half-life of the aerosolized virus ranges between 1.1 and 1.2 hours, and air may contain viruses for a long time (7). This finding suggests that uninterrupted masking is important for protection at centers such as hospitals which carry a high risk of viral load.

Surgical mask, double surgical mask, N95 type mask, and surgical mask on a N95 type mask are the types of facial masking which have been proved to prevent viral transmissions and used since previous pandemics, such as SARS (17-21). When face masking is necessary or mandatory in the health-care setting, selection of the mask type to be used is related to the governmental or institutional regulations, to the departments of the hospitals (e.g., intensive care unit), to the availability of the mask types and, rarely, to the individual preferences. However, wearing an uninterrupted face mask for a long time may be troublesome for HCWs, for every type of face masking described above.

To the best of our knowledge, there is no study comparing four types of facial masking described above in terms of discomfort and mask-related symptoms. As expected, hypo-oxygenation and hypercarbia are the main side effects of facial masking. Other symptoms such as tachycardia, tachypnea, and elevated blood pressure can be compensatory mechanisms of this low oxygen level. Even at low oxygen levels in the air, its level may be normal in the blood due to these compensatory mechanisms. Therefore, in the present study, we evaluated the pulse rate, blood pressure, and respiratory rate and assessed the related changes and consequences of hypoxemia, thereby, preventing us from failing to notice low oxygen delivery of the face mask types, even if measurement of the oxygen saturation was normal.

As a standard of clinical care, pulse oximetry can measure arterial oxygen saturation with clinically acceptable accuracy. Motion artifact, nail polish, hypotension carboxy-hemoglobinemia, presence of intravascular dyes, change in systemic vascular resistance, vasoconstriction, and anemia may decrease the performance of pulse oximetry (22,23). However, age, sex, body weight, body temperature, hemoglobin concentration, and pulse pressure have little effects on the accuracy of pulse oximeters in detecting hypoxemia, with an absolute mean error of less than 1.0%, compared to *in vitro* saturation measurements (24-26). Therefore, we believe that hypoxia assessment of facial masking in our study can be done with the oxygen saturation levels as measured by pulse oximetry. To increase its reliability, pulse oximetry measurements were performed by an experienced nurse who was unblinded to the study using a standardized measurement method. Constant room temperature and humidity inside the hospital building and the absence of anemia were the other factors which increase the accuracy of these measurements.

In this study, each participant used four types of masking, which makes our study more valuable, since tolerance to hypo-oxygenation was able to be measured and compared in the same participant. However, the number of participants was limited by the available and appropriate HCWs who met the inclusion criteria and eligible at our hospital. The BMI was also included in the study to standardize lung capacities of the participants, as those with high BMI values demonstrated reduced lung volumes and capacities compared to those with normal BMI values in the literature (27). In our study, the mean BMI values were within the normal range. The age of the participants was also restricted (younger than 35 years), as one study performed among surgeons showed that age-related decrease of oxygen levels due to facial surgical masks was more prominent after 35 years old (10). Thus, as the number of participants is limited in this study, additional contribution of BMI and aging on measured masking effects would be a difficult factor for the discriminant statistical analysis, and this limitation led us to apply this age exclusion criterion to form a homogeneous population along with the normal BMIs.

For the evaluation of the step count, we used a free Runtastic Pedometer application which can be downloaded on both android and IOS mobile phones. A previous study showed that the Runtastic Pedometer application was a more accurate step counter in controlled settings than the wearable Yamax SW200™ Digi-Walker (Yamasa Tokei Keiki Co. Ltd., Tokyo, Japan) device, which has a proven reliability in measuring step counts (28). The objective of these studies was counting the steps accurately, as the main goal of a pedometer is to calculate the required step counts daily. However, in our study, we attempted to find the proportion or increase of the step counts during 2 hours of masking, rather than the exact number to eliminate motional artifacts in measurements. The participants were asked to put their mobile phones in the pocket of their pants and to walk at moderate or high speed during their movements to obtain the best results from the pedometer application. The increases in steps between recording times gave us an indirect opinion about the body activity of the participant, which may affect oxygen saturation by consuming it rather than blockage by the mask. Additionally, timing of mask wearing was scheduled at the same time of the working day. The results of step counts did not significantly differ among the mask types. We believe that these considerations prevented the measurements from being effected by the factors unrelated to face masks.

In the current study, the duration of uninterrupted masking was 2 hours. In a study, Lim et al. (9) assessed headaches caused by N95 masks among HCWs for 4 hours of uninterrupted masking, as this duration was the actual daily working hours without any break for the participants of this study. The authors concluded that headaches following the use of the N95 face masks could develop in HCWs and shorter duration of face mask wear could reduce the frequency and severity of these headaches. Nonetheless, these aforementioned authors recommended that durations less than 4 hours of masking should be also investigated for mask-related headache. Again, Kao et al. (29) evaluated physiological effects, mainly oxygenation, in patients with end-stage renal disease during hemodialysis, a 4-hour procedure, and found a decrease in the oxygen saturation caused by N95 type mask. However, in a controlled clinical study in pregnant HCWs, the impacts of N95 type masks on respiratory functions were examined for a total of 50 min including a 15-min light-intensity exercise (30). Wearing N95 masks were found to complicate gaseous exchange and posed an additional workload on the metabolic system of pregnant HCWs. In this study, mask wearing for longer periods was unable to be evaluated due to ethical concerns. In our hospital, HCWs have an 8-hour working schedule with 2-hour breaks daily designated by the hospital regulations and additional breaks must be used in separate times, usually arranged as 2-hour working time and 15- or 30-min breaks, all of which are compatible with the Labour Act of Republic of Turkey (31). We believe that 2-hour time frame is adequate to compare four types of mask, as there is no consensus on optimal duration of face masking to be used in researches in the literature.

In our study, we observed a gradual, but statistically significant decrease in the pulse rate over time with only double surgical masking. This decline would not seem to cause clinically important changes, On the other hand, pulse rates were comparable among the measurements at prespecified time points and in-group mask types, with an exception that pulse rates with single surgical masking were significantly lower than the other types of masking at 60 min. Additionally, although there was a statistically significant increase in the systolic pressure with a double surgical mask, we believe that this level of increase is not of clinical relevance in young population.

Fatigue, exhaustion, and headache are known symptoms of hypo-oxygenation. However, headaches may have a variety of sub-types according to the International Headache Society recommendations (32). We, therefore, evaluated headache symptoms in detail, while fatigue and exhaustion feelings were also asked using a self-administered questionnaire with a score ranging from 0 to 5. The use of face masks may lead to headaches and previous studies have demonstrated that masking duration of more than 4 hours and pre-existing headaches may trigger headache (9,33). This may be related to mask type (i.e., tight elastic straps), while external factors such as inadequate hydration, irregular eating or sleep deprivation during pandemic may be also causative and physiological changes to oxygen and CO_2 balance are unlikely to cause headaches during face masking as mentioned in the literature (34) As in fatigue and exhaustion, we believe that the increased severity of headache with masking for less than 4 hours may be related to psychological or emotional stress in an individual having no pre-existing headache.

Limitations

There are some limitations to this study. First, the sample size is limited, due to the nature of the study. During these difficult times of the pandemic, it is not easy to accomplish a study with a large number of participants, since strict study rules and auditing would put more stress on HCWs, when they are already working under a heavy workload. Additionally, exact oxygen and carbon dioxide levels can be obtained by obtaining partial pressures, but this measurement is also impossible to be performed at HCWs during pandemic. Nonetheless, the main strength of this study is that it was performed at a homogenous population of HCWs and comparisons are done without any artifacts that may affect oxygenation other than face masking.

CONCLUSION

In conclusion, the COVID-19 pandemic has forced the whole world to adopt new ways of living, working in this COVID-19 era. front-line HCWs are defined as the riskiest population during this war and mask wearing in the prevention of droplet-borne and airborne virus infection is critical. On the other hand, the use of different types of masks has not much questioned whether they cause physiological changes in the human body. Therefore, in this study, we attempted to evaluate changes objectively and subjectively with prespecified parameters. Our results showed that, during 2 hours of working period, face mask types affected only subjective parameters such as headache, exhaustion, and fatigue without any changes in the objective parameters such as oxygen saturation, and pulse and respiratory rates among HCWs. Pulse rates changed at only 60 min in favor of a lower measurement with only one surgical mask type. We believe that this increase in other types is due to the habits of the participants, as they were used to wearing a single surgical mask at work with interruptions probably coinciding with one-hour period. This may have produced a feeling of suffocation with other mask types, increasing the pulse rate emotionally. Again, systolic pressure increase with a double surgical mask can be explained by this effect. Nonetheless, further well-designed, large-scale, prospective studies are needed to confirm these findings and to draw a firm conclusion.

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Tables

Table 1. Baseline demographic characteristics of the participants

		Minimum-Maximum	Median	Mean±SD /n-% †
Age		23.0 - 35.0	27.0	28.0 ± 4.3
Gender	Female			24 - 72.7%
	Male			9 - 27.3%
Height (cm)		150.0 - 187.0	166.0	165.6 ± 8.6
Weight (kg)		45.0 - 88.0	57.0	61.2 ± 11.3
Body Mass Index		18.7 - 30.5	22.1	22.2 ± 2.7

†: Mean ± Standart Deviation/ Number -Percentage

Table 2. Oxygen saturation levels in the intra- and inter-group comparisons according to the timepoints.

		Oxygen Saturation				Inter-group Variance p values
		Single Surgical Mask	Double Surgical Mask	N95 Mask	SM+N95 Mask†	
Baseline	Mean±SD	98.3 ± 1.2	97.8 ± 1.6	98.2 ± 1.4	98.0 ± 1.4	0.383 ‡
	Median §	99.0	98.0	98.0	98.0	
30.Minute	Mean±SD	97.8 ± 1.4	97.8 ± 1.6	97.8 ± 1.5	97.9 ± 1.5	0.948 ‡
	Median §	98.0	98.0	98.0	98.0	
60.Minute	Mean±SD	97.8 ± 1.3	97.4 ± 1.5	97.7 ± 1.8	97.5 ± 2.0	0.292 ‡
	Median	98.0	97.0	98.0	98.0	
90.Minute	Mean±SD	97.8 ± 1.5	97.6 ± 1.4	97.5 ± 1.7	97.6 ± 1.6	0.779 ‡
	Median §	98.0	97.0	98.0	98.0	
120.Minute	Mean±SD	97.8 ± 1.6	97.5 ± 2.2	97.7 ± 1.8	97.1 ± 2.7	0.051 ‡
	Median §	98.0	98.0	98.0	97.0	
In-group Variance p values		0.125 ‡	0.327 ‡	0.604 ‡	0.054 ‡	

†: Single Surgical Mask with N95 ‡: Friedman test §: Mean ± Standart Deviation

Table 3. Pulse rates in the intra- and inter-group comparisons according to the timepoints.

		Pulse Rates				Inter-group Variance p value
		Single Surgical Mask	Double Surgical Mask	N95 Mask	SM+N95Mask †	
Baseline	Mean±SD§	80.8 ± 12.9	81.4 ± 12.0	80.9 ± 11.6	81.8 ± 13.9	0.370 ‡
	Median	80.0	78.0	80.0	82.0	
30.Minute	Mean±SD§	79.3 ± 9.4	78.7 ± 10.6	79.2 ± 10.1	81.3 ± 10.7	0.109 ‡
	Median	80.0	77.0	78.0	82.0	
60.Minute	Mean±SD§	77.5 ± 10.8[4]	77.9 ± 12.0[4]	79.4 ± 9.6[4]	81.6 ± 9.3	***0.012*** ‡*
	Median	76.0	77.0	78.0	82.0	
90.Minute	Mean±SD§	78.2 ± 12.6	76.8 ± 10.6	80.0 ± 11.0	79.2 ± 11.4	0.118 ‡
	Median	75.0	77.0	80.0	80.0	
120.Minute	Mean±SD§	77.4 ± 12.1	75.3 ± 10.5	78.7 ± 13.6	80.7 ± 12.6	0.052 ‡
	Median	76.0	74.0	77.0	80.0	
In-group Variance p value		0.156 ‡	***0.017*** ‡,*	0.901 ‡	0.151 ‡	

†: Single Surgical Mask with N95/ ‡: Friedman test (Wilcoxon test)/ §: Mean ± Standart Deviation
*: p<0.05

Table 4. Systolic pressure levels in the intra- and inter-group comparisons according to the timepoints.

		Systolic Pressure				Inter-group Variance- p value
		Single Surgical Mask	Double Surgical Mask	N95 Mask	SM+N95Mask †	
Baseline	Mean±SD§	113.3 ± 14.2	111.1 ± 12.6	110.7 ± 10.2	114.9 ± 12.8	0.051 ‡
	Median	110.0	110.0	110.0	115.0	
30.Minute	Mean±SD§	112.9 ± 13.0	115.2 ± 13.5	111.4 ± 12.6	112.9 ± 10.7	0.237 ‡
	Median	110.0	110.0	110.0	115.0	
60.Minute	Mean±SD§	109.2 ± 10.5	112.3 ± 11.5	113.0 ± 13.5	112.1 ± 11.2	0.055 ‡
	Median	110.0	110.0	110.0	115.0	
90.Minute	Mean±SD§	111.0 ± 11.1	114.7 ± 12.1	109.7 ± 11.4	113.7 ± 13.8	0.051 ‡
	Median	110.0	115.0	110.0	111.0	
120.Minute	Mean±SD§	111.1 ± 10.1[2]	115.6 ± 11.0	112.0 ± 11.1[2]	113.3 ± 12.2[2]	0.084 ‡
	Median	110.0	118.0	110.0	112.0	
In-group Variance-p value		0.115 ‡	***0.002*** ‡*	0.577 ‡	0.424 ‡	

†: Single Surgical Mask with N95 ‡: Friedman test (Wilcoxon test) §: Mean ± Standart Deviation *: p<0.05

Table 5. Headache scores in the intra- and inter-group comparisons according to the

timepoints.

		Head Ache				Inter-group Variance p
		Single Surgical Mask	Double Surgical Mask	N95 Mask	SM+N95Mask†	
Baseline	Mean±SD §	1.40 ± 1.62	1.70 ± 1,74	1.46 ± 1.60	1.58 ± 1.98	0.316 ‡
	Median	2.00	2.00	2.00	2.00	
30.Minute	Mean±SD§	1.58 ± 1.56[234]	2.36 ± 2.22[4]	2.18 ± 1.88[4]	2.36 ± 2.32	***0.032*** ‡,*
	Median	2.00	2.00	2.00	2.00	
60.Minute	Mean±SD§	2.06 ± 1.96[34]	2.36 ± 1.96	2.84 ± 2.56	3.10 ± 2.40	***0.006*** ‡,*
	Median	2.00	2.00	2.00	2.00	
90.Minute	Mean±SD§	2.18 ± 2.20[234]	2.90 ± 2.30	3.28 ± 2.58	3.76 ± 2.78	***0.001*** ‡,*
	Median	2.00	2.00	2.00	2.00	
120.Minute	Mean±SD§	2.66 ± 2.76[34]	3.10 ± 2.62[34]	4.06 ± 2.56[4]	4.54 ± 2.88	***0.000*** ‡,*
	Median	2.00	2.00	4.00	4.00	
In-group Variance p-value		***0.000*** ‡,*	***0.000*** ‡,*	***0.000*** ‡,*	***0.000*** ‡,*	

†: Single Surgical Mask with N95 / ‡: Friedman test (Wilcoxon test)/ §: Mean ± Standart Deviation / / 2:Difference with Double Surgical Mask p < 0.05/ 3: Difference with N95 Mask p < 0.05 / 4:Difference with Single Surgical Mask and N95 p < 0.05 /*: p<0.05

Table 6. Fatigue scores in the intra- and inter-group comparisons according to the timepoints.

		Fatigue				Inter-group Variance p-value
		Single Surgical Mask	Double Surgical Mask	N95 Mask	SM+N95Mask†	
Baseline	Mean±SD§	1.09 ± 1.26	0.97 ± 1.02	0.91 ± 0.98	0.97 ± 1.10	0.928 ‡
	Median	1.00	1.00	1.00	1.00	
30.Minute	Mean±SD§	1.33 ± 1.38	1.39 ± 1.20	1.39 ± 1.12	1.48 ± 1.30	0.469 ‡
	Median	1.00	1.00	1.00	1.00	
60.Minute	Mean±SD§	1.27 ± 1.23[4]	1.64 ± 1.16[4]	1.73 ± 1.39[4]	2.06 ± 1.46	***0.010*** ‡,*
	Median	1.00	1.00	1.00	2.00	
90.Minute	Mean±SD§	1.24 ± 1.29[234]	1.76 ± 1.25[34]	1.88 ± 1.36	2.36 ± 1.43	***0.000*** ‡,*
	Median	1.00	2.00	2.00	2.00	
120.Minute	Mean±SD§	1.45 ± 1.34[234]	2.00 ± 1.27	2.36 ± 1.34	2.39 ± 1.43	***0.003*** ‡,*
	Median	1.00	2.00	2.00	2.00	
In-group Variance p-value		***0.005*** ‡,*	***0.000*** ‡,*	***0.000*** ‡,*	***0.000*** ‡,*	

†: Single Surgical Mask with N95 / ‡: Friedman test (Wilcoxon test)/ §: Mean ± Standart Deviation / 2:Difference with Double Surgical Mask p < 0.05/ 3: Difference with N95 Mask p < 0.05 / 4:Difference with Single Surgical Mask and N95 p < 0.05 / *: p<0.05

Table7. Exhaustion scores in the intra- and inter-group comparisons according to the timepoints.

		Exhaustion				Inter-group Variance p value
		Single Surgical Mask	Double Surgical Mask	N95 Mask	SM+N95Mask†	
Baseline	Mean±SD§	0.79 ± 0.86	0.85 ± 0.80	0.91 ± 0.98	0.91 ± 1.10	0.823 ‡
	Median	1.00	1.00	1.00	1.00	
30.Minute	Mean±SD§	0.91 ± 0.91^{234}	1.21 ± 0.99	1.24 ± 1.03	1.42 ± 1.23	***0.032*** ‡,*
	Median	1.00	1.00	1.00	1.00	
60.Minute	Mean±SD§	1.12 ± 1.13^{34}	1.36 ± 1.11^{34}	1.61 ± 1.41	2.06 ± 1.41	***0.006*** ‡,*
	Median	1.00	1.00	1.00	2.00	
90.Minute	Mean±SD§	1.09 ± 1.15^{234}	1.76 ± 1.36^{34}	1.94 ± 1.27	2.27 ± 1.28	***0.000*** ‡,*
	Median	1.00	1.00	2.00	2.00	
120.Minute	Mean±SD§	1.36 ± 1.31^{234}	1.91 ± 1.40	2.21 ± 1.41	2.30 ± 1.40	***0.000*** ‡,*
	Median	1.00	2.00	2.00	2.00	
In-group Variance p value		***0.000*** ‡,*	***0.000*** ‡,*	***0.000*** ‡,*	***0.000*** ‡,*	

†: Single Surgical Mask and N95 / ‡: Friedman test (Wilcoxon test)/ §: Mean ± Standart Deviation / 2:Difference with Double Surgical Mask $p < 0.05$/ 3: Difference with N95 Mask $p < 0.05$ / 4:Difference with Single Surgical Mask and N95 $p < 0.05$ / *: $p<0.05$

FIGURE LEGENDS

Figure-1. :Oxygen saturation levels of 4 types face masking groups by time

Figure-2. :Pulse rates of 4 types face masking groups by time.

Figure-3. :Step counts of 4 types of masking groups by time.

Figure-4. :Respiratory rates of 4 types of masking groups by time.

Figure-5. :Systolic pressure level measurements of 4 types of masking groups by time.

Figure-6. :Diastolic pressure level measurements of 4 types of masking groups by time.

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