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Physiological Changes and Mask-Related Discomforts in Healthcare Personnel Working With Surgical Face Masks at 4-hour and 8-hour Shifts During the COVID-19 Pandemic

COVID-19 Pandemisi Sırasında 4 ve 8 Saatlik Vardiyalarda Cerrahi Yüz Maskesi ile Çalışan Sağlık Personelinde Fizyolojik Değişiklikler ve Maskeye Bağlı Rahatsızlıklar

ABSTRACT

Objective:

Disturbing effects of face masks may be beyond the psychological effect and may endanger healthcare personnel's health. Based on this theory, here, we investigated the mask-related psychological and physiological changes in healthcare personnel working with a surgical face mask for a 4 and 8-hour shift.

Method:

The study was conducted in a tertiary hospital with 102 healthcare workers between January-March 2021. Individuals with heart/lung disease or current smokers were excluded. Body temperature, respiratory/heart rate, blood pressure, fingertip oxygen-saturation (SpO2) measurements of participants, and the mask-discomfort questionnaire were performed at the beginning, mid and end-shift.

Results:

Of the 102 volunteers participating in the study, 63 (61.8%) were women and the mean age was 30.92 ± 6.38. The most disturbing mask discomfort was resistance at mid-shift and fatigue at end-shift. The scores of all parameters in the questionnaire were significantly higher at both mid-shift and end-shift compared to the beginning ($p=0.000$. for all parameters). There were significant increases in scores of humidity, resistance, temperature, salinity, smell, and fatigue at end-shift compared to mid-shift ($p=0.001$, $p=0.023$, $p=0.024$, $p=0.022$, $p=0.013$ and $p<0.000$, respectively). Temperature, blood pressure, heart, and respiratory rate increased significantly ($p<0.001$, for all) at mid-shift compared to the beginning, while SpO2 decreased significantly ($p=0.003$). All parameters except diastolic blood pressure showed significant changes at end-shift compared to the beginning. However, there was no significant difference in parameters at mid-shift and at end-shift.

Conclusion:

Our study revealed significant physiological effects and mask-related discomforts in healthcare personnel working with surgical face masks.

Key Words:

Surgical masks, Physiology, Health Personnel, Psychological Side Effects

Amaç:
Yüz maskelerinin rahatsız edici etkileri psikolojik etkinin ötesinde olabilir ve sağlık personelinin sağlığını tehlikeye atabilir. Bu çalışmada, 4 ve 8 saatlik vardiyalı cerrahi yüz maskesi ile çalışan sağlık personelinde maskeye bağlı psikolojik ve fizyolojik değişiklikleri saptamaktır.

Yöntem:
Çalışma, Ocak-Mart 2021 tarihleri arasında 102 sağlık çalışanı ile üçüncü basamak bir hastanede gerçekleştirildi. Kalp/akciğer hastalığı olan veya halen sigara içen kişiler çalışma dışı bırakıldı. Katılımcıların vücut ısısı, solunum/kalp hızı, kan basıncı, parmak ucu oksijen doygunluğu (SpO2) ölçümleri ve maske-rahatsızlık anketi vardiya başında, ortasında ve sonunda yapıldı.

Bulgular:
Araştırmaya katılan 102 gönüllünün 63'ü (%61,8) kadın olup, yaş ortalaması 30,92 ± 6,38'dir. En rahatsız edici maske rahatsızlığı, vardiya ortasında direnç ve vardiya sonunda yorgunluktu. Anketteki tüm parametrelerin puanları hem vardiya ortasında hem de vardiya sonunda başlangıca göre anlamlı olarak daha yüksekti (tüm parametreler için p=0,000). Vardiya sonunda nem, direnç, sıcaklık, tuzluluk, koku ve yorgunluk puanlarında vardiya ortasına göre anlamlı artışlar vardı (p=0,001, p=0,023, p=0,024, p=0,022, p=0,013 ve p <0,000, sırasıyla). Sıcaklık, kan basıncı, kalp ve solunum hızı, vardiyanın ortasında, başlangıca kıyasla önemli ölçüde artarken (tümü için p<0,001) SpO2 önemli ölçüde azaldı (p=0,003). Diyastolik kan basıncı dışındaki tüm parametreler, vardiya sonunda başlangıca göre önemli değişiklikler gösterdi. Ancak, orta vardiyada ve son vardiyada parametrelerde anlamlı bir fark yoktu.

Sonuç:
Çalışmamız, cerrahi yüz maskeleri ile çalışan sağlık personelinde önemli fizyolojik etkiler ve maskeye bağlı rahatsızlıkları ortaya çıkarmıştır.

Anahtar Kelimeler:
Cerrahi maskeler, Fizyoloji, Sağlık Personeli, Psikolojik Yan Etkiler

INTRODUCTION
Coronavirus disease (COVID-19) is a highly contagious disease caused by a newly discovered virus called severe acute respiratory syndrome coronavirus 2 (SARS-CoV2) (1). SARS-CoV-2 can cause clinical manifestations ranging from mild respiratory symptoms to severe acute respiratory failure syndrome. This virus is spread from person to person primarily through droplets scattered during coughing or sneezing (2). One of the most effective ways of protection from this virus, which spreads rapidly all over the world with these droplets, is the use of masks.

Many international associations and health authorities have recommended the use of masks in all outdoor activities and closed collective work areas. Healthcare workers have to work with masks for long hours. This puts a little more strain on healthcare professionals who are already overwhelmed by too much stress and workload. Moreover, working with a mask during the entire shift under these difficult conditions may endanger the health of healthcare workers.

In this study, we investigated the disturbing effects of the masks and the physiological changes in healthcare personnel working with surgical face masks, and the alterations of these parameters with the working hours.

MATERIAL and METHOD
Written permission was obtained from Akdeniz University Hospital Management for the study.Approval for the study was granted by the Clinical Research Ethics Committee of Akdeniz University (Number: KAEK-235). The research was carried out in accordance with publication ethics and the Declaration of Helsinki. Written informed consent was obtained from the participants.

Participants:
All the participants (n=102) were healthcare personnel working with a surgical face mask in various clinics for 8-hours-daytime-shift. Since they were caring for post-COVID patients or patients with diseases other than COVID-19, they wore only their uniforms and a three-layer surgical face mask as personal protective equipment. Individuals with heart/lung disease or active smokers were not included in the study. A written informed consent was obtained from all participants.

Measurements:
The age, gender, height, and weight information of the healthcare personnel included in the study were recorded. Pre-shift body temperature, respiratory rate, heart rate, blood pressure, fingertip oxygen saturation (SpO2) measurement and the mask discomfort questionnaire were performed. The same measurements were repeated 4 hours later (mid-shift) and 8 hours later (end-shift). All measurements were made by the same assistant physician while wearing a mask and after resting for at least 15 minutes. The mask discomfort questionnaire was developed from a previously performed study conducted by Li et al (2). The 'Mask discomfort questionnaire' contained 10 questions. The participants were questioned “How do you feel with the mask?” and asked rating on a scale ranging from 0 to 10, with 0 representing “not at all”, 5 representing “acceptable” and 10 representing “very fond of”. Pre, mid, and end-shift physiological parameters and mask discomfort questionnaire scores were compared with each other. We used Erka Perfect Aneroid (München, GERMANY) for blood pressure, Jumper Infrared Thermometer (JPD-FR202, Guangdong, CHINA) for body temperature and Carescape Monitor B650, GE Healthcare (Helsinki, Finland) for heart and respiratory rate. All the devices had been calibrated before the measurements.

RESULTS

Of the 102 volunteers participating in the study, 63 (61.8%) were women and the mean age was 30.92 ± 6.38. The measurements were made at the beginning, middle (4th hour), and end (8th hour) of the shifts, and in total, 306 measurements were performed in this study. The average values of the measurements, standard deviations, between-subject repeated measurements ANOVA results, and paired t-test results of physiological parameters at the beginning, mid and end shift are given in table I.

Table I: Physiological parameters of healthcare workers with surgical face mask at the beginning of the shift, mid-shift, and end-shift.

Parameter	Begining of Shift (0th hour)	Mid-shift (4th hour)	End of Shift (8th hour)	ANOVA	0th vs. 4th	4th vs. 8th	0th vs. 8th
Skin Temperature (°C)	36.25 ± 0.22	36.39 ± 0.26	36.44 ± 0.36	**<0.001[b]**	**<0.001**	0.343	**<0.001**
Systolic Blood Pressure (mmHg)	109.53 ± 11.20	113.43 ± 11.15	114.24 ± 13.90	**0.001[b]**	**<0.001**	1.000	**0.006**
Diastolic Blood Pressure (mmHg)	69.10 ± 8.40	71.89 ± 8.04	71.01 ± 9.11	**0.001[a]**	**<0.001**	0.705	0.052
Hearth Rate (beat/min)	83.02 ± 12.40	86.00 ± 12.23	85.57 ± 12.63	**0.001[a]**	**<0.001**	1.000	**0.018**
Respiratory Rate (resp/min)	17.38 ± 3.14	18.16 ± 2.89	18.15 ± 2.83	**<0.001[b]**	**<0.001**	1.000	**<0.001**
SpO_2 (%)	97.79 ± 1.34	97.36 ± 1.49	97.46 ± 1.34	**0.002[b]**	**0.003**	1.000	**0.005**

Measurements of healthy volunteers while wearing surgical mask, at begining shift (begining of shift 0th hour), at mid-shift (mid-shift 4th hour) and, end of shift (end of shift 8th hour) given as mean ± standard deviation. Within subjects repeated measures ANOVA results and paired samples t-test results between begining and 4th hour of shift (0th vs 4th), between 4th hour and end of the shift (4th vs. 8th), between begining and end of the shift (0th vs 8th), given as p-values. Statistically significant results are indicated in bold. a Mauchly's Test of Sphericity a Mauchly's Test of Sphericity was assumed. b Mauchly's Test of Sphericity was not performed, Greenhouse-Geisser correction was used (Ɛ<0.75).

Changes in physiological parameters

The mean body temperature of the participants at the beginning of the shift was 36.25 ± 0.22°C. Body temperature increased by an average of 0.133°C (0.37%) at the mid-shift (4th hour) while it increased by 0.189°C (0.52%) at the end of the shift (8th hour). There was a significant increase in the body temperature at the end of the shift compared to the beginning of the shift (p<0.001). There was no statistically significant difference in body temperature between the mid and end of the shift (p=0.343).

There was an also progressive increase in blood pressure with the working hours. Systolic blood pressure increased significantly by the mid and end of the shift compared to the beginning of the shift (p<0.001, p=0.006, respectively). Systolic blood pressure increased by an average of 3.902 mmHg (3.56%) in the middle of the shift and 4.706 mmHg (4.15%) at the end of the shift, compared to the beginning of the shift. But there was no statistically significant difference in systolic blood pressure between the mid and end of the shift (p=1.000). Diastolic blood pressure at the mid-shift increased by an average of 2.794 mmHg (4.04%), compared to the beginning of the shift and this increase was statistically significant (p<0.001). But there was no significant difference in diastolic pressure between neither the beginning and the end shift and nor the mid and end shift (p<0.001 and p=0.069, respectively).

At mid-shift, the heart rate increased by an average of 2.98 beats/min (3.59%), while at the end-shift, heart rate increased by an average of 2.45 beats/min (2.96%) compared to the beginning, and these increases were statistically significant (p=0.001, p=0.018, respectively). But there was no significant difference between mid-hours and end-of-hours heart rate measurements (p=1.000).

The mean respiratory rate at mid and end shifts was significantly higher than in the beginning (p<0.001, p<0.001, respectively).There was an average increase of 0.775 breaths/min (4.46%) in the respiratory rate at the mid-shift and 0.765 breaths/min (4.21%) at the end-shift. Fingertip oxygen saturation decreased significantly at the end shift compared to the beginning (p=0.005). The decrease in oxygen saturation at mid-shift compared to the beginning was also significant (p= 0.003). But there was no significant difference in oxygen saturation at mid shift and end shift (p=1.000).

Mask Incompatibility Survey

The average values and standard deviations of the scores given by the participants to the mask incompatibility survey and repeated measurements in ANOVA and the results of the matched t-test analysis are given in table II.

The most disturbing mask discomfort was resistance at mid-shift and fatigue at the end shift. All the scores of the parameters in the Mask Incompatibility Survey increased progressively with the working hours. There was a significant increase in the scores of all mask-discomfort parameters at the mid and end shifts compared to the beginning. There was a significant increase in scores of some mask-discomfort parameters at the end shift compared to the mid-shift also. These were humidity, resistance, temperature, salinity, smell,

and p<0.000, respectively). However, there was no significant difference between mid-shift and end-shift scores to itching, tightness, and incompatibility questions (p=0.056, p=0.125, p=0.230, respectively).

Table II: Disturbing effects of surgical face mask in healthcare workers at the beginning of the shift, mid-shift, and end-shift.

Parameter	Begining of Shift (0th hour)	Mid-shift (4th hour)	After Shift (8th hour)	ANOVA	0th vs. 4th	4th vs. 8th	0th vs. 8th
Moisture	2.88 ± 2.94	5.71 ± 2.84	6.73 ± 2.96	**0.000[a]**	**0.000**	**0.001**	**0.000**
Heat	3.11 ± 3.02	6.10 ± 2.77	6.86 ± 2.84	**0.000[b]**	**0.000**	**0.024**	**0.000**
Resistance	3.51 ± 2.94	6.32 ± 2.53	7.10 ± 2.85	**0.000[a]**	**0.000**	**0.023**	**0.000**
Itchiness	1.81 ± 2.40	3.83 ± 3.30	4.35 ± 3.80	**0.000[b]**	**0.000**	0.056	**0.000**
Tightness	3.61 ± 3.08	5.66 ± 2.81	6.21 ± 3.13	**0.000[b]**	**0.000**	0.125	**0.000**
Saltiness	1.50 ± 2.46	3.22 ± 3.32	3.80 ± 3.83	**0.000[b]**	**0.000**	**0.022**	**0.000**
Incompatibility	3.24 ± 2.96	4.73 ± 3.28	5.18 ± 3.48	**0.000[a]**	**0.000**	0.237	**0.000**
Odor	3.35 ± 3.34	4.81 ± 3.14	5.45 ± 3.49	**0.000[b]**	**0.000**	**0.013**	**0.000**
Fatigue	3.09 ± 3.25	5.99 ± 2.93	7.44 ± 3.11	**0.000[b]**	**0.000**	**0.000**	**0.000**
Overal discomfort	5.25 ± 3.65	6.98 ± 2.90	7.48 ± 3.18	**0.000[b]**	**0.000**	**0.047**	**0.000**

Discomfort survey results of healthy volunteers at begining of shift (0th hour), mid-shift (4th hour) and end-shift (8th hour) given as mean ± standard deviation. Repeated measures ANOVA and paired samples t-test results between begining and 4th hour of shift (0th vs 4th), between 4th hour and end of the shift (4th vs. 8th), between begining and end of the shift (0th vs 8th), given as p-values. Statiscally significant results are indicated in bold. a Mauchly's Test of Sphericity was performed. b Mauchly's Test of Sphericity was not performed , used Greenhouse - Geisser correction (Ɛ<0.75).

DISCUSSION

Here in this study, we investigated the discomfort caused by the use of masks and the physiological changes that develop during the work in healthcare workers. We observed that the most disturbing mask effects were resistance, heat, fatigue, and moisture in descending scores. Relatively, itchiness, saltiness, odor were more tolerable ailments. Healthcare workers did not complain too much about the tightness and incompatibility of the masks. All these mask-related disturbing perceptions increased by the progressing working hours. At the end of the shift, the hardest mask-related discomforts to endure were resistance, heat, and fatigue. In addition, the mask may not only cause the perception of mask-related discomfort but may also be responsible for some important physiological changes. There was a significant increase in body temperature, blood pressure, heart rate and respiratory rate and a significant decrease in oxygen saturation during working with surgical face mask.

Resistance seems to be the most bothering feeling in surgical face mask use among healthcare workers. It is not known whether this is psychological, or perception of the physiological changes related to face masks. Masks may change the airway resistance. N95 has been shown to increase inspiratory and expiratory airflow resistance (3,4). Additionally, the average minimum cross-sectional area of the nasal cavity increased with the use of a 3-hour face mask that caused an increase in nasal resistance (5). Moreover, N95 resulted in greater nasal resistance than the surgical face mask and this change in the nasal cavity continued for a while after the mask was removed (5). Apart from changes in nasal resistance, the mask may also impair respiratory functions. Previously, the surgical mask was determined to cause a significant decrease in forced expiratory volume in one second (FEV1), forced vital capacity (FVC) and peak expiratory flow (PEF) (6). In contrast, in another study, the only pulmonary function test parameter that decreased significantly after mask use was maximal voluntary ventilation, and FEV1, FVC, PEF did not change with mask use (7). It is not certain whether the masks contribute to the increase in upper and even lower airway resistance or not, but it is obvious that they cause a resistance perception that contributes to the overall discomfort during working.

The second most disturbing mask-effect was the heat in our study. Body temperature is regulated by many mechanisms based on the stimuli from thermoreceptors all over the body. The majority of these receptors are located in the skin of the face (8-10). Previously, the facial mask was found to increase the facial temperature by 5 °C in surgeons (11). Recently, Scarano et al. demonstrated perioral skin temperature increase by thermal infrared imaging (12). It is estimated that there occurs a microclimate beneath the mask. Presumably, the temperature of this microclimate is higher than in the outer region of the mask, which is why mask wearers perceive more heat. While the heat felt by the stimulation of the perioral temperature receptors increases, the body skin temperature is expected to decrease through negative

feedback such as sweating. But, in our study, body temperature also increased beside the perception of heat. Reflex negative feedbacks, during the intense muscle activity, seem to be insufficient to reduce body temperature. Thus, working with masks results in much more heat perception.
The other major discomforts of the healthcare personnel working with surgical face masks were fatigue, moisture, tightness, and odor in our study. The most disturbing effects of the masks were more tolerable by the mid-shift. Working with a mask for 8 hours was tiring. Both resistance and fatigue at the end shift were significantly higher compared to mid-shift. The severity of all other mask-related discomforts other than itchiness, tightness, and incompatibility at the end shift was significantly higher than the mid shift also. Overall discomfort related to working with masks for 8 hours in healthcare centers was much more intense than working for 4 hours. Moreover, fatigue and resistance reached levels that pushed the limits of endurance by the end of the shift. Therefore, we suggest rearranging the shift hours of healthcare professionals working with surgical face masks during pandemics.

Apart from the subjective-perceptional effects, working with a surgical face mask resulted in also significant objective-physiological changes in healthcare workers. We found that the respiratory rate in healthcare workers with surgical face masks increased significantly in the mid and end shift compared to the beginning. Based on previous studies, masks are supposed to cause an increase in airway resistance (5,6, 13). The increasing respiratory rate could be a compensation mechanism to maintain tidal volume despite increased airway resistance. However, increased breathing rate and respiratory resistance can cause respiratory overload and fatigue in healthcare workers. So, one of the reasons for this so much fatigue at the end of the shift may be respiratory overload during working with masks.

Excessive respiratory muscle activity results in increased energy consumption and heat release. Besides these, it is well-known that in case of an increase in respiratory work, a significant part of the cardiac output is directed to the respiratory musculature (14). Additionally, also heart rate increases to meet the energy demand of respiratory muscles. In a previous study, the heart rates of workers working with a respirator both in the experimental laboratory environment and in the real field were found to be significantly increased (15). Previous studies have revealed that the increase in intrathoracic pressure due to increased airway resistance caused by masks give rise to the augmentation in both preload and afterload, and overall cardiac overload (16-18).

Besides heart and respiratory rate increase, we found that the oxygen saturation decreased significantly at mid-shift and end-shift. Similarly, the surgical mask caused decreased SpO2 during major surgery (19). Decreased O2 delivery leads to an increase in heart rate and blood pressure. All of these can lead to increased left ventricular pressures and thus coronary demand (20). This excessive cardiac and pulmonary stress possibly contribute to the early and exaggerated feeling of fatigue at the end of the shift.
There are also some limitations of this study. Firstly, the workload and working areas were not uniform in our study, so we could not measure the workload of healthcare workers. We did not perform any external intervention to the daily workload of the individuals in this real-life study. Secondly, we could not standardize the temperature and humidity that may affect the discomfort score. Finally, in our study, there was no control group. Especially fatigue and all other findings may not be directly associated with the mask. Prolonged workload and overtime may have caused all of these. There should have been a control group to distinguish whether they were caused by the mask, but due to the pandemic, a control group could not be created. It was not possible to perform the measurements in healthcare personnel working without surgical face masks.

CONCLUSION

In conclusion, we observed in our study that the healthcare personnel working with surgical face masks during the whole shift have some mask-related discomforts. The most disturbing-mask-effects were resistance, heat, fatigue, and moisture. Our study revealed also significant physiological changes. Many of the psychological and physiological parameters were getting worse by the increasing workhours. Long term effect of these physiological changes over health is not known.

Ethics Committee Approval:
This research complies with all the relevant national regulations, institutional policies and is in accordance with the tenets of the Helsinki Declaration, and has been approved by the Akdeniz Medical Faculty Ethical Committee, Akdeniz University (approval number: KAEK-235).

Informed Consent:
All the participants' rights were protected and written informed consents were obtained before the procedures according to the Helsinki Declaration.

Author Contributions:
Concept – H.D., T.A., E.A.; Design - H.D., T.A.; Supervision - H.D.; Resources - T.A..; Materials - T.A., E.A.; Data Collection and/or Processing - T.A., E.A.; Analysis and/ or Interpretation - E.A.; Literature Search - H.D.; Writing Manuscript - H.D.; Critical Review - H.D., T.A., E.A.

Conflict of Interest:
The authors have no conflict of interest to declare.

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