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Research Article

The Effects of Long-Term N95 Mask Use on Contrast Sensitivity, Distance and Near Visual Acuity

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ABSTRACT

Objectives: We aimed to investigate the effect of long-term N95 mask use on contrast sensitivity, best-corrected distance visual acuity, and near visual acuity.

Method: This cross-sectional study included healthy participants, who were between 20-40 years of age, had BCVA between 20/20-20/16, spherical or cylindrical refraction errors less than 2 diopters, and normal intraocular pressure. Contrast sensitivity, best-corrected distance visual acuity and near visual acuity measurements before wearing an N95 mask and after the participant wore an N95 mask for at least 3 hours mask were compared.

Result: The study included 55 eyes from 55 healthy participants and the mean age of participants was 31.54 years ± 5.48 years (21 years-39 years). The differences in near visual acuitiy and contrast sensitivity between before mask use and 3 hours of N95 mask use were statistically significant ($p<0.05$ for both). However, there was no significant difference in best-corrected distance visual acuity, spherical and cylindrical refractive error.

Conclusıon: Long-term use of masks did not cause a significant decrease in best-corrected distance visual acuity or change in spherical and cylindrical refractive error. However, significant decreases were observed in near visual acuity and contrast sensitivity.

Keywords: Contrast sensitivity; SARS-CoV-2; N95 mask; Best-corrected distance visual acuity; Near visual acuity

INTRODUCTION

The COVID-19 epidemic, which was caused by the "Serious Acute Respiratory Syndrome Coronavirus 2" (SARS-CoV-2), has spread very rapidly all over the world and has been threatening the health of all humanity [1]. The SARS-CoV-2 virus is not only transmitted from person to person through respiratory droplets, but close contact is another mode of transmission [2-4]. COVID-19 is characterized by atypical pneumonia, which can cause fatal disease [5]. New variants resulting from mutations such as omicron and delta variant pose a high potential risk of transmission [6]. Therefore, protection from virus transmission by the use of personal protective equipment and masks has become more important.

After the use of masks has become a priority in our lives, some negative effects such as headache, cognitive impairment, and fatigue have been observed by long-term mask users [7]. So far, there have been a few researches on the possible negative effects of masks [8-12]. In a study compiling the scientifically proven side effects of wearing a mask, the symptoms including mask-induced psychological and physical deterioration was defined as Mask-Induced Exhaustion Syndrome (MIES).

Adverse changes caused by the mask may be considered relatively insignificant at first, but after repeated exposure over long periods, long-term adverse effects of the masks can occur. Therefore, studies that present the possible effects of masks are clinically relevant. Especially in studies examining the relationship between mask use and headache, it has been shown that mask use causes carbon dioxide re-inhalation and cerebral vasodilation due to hypercapnia [13]. Studies examining the effect of long-term mask use on choroidal thickness and circulation have shown that; a significant increase in choroidal thickness is observed during mask use [14,15].

Based on this, we planned to investigate the clinical significance of this condition. Additionally, since the beginning of the

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pandemic, we have noticed an increase in complaints of visual impairment, especially in healthcare workers who have to work for long hours with N95 masks. We aimed to investigate the effect of long-term mask use on contrast sensitivity, distance, and near visual acuity.

MATERIALS AND METHODS

This cross-sectional study was performed at the ophthalmology department of hospital between November 2021 and December 2021. The study was approved by a local ethics committee, and written informed consent was obtained from each participant in accordance with the principles of the declaration of helsinki.

The medical and ophthalmological history was obtained from all the participants included in the study. Participants were included in the study if they were between 20 years-40 years of age and had BCVA between 20/20-20/16, spherical or cylindrical refraction errors less than 2 diopters, normal IOP. Participants were excluded from the study if they had more than 2 diopters of spherical or cylindrical refractive error, a history of ocular trauma, ocular surgery or any ocular disease, BCVA less than 20/20.

All participants underwent a detailed ophthalmological examination, which included refraction, Best-Corrected Distance Visual Acuity (BCDVA), Near Visual Acuity (NVA), Contrast Sensitivity (CS), slit-lamp biomicroscopy, Intraocular Pressure (IOP) measurements, and fundus examination. The right eyes of all participants were included and the non-tested eye was covered with an occluder. BCDVA was tested using the snellen chart at 6 meters. NVA was tested using a near chart raging between 20/200 and 20/20 in 0.1 Logarithm of the Minimal Angle of Resolution (logMAR) intervals at 0.35 meters (Figure 1) [16]. Visual acuity values were converted to logMAR units. The contrast sensitivity testing was obtained using a pelli robson test, which has 16 triplets of sloan letters of constant size at 1 meter. The triplets were ranged between 0.00 log units to 2.25 log units. If the participant could not read 2 out of 3 letters correctly in a triplet, the test was terminated and the log CS score was recorded. The tests were performed twice by two different observers (G.G, G.K.D) in order to prevent bias and the scores averaged. Measurements were first made before wearing an N95 mask and after the participant wore an N95 mask for at least 3 hours without removing it while doing office work without effort. The BCDVA, CS, and NVA before and after wearing the N95 mask were compared.

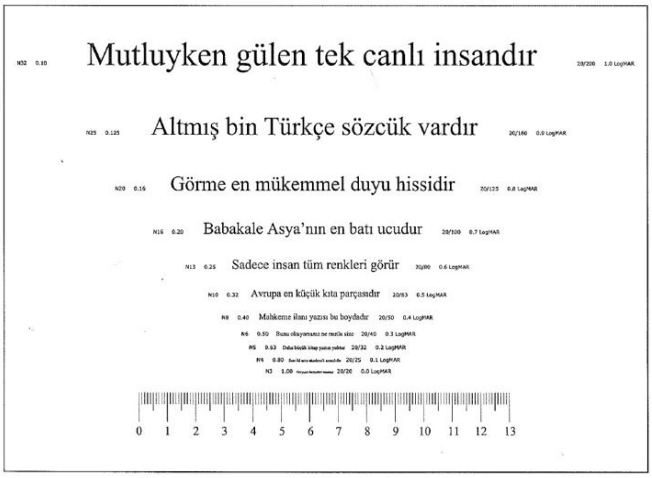

Figure 1: NVA was tested using a near chart raging between 20/200 and 20/20 in 0.1 logarithm of the minimal angle of resolution (logMAR) intervals at 0.35 meters.

Statistical analysis

All statistical analyses were performed using SPSS 20.0® for windows (IBM corporation, Armonk, NY). Descriptive statistics included the mean ± Standard Deviation (SD), percentage, minimum (min), and maximum (max) for normally distributed variables. The distributions of variables were measured with the kolmogorov smirnov test. For quantitative analysis, the dependent-sample t-test was used for normally distributed variables, and the wilcoxon signed-rank test was used when the measurements did not fit the normal distribution. A p value<0.05 was considered statistically significant.

RESULTS

The study included 55 eyes from 55 healthy participants (28 women (50.9%); 27 men (49.09%)). The mean age of participants was 31.54 ± 5.48 years (21-39 years). The mean of spherical refractive error was 0.31 ± 1.17 (min: -2.00, max: 2.00) diopter and the mean of cylindrical refractive error was -0.75± 0.48 (min: -2.00, max: 0.00) diopter (Table 1).

Table 1: The baseline data of participants.

The number of participants (n)	**55**
Gender (n)	
Woman	28 (50.9%)
Men	27 (49.09%)
The mean of age	31.54 ± 5.48 (21-39) years
The mean of spherical refractive error	0.31 ± 1.17 (min: -2.00, max: 2.00) D

The mean of cylindrical refractive error	0.75± 0.48 (min: -2.00, max: 0.00) D
D: Diopter; min: minimum; max: maximum	

Before wearing the N95 mask, the mean BCDVA was -0.02± 0.04 (min: -0.1, max: 0.0) logMAR, NVA was 0.04 ± 0.06 (min: 0.0, max: 0.2) logMAR, and CS was 2.1± 0.03 (min: 1.95, max: 2.25). Three hours after wearing of the N95 mask, the mean BCDVA was -0.02± 0.03 (min: -0.1, max: 0.05) logMAR, NVA was 0.09 ± 0.07 (min: 0.0, max: 0.3) logMAR, and CS was 2.04± 0.13 (min: 1.65, max: 2.10). The mean of spherical refractive error was 0.27 ± 1.17 (min: -2.00, max: 2.25) diopter and the mean of cylindrical refractive error was -0.77 ± 0.48 (min: -2.00, max: 0.00) diopter 3 hours after mask use. The differences in NVA and CS between before mask use and 3 hours of N95 mask use were statistically significant ($p<0.05$ for both). However, there were no significant difference in spherical refractive error, cylindrical refractive error and BCDVA. (p=0.81, p=0.89 and p=0.07 respectively (Table 2).

Table 2: The Spherical refractive error, cylindrical refractive error, BCDVA, NVA and CS measurements before and 2 hours after wearing of N95 mask.

BCDVA (logMAR)	**Before N95 wearing**	**3 hours after N95 wearing**	**p Value**
	-0.02 ± 0.04	-0.02 ± 0.03	0.07
	(min: -0.1, max: 0.0)	(min: -0.1, max: 0.05)	
Spherical refractive error (D)	0.31 ± 1.17	0.27 ± 1.17	0.81
	(min: -2.00, max: 2.00)	(min: -2.00, max: 2.25)	
Cylindrical refractive error (D)	-0.75 ± 0.48	-0.77± 0.48	0.89
	(min: -2.00, max: 0.00)	(min: -2.00, max: 0.00)	
NVA (logMAR)	0.04 ± 0.06	0.09 ± 0.07	<0.05
	(min: 0.0, max: 0.2)	(min: 0.0, max: 0.3)	
CS (logMAR)	2.1 ± 0.03	2.04 ± 0.13	<0.05
	(min: 1.95, max: 2.25)	(min: 1.65, max: 2.10)	

D: Diopter, BCDV: Best-Corrected Distance Visual acuity, NVA: Near Visual Acuity, CS: Contrast Sensitivity, logMAR; logarithm of the Minimal Angle of Resolution, min: minimum, max: maximum.

DISCUSSION

After the widespread use of masks, some negative symptoms have begun to be observed, especially in long-term mask users, and headache has been one of them. In a study of 343 participants examining the effects of wearing surgical-type masks and N95 masks among healthcare professionals, it has been observed that wearing a mask caused detectable physical side effects such as cognitive impairment (24% of participants) and headaches (71.4% of participants) [17]. There have been other studies examining the increase in headache frequency and its causes due to the widespread use of masks [18-21]. The scientists explained these neurological disorders based on proven quantitative data as a mask-induced latent decrease in blood gas Oxygen (O_2) levels (toward hypoxia) or a latent increase in blood gas Carbon Dioxide (CO_2) levels (toward hypercapnia). In a trial involving 154 healthy N95 healthcare mask-wearers, researchers observed that mask-induced increase in blood carbon dioxide levels resulted in a significant increase in cerebral artery flow and they claimed that this caused headaches. Accordingly, neurologists have reported that mask is not suitable for patients who has epilepsy because it induces hyperventilation.

In an experimental study, a significant increase in brain parenchyma volume and a decrease in cerebrospinal fluid spaces were observed under increased arterial CO_2 levels. The authors interpreted this increase in brain volume as an increase in blood volume and dilation of cerebral vessels due to increased CO_2. Related to this study, studies reporting the changes in choroidal thickness and choroidal vascular area have been reported. These changes indicate an increase in choroidal blood volume and dilation of the choroidal vessels due to relative hypercapnia.

Complaints of visual impairment by mask-users have increased since the beginning of the pandemic. There are not many studies on the clinical effects of mask use in the literature. Significant decrease in the schirmer-1 test, tear break-up time and increase in Ocular Surface Disease Index (OSDI) scores after prolonged mask use have been reported. In a study evaluating patients with primary open-angle glaucoma, it was reported that N95 and surgical masks did not affect IOP levels at rest, but increased IOP when walking. A study with a great number of participants demonstrated that the longer time of mask use resulted in greater OSDİ and patients with prior dry eye disease had greater OSDI scores compared to those without it to the best of our knowledge, there is not any study reporting the clinical effects of prolonged N95 mask use on visual functions. In our study, we aimed to address the clinical significance of prolonged mask use and evaluated the changes in best-corrected distance visual acuity, near visual acuity, and contrast sensitivity after 3 hours of mask use. In our study with 55 participants, the NVA and CS values which were measured after 3 hours of mask use were found to be statistically significantly lower compared to measurements without a mask. (both $p<0.05$) However, no significant difference in spherical refractive error, cylindrical refractive error, and best-corrected distance visual acuity was observed (Supplementary file).

The reason for the significant decrease in NVA in patients in our study is that, according to our hypothesis, the significant amount of choroidal thickening seen as a result of long-term mask use affects the accommodation process. In one study, it was reported that sub foveal choroidal thickness thinning was observed with accommodation. Both sub foveal and para foveal choroidal thinning were found to be statistically significant at 3D and above accommodation levels. Other studies have shown that during accommodation, contractile cells called Nonvascular Smooth Muscle (NVSM) in the choroid contract in response to increased parasympathetic input and subsequently cause thinning of the choroid. We suggest that the increase in choroidal thickness, which we think is due to hypercapnia as a result of long-term use of masks, negatively affects the accommodation process and decreases NVA.

Contrast sensitivity and visual acuity are important constituents of visual functions. Many factors such as opacities in the optic path, tear film changes, neural factors, or age may affect CS. Decreased contrast sensitivity in response to hypercapnia has been previously reported. An experimental study evaluating the effects of hypoxia on visual functions showed decreased contrast sensitivity, although visual acuity remained unchanged. According to our findings, relative hypercapnia due to CO_2 re-inhalation may result in CS reduction after prolonged mask use.

The effects of the pandemic still continue all over the world and the use of masks continues to be a part of our lives. We think that long-term and repetitive mask exposure may lead to negative consequences in the long run. Our study is important in terms of the clinical meaning of the effects of long-term mask use on the eye. As far as we know, there is no other study on this subject in the literature.

There were several limitations to our study; our relatively small sample size and our evaluation of healthy patients aged 20 years-40 years in our study. Further studies evaluating different age groups and more patients are needed. In our study, the participants were evaluated during office work. We believe that the results of using masks during work that requires more effort will be more exaggerated. There is a need for studies examining the effects of mask use at different effort levels with more participants.

CONCLUSION

In our study examining the clinical importance of long-term use of masks, it was observed that long-term use of masks did not cause a significant difference in refractive error and distance vision, but significant decreases were observed in near vision and contrast sensitivity. Visual complaints may be seen in people who perform jobs that require near vision, if they work with the N95 mask on for long hours.

CONFLICT OF INTEREST

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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STATEMENT OF ETHICS

The study was approved by Chiba university ethics committee. (desicion number: 2021/327)

AUTHOR CONTRIBUTIONS

G.G; data collection, writing, statistical analyses, the design of the study, G.K.D; The design of the study, data collection, writing, and interpretation of data.

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