Available online at **www.ijmrhs.com**

ISSN No: 2319-5886

International Journal of Medical Research & Health Sciences, 2021, 10(2): 51-54

The Effect of Wearing an N95 Mask on the Blood Gas Values of Healthcare Providers

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ABSTRACT

Background: *The use of N95 masks by Healthcare Providers (HCPs) has increased throughout the COVID-19 pandemic. Thus, the question arises as to whether wearing this type of mask influences the concentration of carbon dioxide (CO_2) and oxygen (O_2) in the blood.* ***Methods:*** *We analyzed CO_2 and O_2 concentrations, measured in millimeter mercury. Our inclusion criteria were as follows: wearing N95 mask continuously for four hours, and working in an acute care setting that mandates continuous physical activity. Excluded were those who interrupted the four hours and those who voluntarily quit the study. We measured the partial pressure of CO_2 and O_2 from venous blood samples taken before and after wearing the N95 mask.* ***Results:*** *The total number of participants included in our analysis was 43, with a 100% follow-up rate. We noted that there is a significant difference in pCO_2 level between the first reading (M=42.37, SD=6.77) and the second reading (M=44.56, SD=6.39); t(42)= -201, p=0.05. We also noted a significant difference in the level of the first pO_2 (M=55, SD=24.59) and the second pO_2 readings (M=45.71, SD=24.46); t(42)=2.62, p<0.05.* ***Conclusion:*** *The wearing of the N95 mask for as long as four continuous hours is associated with the risk of hypoxia and a slight increase in CO_2 concentrationsy.*

Keywords: N95 mask, COVID-19, Respiratory protective devices, Health personal

INTRODUCTION

The wearing of N95 masks by Healthcare Providers (HCPs) has increased during the COVID-19 pandemic. The virulence of such a virus, questions surrounding its airborne transmissibility, and the asymptomatic nature of some cases, begs the use of N95 masks when interacting with patients [1,2]. In a recent meta-analysis, surgical masks demonstrated protection comparable to that of N95 masks for non-aerosol generating procedures; however, at the onset of any pandemic, when facts are still scarce, the N95 mask remains the first option [3].

Several physiological parameters are influenced by the wearing of the N95 mask. These include an increased heart rate and respiratory rate; while the effect on the blood gas analysis, after an hour's physical activity, is an increased carbon dioxide level and reduced oxygen saturation [4-6]. Furthermore, the forced expiratory volume and the peak expiratory flow were both reduced [7]. Those with underlying respiratory illnesses exhibit more profound effects from such changes [8]. The aim of this study, therefore, is to investigate the CO_2 and O_2 blood concentrations of HCPs who wear N95 masks during their duties.

MATERIALS AND METHODS

We conducted a cross-sectional study in a tertiary hospital over the period 19/06/2020 to 03/08/2020. Those eligible for inclusion were HCPs who wore the N95 mask continuously for four hours. Moreover, to capture those with a high level of physical activity while wearing the N95 mask, we included only those working in an acute care setting, such as a busy Emergency Department (ED)-the ED in which the study took place received, during the period of analysis, a mean of 140 patients per day with a standard deviation of 20 patients. Excluded were those who interrupted the four-hour continuous period and those who voluntarily quit the study. The N95 mask used was 3M N95 NIOSH

size 1680, the 1680s, and 1870 (Maplewood, Minneapolis, USA) and Kimberly-Clark standard size (Roswell, New Mexico, USA).

We obtained two samples of Venous Blood Gas (VBG) from each of the participants. The participation was voluntary and consented. The data collectors were two registered nurses, who were responsible for data collection and drawing blood-all the blood was drawn from the upper limb veins. The blood was analyzed using the ABL90 Flex blood gas analyzer (Copenhagen, Denmark). The data were analyzed by the Statistical Package for Social Sciences (SPSS) software version 25. We reported the mean and the SD in mmHg before and after the specified period of the study, and we compared the levels using a paired sample t-test. We also explored the effect of age on CO_2 and pO_2 using a correlation coefficient. The effect of gender was investigated using an independent sample t-test, while one-way Analysis of Variance (ANOVA) was used to measure the effect of comorbidities on blood gas levels. We adhered to the STROBE guidelines for reporting our analysis [9].

Using VBG readings for pCO_2 is highly accurate compared to Arterial Blood Gas (ABG) analysis in those who are non-mechanically ventilated [10,11]. The measurement of venous oxygen concentration correlates with the arterial concentrations even in patients with lung diseases [12]. Consequently, we used a venous sample, also to mitigate the risk of injury from arterial cannulation.

RESULTS

Demographics

The total number of participants included in our analysis was 43. The majority were female 86% (n=37), while males comprised 14% (n=6). The participants' mean age was 35 years old, SD=7.95, ranging between 24 to 54 years of age. Only two of the participants were smokers. An inquiry about comorbidities revealed that only one of the participants had Diabetes Mellitus, five were hypertensive, while the majority were medically free. The follow-up rate was 100%.

CO_2 Level Pre-and Post-Wearing of the N95 Mask

Using a paired sample t-test, we noted that there is a significant difference in pCO_2 level between the first reading (M=42.37, SD=6.77) and the second reading (M=44.56, SD=6.39); t(42)= -201, p=0.05. The mean difference was 2.19 mmHg (95% CI= -0.004 to 4.382), SD of 7.13 mmHg.

O_2 Level Pre-and Post-Wearing of the N95 Mask

Likewise, using a paired sample t-test, we noted a significant difference in the level of the first pO_2 (M=55, SD=24.59) and the second pO2 readings (M=45.71, SD=24.46); t(42)=2.62, $p<0.05$. The mean difference is 9.31 mmHg (95% CI=2.14 to 16.474), SD of 23.28 mmHg.

Age, Gender and Comorbidities

The age, gender, and comorbidities did not influence the pCO_2 and pO_2, as illustrated in Table 1.

Table 1 Illustrates the influence of age, gender, and comorbidities on the difference in the pCO_2 and pO_2 concentrations

	The difference in the CO_2 concentrations	The difference in the O_2 concentrations	p-value
The effect of age	r=0.133	r=0.08	>0.05
The effect of gender	t(41)=-0.20	t(41)=-0.52	>0.05
The effect of comorbidities	F(3)=0.23	F(3)=0.43	>0.05
r: Pearson's Correlation; t: Levene's Test for Equality of Variances; F: one-way ANOVA test			

DISCUSSION

To our knowledge, this is the first study to examine the effect of wearing the N95 mask for a continuous four-hour period accompanied by physical activity. We noted a significant difference in the levels of venous CO_2 and O_2 in those wearing the N95 mask for four continuous hours. While the rise in CO_2 levels was small, the reduction in O_2 levels was far more noticeable. We noted an approximately 10-millimeter mercury decrease in O_2 levels in the venous system.

Wearing N95 mask during exertion produces a more noticeable physiological effect. We assert that such hypoxia and hypercapnia may seem clinically insignificant in healthy individuals; however, this does not hold for those with baseline mild hypoxia, those prone to hypoxia, or hypoxia-related illnesses.

This analysis implies that wearing the N95 mask has its consequences. Healthcare providers should protect themselves during epidemics but should have the opportunity to remove their masks more often during their shift. In our analysis, mask "time off" was zero minutes during the four hours, which resulted in a reduction in O_2 and slight CO_2 retention. We advocate a frequent mask "time off", within less than four hours in a healthy individual. It may also be prudent to extrapolate such findings and recommend a more frequent mask "time off", especially among those who may be harmed by a slight degree of hypoxia.

Recently, equal protection was noted between surgical masks and N95 masks for non-aerosol generating procedures [3]. However, in ED, various aerosol-generating procedures are implicated in spreading infection, including manual ventilation, intubation, and non-invasive positive pressure ventilation [13]. Such risk is assumed in every ED practice, notably in a setting that enforces proximity or confinement. Overall, our study's limitation lies in the fact that our participants did not have respiratory comorbidities; hence, further studies are encouraged with a larger sample size to assess the clinical effects of decreased pO_2 and CO_2 retention on at-risk and comorbid populations.

CONCLUSION

Overall, wearing N95 mask continuously for a long duration significantly decreases pO_2 levels and increases CO_2 concentrations, although it is uncertain whether these physiological parameters would produce a clinical impact on a healthy individual. We advocate removing the N95 mask more frequently within four hours to preserve the health of the HCPs and their masks.

DECLARATIONS

Conflicts of Interest

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

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