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EFFECTS OF THE USE OF N95 MASK ON OXYGEN SATURATION, HEMODYNAMIC STATUS AND PHYSICAL PERFORMANCE OF NURSES

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ABSTRACT
COVID-19 was an emerging disease that can be transmitted rapidly via droplets and aerosols with a high mortality rate. During pandemic, nurses had a high risk of contracting COVID-19 so efforts to prevent transmission need to be made by using personal protective equipment (PPE). N95 masks were the standard personal protective equipment recommended by WHO, however wearing N95 masks for a long period of time can cause physiological stress, namely breathing, body heat balance, vision, communication, feeling comfortable, difficulty eating and sneezing as well as other PPE worn. This study aimed to identify the effect of using N95 masks on oxygen saturation, hemodynamic status and physical performance in nurses at X Hospital. The research method used was a pre-experimental design, one group pre and post test, including one intervention group that measured lung function and physical performance. The sampling technique in this research was non-probability sampling with purposive sampling of 94 respondents. Respondents underwent a pretest, then lung function and physical performance were examined after 4 hours of using an N95 mask. The results of data analysis using the Wilxocon test showed that there were differences in oxygen saturation (p-value = 0.000), hemodynamic status such as respiratory frequency (p-value = 0.000), systolic blood pressure (p-value = 0.012) and pulse frequency (p- value = 0.000), as well as the physical performance of nurses (p-value = 0.000) before and after using the N95 mask. The results of this research can contribute to standardizing the use of PPE and preventing complications due to changes in oxygen saturation and hemodynamic status so that nurses physical performance improves.

Keywords: hemodynamic status; N95 mask; nurse performance; oxygen saturation

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INTRODUCTION

COVID-19 or Corona virus disease was an emerging disease during 2019 which had aggressive spread, high mortality rate, no definitive theraphy, and increasing new cases during 2019 – 2021 pandemic (Susilo et al., 2020). Signs and symptoms of COVID-19 patients vary from asymptomatic to mild, moderate and severe. COVID-19 patients with signs and symptoms such as pneumonia, ARDS, sepsis to septic shock are included in the severe signs and symptoms requiring hospitalization (Gugus Tugas Percepatan Penanganan Covid-19, 2020). In healthcare, nurses are part of the frontline in managing COVID-19 cases. One of the roles of nurses, namely as caregivers, was to provide 24 hours care for COVID-19 patients in clinical settings (Chen et al., 2020). COVID-19 was an RNA virus of the genus betacoronavirus that can be transmitted from person to person via droplets when coughing or sneezing (Han & Yang, 2020). The virus can also be transmitted via aerosols for at least 3

hours (Doremalen et al., 2020). Therefore, during that time nurses, which serve as care providers in hospitals, were at high risk of contracting COVID-19.

Efforts to prevent the spread of COVID-19 were a top priority for WHO, which had issued guidelines for the rational use of personal protective equipment (PPE) for health workers who provide direct health services to patients to avoid contracting COVID-19. One of the PPE that must be worn by nurses was the N95 mask. The benefits of N95 masks were to filter fine airborne particles from the respiratory tract and to prevent person-to-person transmission. Research conducted by Loeb et al., (2009) on 446 randomized nurses found that surgical masks can also protect against influenza viruses from laboratory results. However, the difference in protection between surgical masks and N95 masks was significant, with N95 masks being more effective at filtration than surgical masks (Zhu, Jian Hua Zhu, Lee, Shu Jin, Wang, De Yun, Lee, 2014). This result was also supported by the results of a study by Ng et al., (2020) who found that 85% of nurses were exposed to COVID-19 through aerosols during procedures while wearing surgical masks.

N95 masks have a protective function, but they also have a wearing effect on the respiratory microclimate, respiratory function, and comfort of the individual wearing them. A study conducted by Zhu, Jian Hua Zhu, Lee, Shu Jin, Wang, De Yun, Lee (2014) on 77 healthy healthcare workers on the effects of wearing N95 masks and surgical masks for 3 hours using rhinomanometry found that all respondents felt uncomfortable breathing, the level of discomfort increased over time while wearing a mask, and the N95 mask caused higher nasal resistance after use than surgical masks. Long-term use of N95 respirators has also been reported to cause physiological stress, including respiration, body heat balance, vision, communication, comfort, difficulty eating, and sneezing and other PPE worn (Johnson, 2016).

Respiration does not normally limit the performance of healthy individuals; however low respiration rate can limit the working time when N95 masks are worn. This causes a limit when breathing time is reduced to half or more. A longed low respiration rate can cause discomfort for nurses while providing care to patients, reduce the physical performance of nurses, and may affect hospital management in terms of human resource management. The purpose of this study was to determine the effect of using N95 masks on oxygen saturation, hemodynamic status, and physical performance of nurses. The results of this study are expected to be useful for nursing services, especially hospitals, in preventing the effects of using N95 masks, setting standards in the use of N95 masks on nurses, and improving the physical performance of nurses so that they can provide holistic nursing care to COVID-19 patients.

METHOD

This research was a quantitative study with pre-experimental designs one group pre and post test, which was conducted at Hospital X Jakarta in September - November 2021. Total subjects enrolled in this study was 94 people. Sampling was done using non-probability sampling method with purposive sampling technique, where sampling from the population was in accordance with the inclusion and exclusion criteria determined by the researcher. The population used in this study were nurses at Hospital X Jakarta with inclusion criteria, namely nurses who served in a special unit for the care of COVID-19 patients, aged 21-56 years, not short of breath and chest pain, and willing to participate in research activities. Exclusion criteria were nurses working in the regular treatment room and suffering from ARI or other respiratory diseases. The intervention was administered once when the respondent was on

duty in the COVID-19 isolation unit. Before using the N95 mask, the respondents measured oxygen saturation, hemodynamic status, i.e. blood pressure, pulse rate, respiratory rate, and body temperature, and completed a physical performance questionnaire with 18 questions related to physical complaints. The post-test was conducted 4 hours after the nurses wore the N95 masks in the form of measuring oxygen saturation, hemodynamic status, and completing the physical performance questionnaire for nurses.

The Physical Performance Questionnaire, comprising 18 closed questions, was employed to assess the physical performance of nurses before and after the use of N95 masks during their work. The questionnaire comprised affirmative statements pertaining to numbers 5, 9, 10, 11, and 17. The negative statements were numbered 1, 2, 3, 4, 6, 7, 8, 12, 13, 14, 15, 16, and 18. The questionnaire employs a Guttman scale, whereby respondents are assigned a score of 1 for affirmative responses and 0 for negative responses. For positive statements, a "yes" response is scored as 1, while a "no" response is scored as 0. Conversely, for negative statements, a "no" response is scored as 1, while a "yes" response is scored as 0. The maximum score on the questionnaire is 18, while the minimum score is 0. In this study, the Cronbach's alpha value on the nurse's physical performance questionnaire was 0.678, exceeding the 0.6 threshold, indicating that the questionnaire was suitable for use and distribution to respondents. T-tests were employed to identify any statistically significant differences between more than two groups of interrelated samples. The analysis employed the Wilcoxon test with a p-value less than α (0.05) (Polit & Beck, 2010). A comprehensive analysis was conducted to assess the hemodynamic status (including blood pressure, pulse frequency, respiratory frequency, and body temperature) and physical performance of the subjects both before and after the administration of the test.

RESULTS

Table 1 reveals that the majority of respondents (41.5%) were in the late adolescent age range (18-25 years), and the gender distribution was heavily skewed towards females (90.5%). With regard to body mass index (BMI), the results for respondents with a normal weight were 38.3%. In the history of respiratory and cardiovascular disorders, the majority of respondents who served in the COVID-19 isolation unit did not have a history of respiratory problems (91.5%) or cardiovascular disorders (96.8%). The majority of respondents (73.4%) did not smoke, while 24.5% were passive smokers. With regard to coffee consumption, the findings indicated that the majority of respondents (54.3%) had never consumed coffee.

Table 2 indicates that the majority of respondents (98.9%) exhibited normal oxygen saturation (96-100 %) prior to wearing N95 masks. Following the use of N95 masks, there was a notable decrease in oxygen saturation (88.3%). Additionally, the majority of respondents (94.7%) exhibited normal systolic and diastolic blood pressure before and after the use of N95 masks. The majority of respondents (94.7%) had a pulse frequency within the normal range before wearing N95 masks. After wearing N95 masks, this frequency decreased by 83%. For respiratory rate, The majority of respondents (95.7%) are within the normal range before wearing N95 masks. After using N95 masks, this frequency decreased by 71.3%. The majority of respondents exhibited normal body temperature before the use of N95 masks, with 97.9% of respondents reporting normal body temperature. Similarly, after the use of N95 masks, the majority of respondents (98.9%) still exhibited normal body temperature.

Table 1.

Responden Characteristics

Characteristics	f	%
Age		
Adolescence (18-25)	39	41,5
Adulthood (26-35)	32	34
Late adults (36-45)	11	11,7
Elederly (46-55)	12	12,8
Gender		
Male	9	9,5
Female	85	90,5
Body Mass Index (BMI)		
Underweight	6	6,4
Normal range	36	38,3
Overweight (pre-obese)	24	25,5
Obese (class 1)	21	22,3
Obese (class 2)	7	7,4
History of Respiratory Disorders		
None	86	91,5
There is	8	8,5
History of Cardiovascular Disorders		
None	91	96,8
There is	3	3,2
Smoking History		
Yes	2	2,1
Passive	23	24,5
No	69	73,4
Coffee Habits		
Every day	14	14,9
Sometimes	29	30,9
Never	51	54,3

Table 2.
Oxygen Saturation And Hemodynamic Status Before And After N95 Mask Use

Variables	Pre test		Post test	
	f	%	f	%
Oxygen saturation				
Low (90-95%)	1	1,1	11	11,7
Normal (96-100%)	93	98,9	83	88,3
Systolic Blood Pressure				
Normal	88	93,6	85	90,4
Elevated	5	5,3	8	8,5
Hypetension stage 1	1	1,1	1	1,1
Diastolic Blood Pressure				
Normal	88	93,6	82	87,2
Hypertension stage 2	6	6,4	12	12,8
Pulse Rate				
Bradycardia (<60 bpm)	1	1,1	0	0
Normal (60-100 bpm)	89	94,7	78	83
Tachycardia (>100 bpm)	4	4,3	16	17
Respiratory Rate				
Normal (12-20 bpm)	90	95,7	67	71,3
Tachypnea (>20 bpm)	4	4,3	27	28,7
Body Temperature				
Hypothermia (<36^{o} C)	2	2,1	1	1,1
Normothermia (36-37,3^{o} C)	92	97,9	93	98,9

Table 3.

Nurses' physical performance before and after using N95 masks

Variable	Pre test		Post test	
	f	%	f	%
Nurses' Physical Performance				
Good	94	100	54	57,4
Sufficient	0	0	35	37,2
Low	0	0	5	5,3

Table 3 indicates that the majority of nurses exhibited good physical performance prior to the use of N95 masks, with 100% of nurses demonstrating this level of performance. Following the use of N95 masks, there was a notable decline in the proportion of nurses exhibiting good physical performance, with 57.4% of nurses demonstrating this level of performance, 37.2% exhibiting sufficient physical performance, and 5.3% exhibiting low physical performance.

Table 4.
A comparison of the oxygen saturation, hemodynamic status, and physical performance of nurses following the use of N95 masks revealed significant differences.

Variables	p-value
Oxygen saturation *Pre test – post test* oxygen saturation	0,000
Hemodynamic Status	
Pre test – post test respiratory rate	0,000
Pre test – post test systolic blood pressure	0,012
Pre test – post test diastolic blood pressure	0,058
Pre test – post test pulse rate	0,000
Pre test – post test body temperature	0,052
Nurses' Physical Performance	
Pre test – post test Nurses' Physical Performance	0,000

The results of the pre-post analysis using the Wilcoxon test (table 4) with a p-value < 0.05 indicate that there were differences in oxygen saturation before and after the use of N95 masks (p-value = 0.000). Additionally, differences in hemodynamic status were found, specifically respiratory rate (p-value = 0.000). Further analysis revealed statistically significant differences in systolic blood pressure and pulse frequency before and after the use of N95 masks. Additionally, the results indicated that there were differences in the physical performance of nurses before and after the use of N95 masks (p-value = 0.000).

DISCUSSION

This study showed differences in oxygen saturation before and after the use of N95 masks. Low oxygen saturation, or hypoxemia, is typically attributed to ventilation-perfusion disorders in the lungs, hypoventilation, shunting mechanisms, reduced diffusion capacity, and decreased partial pressure of oxygen in the inspiratory air (Johnson, 2007). There is no universally accepted threshold for oxygen saturation (SpO2), although it is frequently utilized in adults with values ≤ 95% (Crapo et al., 1999). The reduction in oxygen saturation observed in nurses after the use of N95 masks in this study is consistent with the findings of Kurniawan (2021) on the impact of N95 Filter Facepiece Respirators (FFRs) on the oxygen saturation of nurses at the Central Surgical Installation of RSUD dr. Soebandi Jember. The mean oxygen saturation before the use of N95 FFRs was 98.73%, while the mean saturation after wearing the masks was 96.35%. This is caused by nasal resistance of N95 which exceeding 100% compared to conditions without a mask. Additionally, the presence of a mask during exhalation limits the amount of moisture that can be expelled, which subsequently affects respiratory resistance (Zhu, Jian Hua Zhu, Lee, Shu Jin, Wang, De Yun, Lee, 2014). The use of masks is also known to cause the generation of heat and humidity beneath the mask. Furthermore, some exhaled CO2 is also trapped beneath the mask, which induces a decrease

in blood oxygenation. An extreme case of elevated level of carbon dioxide in exhaled breath can result in disorientation, confusion, and even death (Johnson, 2016). Furthermore, alterations in overall body temperature perception are associated with the duration of mask utilization, wich exerts a physiological stressor effect on users. The necessity of mask usage during occupational activities has been identified as a contributing factor to the onset of headaches (Lim et al., 2006). This discrepancy can be attributed to variations in mask material properties, such as reduced air permeability and water vapor permeability in N95 respirators (Li et al., 2006). Following prolonged mask use, accompanied by increased physical exertion and elevated respiratory resistance due to water vapor generation upon exhalation (Lee & Wang, 2011) (Roberge et al., 2010).

This study also showed differences in hemodynamic status, including respiratory rate, systolic blood pressure, and pulse rate due to use of N95 mask. This is consistent with the findings of Kumar et al., (2023), which indicate that the use of N95 masks affects the physiological examination of the body, specifically oxygen saturation, respiratory rate, and pulse rate. These measurements were taken in the presence of sports activities. The results of this study are also supported by research conducted by (Wulandari et al., 2022), which found that there was an increase in respiratory rate of 1.7 times per minute and heart rate of 8 times per minute in moderate health worker activities for 2 hours when using an N95 mask. Wearing an N95 mask may result in a decrease in oxygen availability and an increase in the amount of carbon dioxide, which can lead to an exponential increase in heart rate and blood pressure, even at low workloads. These physiological alterations can elevate aortic and left ventricular pressure, thereby increasing cardiac load (Mediawati et al., 2020). In this study, a decrease in oxygen saturation and an increase in pulse rate are physiological changes within normal limits and have no harmful effects on health. Changes in vital signs can be due to adaptive processes. It is important to consider the health of workers who wear full protective gear for up to four hours without a break, as fatigue due to high workload and activity may lead to hypoventilation (Vold et al., 2015). The fatigue that occurs as a result of the recovery of resistance does not manifest immediately. However, it should be possible to return to the aforementioned recovery condition after approximately an hour and a half of mask removal. Nevertheless, due to the routine and prolonged use of the mask, the impact is different (Li et al., 2005).

The use of N95 masks also affects the physical performance of nurses before and after the use of N95 masks. Wearing a mask for four hours or more frequently results in physical discomfort, fatigue, and a decline in physical performance. The decline in physical performance resulting from mask use is attributed to the heat and humidity generated beneath the mask, which traps exhaled CO2 and impairs blood oxygenation (Beder et al., 2008). The accumulation of sweat beneath the mask can also result in discomfort, interfere with breathing, and impair motor coordination (Johnson et al., 1997). Furthermore, the facial area is typically inaccessible when wearing a mask, which can impede activities such as eating, drinking, eye rubbing, and other necessary actions (Koh et al., 2006). Prolonged periods of activity can also lead to hypoglycemia and hinder the efficiency of work. Furthermore, the physical performance of mask users is also affected by their ability to tolerate the hot and humid conditions inside the mask. Some mask users may experience adverse effects, including tightness, rash, and edema I the surrounding skin, due to the mask strap being too tight. Some individuals are more anxious about wearing a mask than others, and this anxiety is further compounded by the necessity of wearing protective clothing and masks for extended periods of time while performing their tasks or jobs (Johnson, 2016). The use of masks and protective clothing generally results in a reduction in the time required to reach an optimal

activity level. Furthermore, the additional weight of the mask and protective clothing, in addition to the body weight, can also exert a stress on the cardiovascular system, affecting physical performance due to the additional energy required to perform activities. The effects of temperature, humidity, and skin temperature under the mask increase with the commencement of stepping activities, resulting in discrepancies in the perception of humidity, heat, and elevated respiratory resistance among subjects wearing masks. A deficiency in oxygen stimulates the sympathetic nerves, which in turn increases the heart rate (Ganong, 2003). As a result of these conditions, the subjects reported feelings of unfitness, fatigue, and overall discomfort. White et al., (1991) demonstrated that elevated heart rate, skin temperature, and subjective perception can significantly contribute to the stress experienced by the wearer, ultimately reducing work tolerance. This may be the reason why Farquharson reported that working 12-hour shifts while wearing an N95 mask is indeed a challenge (Farguharson & Baguley, 2003). In this setting, some degree of physical or mental adjustment is required to perform the activity. Consequently, training is crucial for enhancing the wearer's capacity to respond to the impact of occupational conditions, although it does not entirely eliminate performance limitations due to physiological and psychological factors

CONCLUSION

The results indicated that there were differences in oxygen saturation, hemodynamic status, namely respiratory rate, systolic blood pressure, and pulse rate, as well as differences in the physical performance of nurses before and after the use of N95 masks.

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