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The Effect of Medical Mask Usage during Physical Activities on Vital Signs, Muscular Endurance, and Physical Fitness Index

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Abstract

The COVID-19 pandemic requires everyone to wear a mask as a preventive measure, including performing physical activities. This study aimed to determine the effect of medical mask use when performing physical exercises on oxygen saturation, vital signs, muscle endurance, and physical fitness index. The experimental analytical quantitative approach, with pre-test and post-test design, was used. Vital signs and oxygen saturation were measured briefly after brisk walking. The Push-up Test was conducted to measure muscle endurance, while the Harvard Step-up Test was used to measure Physical Fitness Index. The procedures were repeated twice, using medical masks and not using medical masks. The research subjects were 28 males aged 17-21 years with normal BMI. The results showed significant differences in the value of systolic blood pressure, pulse, respiratory rate, body temperature, oxygen saturation, muscle endurance, and physical fitness between the exercise using medical masks and not using medical masks. The p-values were 0.000 on all of these variables. A significant difference was also found in diastolic blood pressure with a p-value of 0.001. This study concludes that using medical masks during physical activity increases all vital sign parameters and decreases oxygen saturation, muscle endurance, and physical fitness levels.

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INTRODUCTION

Up to April 8, 2022, 496,752,563 cases of COVID -19 had been confirmed worldwide and caused 6,196,442 deaths. (Worldometer, 2022) In Indonesia, up to the same date, there were 6,030,168 confirmed cases of COVID-19 with 155,556 deaths. (Satuan Tugas Penanganan COVID-19, 2022)

COVID-19 spreads mainly from human to human through droplets from the nose or mouth when someone infected with COVID-19 sneezes, coughs, or even talks. (Rochwerg, Siemieniuk, & Jacobs, 2021). Transmission of the disease primarily occurs through the route between people in close contact with each other, through respiratory droplets produced when people are infected, which cause infection when inhaled or stored in mucous membranes, such as those lining the nose inside the mouth. People infected but have no symptoms can also pass the virus on to other people. Under certain circumstances, COVID-19 can sometimes spread through airborne transmission, especially in poorly ventilated rooms. (Centers for Disease Control & Prevention, 2021)

To suppress the transmission of COVID-19, people have to apply health protocols such as washing hands with soap and running water for at least 20 seconds after coughing, sneezing, or traveling from public places, using hand sanitizers that contain at least 60 percent (%) alcohol, avoiding close contact and practicing physical distancing, covering mouth and nose using a mask when in contact with other people, practicing proper coughing and sneezing etiquette, cleaning items that are often used daily, and monitoring health status every day. (Centers for Disease Control & Prevention, 2021). A good immune response is also important to prevent the transmission of COVID-19. Routine physical exercise has an important role in strengthening the immune system. (da Silveira et al., 2020). Physical exercise is structured, planned, and repetitive body movements that facilitate the improvement and maintenance of physical fitness. (Heath, 2005) WHO recommends 150 to 300 minutes of moderate-intensity physical exercise per week, 75 to 150 minutes of high-intensity physical exercise, or an equivalent combination of moderate and vigorous-intensity physical exercise. (Paw et al., 2016)

Although regular physical exercise is highly recommended, health protocols must still be implemented by using a face mask during exercise. The use of masks aims to prevent the spread of respiratory droplets that might contain viruses through coughing or sneezing. However, the use of masks during physical exercise might affect the comfort during physical exercise and interfere with respiration. Reinhalation of the exhaled air might cause hypercapnia and hypoxia. (Chandrasekaran & Fernandes, 2020). The reduced level of inhaled oxygen can disrupt human health since the oxygen demand increases during exercise and the accumulation of carbon dioxide. Muscle contraction will also produce lactic acid accumulation that requires oxygen in the removal.(Chandrasekaran & Fernandes, 2020).

Fikenzer et al.(2020) showed that wearing a Filtering Facepiece Respirator (FFP2) / N95 mask during physical activities affects cardiopulmonary function. A significant decrease in lung function and breathing frequency during physical activity using a mask. (Fikenzer et al., 2020). Keely Shaw et al (2020) obtained different results, which showed no significant differences in arterial oxygen saturation, tissue oxygenation index, and heart rate during physical exercise with and without wearing a mask. (Shaw, Butcher, Ko, Zello, & Chilibeck, 2020). These conflicting results indicate a need for further research.

Brisk walking is an easy and effective moderate-intensity physical exercise that plays a role in weight loss, improves cardiovascular health, and decreases blood sugar levels. Brisk walking is defined as walking exercise at a speed that achieves 50-85 percent of the maximum heart rate. The maximum heart rate is obtained by subtracting 220 from the current age. (James Roland, 2019).

Physical exercise performance can be measured through several parameters, such as muscle endurance and physical fitness index. Muscle endurance is the ability of a muscle or muscle group to contract repeatedly and withstand fatigue for a long time. (Hashim, Ariffin, Hashim, & Yusof, 2018) Physical fitness is the ability to carry out daily activities or work and adapt to physical loading without causing excessive fatigue and still have reserves to enjoy leisure time or work that is sudden and free from disease. (Annas, 2011)

However, there is a limited study about the effect of medical mask use on vital signs and oxygen saturation, as well as muscle endurance and physical fitness

index. Taken together, our study presents research that explores the effect of wearing a mask on brisk walking.

METHODS

The experimental analytical quantitative approach was used in this study. All study subjects were asked to do brisk walking with and without using a medical mask. Vital signs, oxygen saturation, and muscle endurance were measured after each exercise. In addition, the push-up test measured muscle endurance, and the Harvard step-up test measured the physical fitness index. This research was conducted at the Faculty of Medicine, Maranatha Christian University, Bandung, Indonesia, from June to August 2021. This research received ethical approval from the Ethics Commission of the Faculty of Medicine, Maranatha Christian University No. 017/KEP/III/2021 and 016/KEP/III/2021.

Participants

Twenty-eight males aged 17-25 years with normal Body Mass Index (BMI) were involved in this study. For safety reasons, a COVID-19 rapid antigen test was conducted before each procedure, and only subjects with non-reactive results were able to proceed. Of 30 subjects that agreed to participate, two subjects showed reactive results and were thereby excluded from the research.

Sampling Procedures

The The selection of research subjects was carried out by distributing an informed consent questionnaire to students of the Faculty of Medicine, Maranatha Christian University Bandung. Through the consecutive sampling method, the subjects who met the requirements and agreed to participate in the study from start to finish were included in this study.

Procedure

One day before the test, the research subjects were asked not to do any strenuous physical activity and to sleep at least six to eight hours at night. The exercise was carried out on a safe and non-slippery surface, with a warm-up procedure before physical exercise and afterward cool-down practice.

Before any given treatment, the maximum heart rate was calculated for each subject using the 220 – age formula. The results were then multiplied by 64% and 76% to get the target heart rate of moderate-intensity physical exercise. Next, subjects were asked to walk at speed to achieve the target heart rate monitored closely throughout the exercise. After completion, the vital signs were immediately measured. Their blood pressure and respiratory rate were measured.

Muscle endurance was carried out by the push-up test. Research subjects must complete as many push-ups as possible. The examiner will record the number of push-ups and the time it takes; the results will be recorded numerically as a times-per-minute ratio. (Hashim et al., 2018). Physical fitness level was measured using the Harvard step-up test and recorded numerically according to the physical fitness index obtained. (Dharmesh & Nikita, 2013). The same treatment and measurement procedures were repeated one week after using medical masks.

Data Analysis

This research was conducted with a pre-test and post-test design. Normally distributed data were analyzed using paired t-tests; otherwise, the Wilcoxon test was used.

RESULT

Systolic Blood Pressure

The mean systolic blood pressure of 28 research samples in the pre-test obtained an average of 122.61 mmHg with a standard deviation of 10.071, and in the post-test obtained an average of 134.32 mmHg with a standard deviation of 12.661. The paired T-Test showed a p-value of 0.00, indicating a very significant difference between treatments.

Diastolic Blood Pressure

The mean diastolic blood pressure of 28 research samples in the pre-test obtained an average of 82.86 mmHg with a standard deviation of 8.074. The post-test obtained an average of 88.18 mmHg with a standard deviation of 11.205. The results of data analysis using the Wilcoxon test between diastolic blood pressure with and without using a medical mask on brisk walking showed a p-value of 0.001. This indicates a significant difference between treatments.

Table 1. The Effect of Mask Usage on Vital Signs, Oxygen Saturation, Muscle Endurance, and Physical Fitness Index

Parameter		Mean	SD	*P* Value
Systolic Blood Pressure	Pre-test	122.61	10.07	0.000
	Post-test	134.32	12.66	
Diastolic Blood Pressure	Pre-test	82.86	8.074	0.001
	Post-test	88.18	11.2	
Pulse	Pre-test	94.64	16.24	0.000
	Post-test	119.93	16.53	
Respiration Rate	Pre-test	24.68	4.73	0.000
	Post-test	28.11	4.58	
Body Temperature	Pre-test	36.07	0.42	0.000
	Post-test	36.43	0.29	
Oxygen Saturation	Pre-test	98.43	0.79	0.000
	Post-test	97.39	1.49	
Muscle Endurance	Pre-test	60.38	19.12	0.000
	Post-test	44.71	16.62	
Physical Fitness Index	Pre-test	12.42	9.39	0.000
	Post-test	6.02	9.81	

Pulse

The mean pulse of 28 research samples in the pre-test obtained an average of 94.64 times/minute with a standard deviation of 16.249, and in the post-test obtained an average of 119.93 times/minute with a standard deviation 16.539. The paired T-Test showed a p-value of 0.00, indicating a very significant difference between treatments.

Respiration Rate

The mean respiration rate of 28 research samples in the pre-test obtained an average of 24.68 times/minute with a standard deviation of 4.730. The post-test obtained an average of 28.11 times/minute with a standard deviation of 4.589. The paired T-Test showed a p-value of 0.00, indicating a very significant difference between treatments.

Body Temperature

The mean body temperature of 28 research samples in the pre-test obtained an average of 36.071 °C with a standard deviation of 0.4285 and the post-test with an average of 36.436 °C with a standard deviation of 0.2984. The results of data analysis using the Wilcoxon test between body temperature with and without using a medical mask on brisk walking showed a p-value of 0.001. This indicates a significant difference between treatments.

Oxygen Saturation

The mean oxygen saturation of 28 research samples in the pre-test obtained an average of 98.43% with a standard deviation of 0.790, and the post-test with an average of 97.39% with a standard deviation of 1.499. The results of data analysis using the Wilcoxon test between oxygen temperature with and without using a medical mask on brisk walking showed a p-value of 0.001. This indicates a significant difference between treatments.

The Effect of the Use of Medical Masks on Muscle Endurance in the push-up test

The mean muscle endurance score of 28 research samples in the pre-test obtained an average of 60.3807 times/minute with a standard deviation of 19.12008 and the post-test with an average of 44.7129 times/minute with a standard deviation of 16.62567. The paired T-Test showed a p-value of 0.00, indicating a very significant difference between treatments.

The Effect of the Use of Medical Masks on the Physical Fitness Index on the Harvard Step-up Test

The mean physical fitness index of 28 research samples in the pre-test obtained an average of 24.0923 times/heart rate with a standard deviation of 9.39120 and in the post-test with an average of 37.50 times/heart rate with a standard deviation of 9.81273. In addition, the paired T-Test showed a p-value of 0.00, indicating a very significant difference between treatments.

DISCUSSION

During the COVID-19 pandemic, people are encouraged to wear masks to prevent droplets that come out of the mouth or nose from spreading and spreading to other people. The use of this mask is required indoors or outdoors when someone is active. However,

the use of masks in physical exercise needs further research because there is not yet strong, consistent scientific evidence regarding the use of masks during physical exercise. (Greenhalgh, Schmid, Czypionka, Bassler, & Gruer, 2020)

In this study, vital signs and oxygen saturation were measured briefly after brisk walking, muscle endurance was measured on the Push-up Test, and the Physical Fitness Index was measured on the Harvard Step-up Test. The procedures were repeated twice, using and without using a medical mask. The results showed that there were very significant differences in the values of systolic blood pressure, pulse, respiratory rate, body temperature, oxygen saturation, muscle endurance, and physical fitness with and without medical masks, with p values of 0.000 on all of these variables, and a significant difference in diastolic blood pressure with and without medical masks with a p-value of 0.001.

Skeletal muscle movements increase skeletal muscle blood flow and cardiac output due to increased oxygen demand during physical exercise. The overall increase in cardiovascular activity and sympathetic nerve activities will increase the vital signs measurements. (Sherwood, 2010)

These adaptations will be more exaggerated while wearing a medical mask. Based on the research results of Y. Li et al. (2005), the N95 mask usage increased pulse rate significantly compared to a medical mask. (Y. Li et al., 2005) Masks are available in various types according to their respective functions. There are two types of masks: medical masks (also known as surgical masks) and respirators masks. Medical masks and respirators have the same protection value. However, respirators masks are specific to certain procedures and events because they have tighter components. (Ippolito et al., 2020).

A medical mask is defined as a surgical or procedure mask that is flat or has pleats; this type of mask is fastened to the head with a strap around the ear or head or both. Its performance characteristics are tested according to a series of standardized test methods (ASTM F2100, EN 14683, or equivalent) aimed at balancing high filtration, adequate breathability, and (optionally) liquid penetration resistance. (WHO, 2020)

Respirator masks are further divided into several types, namely FFP2-mask (face filtering piece) or N95-mask, and FFP3-mask. FFP2-mask can filter > 95% of particles and droplets trapped when inhaled, while FFP3-mask >99%. (Fikenzer et al., 2020)

Studies by J. Lässing et al. (2020) and Sven Fikenzer et al. (2020) showed that using medical masks causes a significant increase in pulse rate and a tendency to increase cardiac output, increasing blood pressure. (Lässing et al., 2020),(Fikenzer et al., 2020) Research, according to Ashley Ying Ying Wong et al. (2020), also stated that there is a physiological effect of using medical masks, namely a significant increase in pulse rate and perceived energy. (Wong et al., 2020)

The use of a medical mask during brisk walking affects respiratory rate because a medical mask might inhibit lung emptying due to a closed airway. Medical masks have been shown to decrease lung function and increase respiratory resistance, which may be higher during stress, leading to increased work of breathing and ventilation restrictions. (Fikenzer et al., 2020) The use of medical masks also causes changes in breathing patterns and a reduction in oxygen absorption, according to the study results by J. Lssing et al. (2020). (Lässing et al., 2020) According to Susan R. Hopkins et al. (2021), it is also possible that re-inhaling the exhaled breath while wearing a mask during physical exercise will increase dyspnea due to the effects of CO2.. (Hopkins et al., 2021) Research on the effects of using masks during activities was also carried out by P. K. Purushothaman et al. (2020) which showed that medical mask usage during activities might cause difficulty in breathing. (Purushothaman, Priyangha, & Vaidhyswaran, 2021).

The movement of muscles during physical exercise produces heat and increases body temperature. An increase in core temperature will cause skin vasodilation and sweating to keep body temperature from exceeding the heat limit because there is also hypothalamic control over skin arterioles. (Sherwood, 2010). Wearing a surgical mask or N95 during continuous use causes an increase in facial skin temperature.(Scarano, Inchingolo, & Lorusso, 2020) The humidity and temperature of the skin inside the medical mask also increase during physical exercise. (Y. Li et al., 2005) A significant change in body temperature was found after wearing a mask for 1 to 6 hours.(Park, Han, Yeon, Kang, & Kim, 2021) This research arrived at the same results as

previous studies that show that the use of medical masks during brisk walking increases body temperature.

The decrease in oxygen saturation was more pronounced in the group using a medical mask, and this finding had statistical significance. The same result was found in another study by Hugo Mendonça Café. (Café, Leitão, Freitas, & Marreiros, 2021) Medical masks block the airway, resulting in partial obstruction of the respiratory tract. As a result of the airway obstruction, the oxygen supply to the body is inhibited, and the oxygen level in the blood decreases. The use of medical masks can also increase dyspnea during exercise due to CO2 rebreathing, based on research by Susan R. Hopkins et al. (2021). (Hopkins et al., 2021) Based on the study of Erzat Toprak et al. (2021), who tested the effect of using a mask before and after the non-stress test on oxygen saturation, it was also found to decrease significantly. (Toprak & Bulut, 2021)

Under normal conditions, when doing heavy-intensity physical exercise, there are several physiological changes, including an adaptation of skeletal muscle metabolism, changes in cardiorespiratory, vascular function, and cell function in mitochondria, namely mediators PGC-1α, HIF1-α, and VEGF, which are associated with with the process of hypoxia. (J. Li et al., 2020) The results of this study are in line with the research conducted by Fikenzer et al. (2020)(Lässing et al., 2020), which stated that the use of FFP2 / N95 masks when doing physical activities affected the cardiopulmonary conditions of 12 healthy men. There is a significant decrease in lung function and breathing frequency during physical activity. Using a mask causes hypoxia and hypercapnia and affects oxygen levels and heart rate, which has an impact on decreasing muscle endurance and fitness. Using an elevation training mask caused a decrease in aerobic and anaerobic capacity and decreased breathing ability compared to subjects who did not use an elevation training mask. (Bernardi et al., 2011). The Elevation Training Mask 2.0 (ETM) is a novel device that purportedly simulates altitude training. (Jagim et al., 2018)

The things found in this study do not mean that due to various unfavorable effects on health, physical exercise should not be carried out using a mask. On the other hand, further research is needed so that physical exercise can be carried out safely without increasing the risk of exposure to COVID-19 but without causing a chronic burden on the body's physiology, especially the work of the cardiovascular system, which can reduce performance such as muscle endurance and physical fitness.

CONCLUSION

This study concludes that using medical masks during physical activity increases all vital sign parameters and decreases oxygen saturation, muscle endurance, and physical fitness levels.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

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