Spor Bilimleri Araştırmaları Dergisi
Journal of Sport Sciences Research
Vol: 8, Issue: 2, 2023
E-ISSN: 2548-0723
URL: http://www.dergipark.org.tr/jssr

Physiological Effects of Using Surgical and N95 Facial Mask in Exercise in the Covid-19 Pandemic

Zait Burak AKTUĞ[1*], Serkan İBİŞ[1], Necdet Eray PİŞKİN[2], Gönül YAVUZ[3], Zeynep KUTLU[3]

[1]Faculty of Sport Sciences, Niğde Ömer Halisdemir University, Niğde.
[2]Bor Youth and Sports District Directorate, Niğde
[3]Physical Education and Sports Department, Niğde Ömer Halisdemir University, Niğde.

Research Article
DOI: 10.25307/jssr.1231926
Received: 10.01.2023 Accepted: 02.04.2023 Online Publishing: 30.06.2023

Abstract

The purpose of this study is to compare the effects of using different masks on respiratory parameters such as maximum oxygen consumption (VO_{2max}), oxygen saturation (SpO_2), and running distance. Twenty men aged 18-22 who exercised regularly four days a week participated in the study. The participants VO_{2max} values with the astrand test, respiratory parameters with the spirometer, SpO_2 with the oximeter, and running distances with the 20m shuttle run test were determined three times on different days, without mask, with the surgical mask and with the N95 mask. In repeated measurements, Friedman Test was used to determine the difference between the measurements. After the exercises, it was determined that the VO_{2max} values, respiratory parameters, and SpO_2 measurements without mask were statistically significantly higher than the measurements with N95 masks. It was also determined that the running distance decreased after the use of surgical masks and N95 masks while N95 masks caused a higher decrease. Masks should not be used in exercises performed outdoors and in places with little contact, gymnasium, etc. In closed areas, it may be recommended to use surgical masks. Considering the changes in all the parameters measured, it is not appropriate to exercise with N95 masks.
Keywords: COVID-19, Exercise, Mask

Covid-19 Pandemisinde Egzersizde Cerrahi ve N95 Yüz Maskesi Kullanımının Fizyolojik Etkileri

Öz

Bu çalışmanın amacı, egzersizde farklı maske kullanımlarının solunum parametreleri, maksimal oksijen tüketimi ($maksVO_2$), oksijen satürasyonu (SpO_2) ve koşu mesafesi üzerine etkisinin karşılaştırılmasıdır. Çalışmaya 18-22 yaşları arasında haftada 4 gün düzenli egzersiz yapan 20 erkek katılmıştır. Katılımcıların maskesiz, cerrahi maskeli ve N95 maskeli olmak üzere farklı günlerde üç kez astrand testi ile $maksVO_2$ değerleri, spirometre ile solunum parametreleri, oksimetre ile SpO_2, 20m mekik koşusu testi ile koşu mesafeleri belirlenmiştir. Tekrarlı ölçümlerde, ölçümler arasındaki farkı belirlemede Friedman Testi kullanılmıştır. Egzersizler sonrası maskesiz $maksVO_2$ değerleri, solunum parametreleri ve SpO_2 ölçümlerinin N95 maskeli ölçümlere göre istatiksel olarak anlamlı şekilde yüksek olduğu belirlenmiştir. Ayrıca koşu mesafesinin maskesiz ölçüme göre sırası ile cerrahi maskeli ve N95 maskeli ölçümlerde azalarak devam ettiği tespit edilmiştir. Sonuç olarak günümüz şartları göz önüne alındığında açık havada ve temasın az olduğu yerlerde yapılan egzersizlerde maske kullanılmaması, spor salonu vb. kapalı alanlarda ise cerrahi maske kullanılması tavsiye edilebilir. Ayrıca ölçüm yapılan bütün parametrelerdeki değişimler göz önüne alındığında N95 maskesi ile egzersiz yapılmasının uygun olmadığı düşünülmektedir.
Anahtar Kelimeler: COVID-19, Egzersiz, Maske

[*] **Corresponding Author:** Assoc. Prof. Zait Burk AKTUĞ, **E-mail:** zaitburak@gmail.com

INTRODUCTION

The China Country Office of the World Health Organization (WHO) reported cases of pneumonia, with unknown cause, in Wuhan, China's Hubei province, on December 31, 2019. On January 5, 2020, it was identified that there was a novel coronavirus, which had not been detected in humans before. It was firstly named as 2019-nCoV while the disease was later named as COVID-19 and affected the whole world within three months after emerging in China (World Health Organization, 2019a). This disease, known as COVID-19, has led to millions of cases and deaths worldwide due to its rapid spread (Lu et al., 2020). The primary route of transmission is through small droplets from disease carriers when talking, breathing, coughing, or sneezing (Esposito et al., 2020; Luo et al., 2020). As long as there is not an effective treatment method or vaccine against the disease, non-pharmacological recommendations such as social distancing, intensified hand hygiene, and wearing face masks have been made to prevent the disease (Shiu et al., 2019). However, many health officials recommend the use of universal face masks by healthy individuals to prevent disease transmission in public places, and some even require them (Leung et al., 2020). Although various measures are taken by many governments, non-governmental organizations, and individuals, it has been recommended to reduce social relations, avoid travelling and staying at home to flatten the curve on cases and reduce the impact of the pandemic in terms of spread (Koo et al., 2020). As a result, sports activities were suspended, gyms and fitness centers have been closed, and outdoor activities were restricted (Toresdahl & Asif, 2020). These mandatory restrictions have a great impact on the daily routine activities of billions of people around the world, and it has been stated that this situation has led to a decrease in physical activity and caused that people have become more sedentary. It also negatively affects the lifestyle of individuals (Amekran & El Hangouche, 2020).

As a result of the restrictions applied, a new lifestyle full of precautions has emerged in every field, although the global epidemic is gradually brought under control, and the pre-epidemic lifestyle and normal lifestyle are gradually eased. Within the scope of these measures, sports halls were opened and people's habits of walking and doing sports in open areas started to be widespread again. The use of masks is among the measures taken in the areas where sports and exercise are counducted, and it is applied during walking and outdoor exercises and in sports centers (Çelik & Yenal, 2020). However, it has been observed that people who do exercise in gyms do not have enough information about what kind of mask to use, and it is valid for walking and doing outdoor exercises (Xiao et al., 2020; Zhang et al., 2021).

It is possible to see comparisons between surgical masks and N95 masks in many places. Disposable surgical masks are one of the most commonly used masks. The function of these masks is to protect the nose and mouth from droplets suspended in the air. Another common mask type is N95 masks. These masks got this name since they can filter 95% of small particles in the air, they can provide more effective protection than surgical masks when the mouth and nose are properly covered (World Health Organization, 2020b).

Although surgical and N95 masks are widely used by healthcare professionals, there are a limited number of studies on their use during intense physical activity and their physiological effects during such activities (Epstein et al., 2021). Silveria et al. (2020) emphasized that

wearing masks during physical exercise can cause deterioration in physical performance and increase the risk of health problems (Silveira et al., 2020). Another study stated that air-filtered protection masks are not suitable for any sports activity since they significantly reduce oxygen intake, and therefore the use of masks in high-intensity sports causes respiratory risks (Dressler et al., 2020). A similar study stated that the direct use of an N95 mask while sitting and walking caused an increase in respiratory amplitude, muscle activity, and abdominal fatigue (Chen et al., 2016). 17.1% of the side effects associated with the use of the N95 mask are respiratory problems including chest tightness, shortness of breath, cough, and dyspnoea (Zuo et al., 2020). The effect of using masks is most pronounced in maximum oxygen consumption. For this reason, the primary effect of face masks on physical performance in healthy individuals is the changes in respiratory functions while the other effect is the fatigue of auxiliary respiratory muscles (Amann et al., 2011; Blain et al., 2016).

We aimed to compare the effects of using different kinds of masks during exercise on respiratory parameters, such as VO_{2max}, SpO_2, and running distance. We hypothesize that the exercises performed with surgical masks and N95 masks negatively affect all measured parameters. A limited number of studies have been found on the preferences about mask use during physical training and the physiological effects of different types of masks during physical exercise during the COVID-19 pandemic. This study must provide the missing information.

MATERIALS And METHODS

Participants

20 male individuals between the ages of 18-22, who did not have any health problems and who did not smoke, who exercised regularly in different branches four days a week, participated in the study.

Data collection

Maximal oxygen consumption measurement, oxygen saturation measurement, 20m shuttle run test, and respiratory function tests were administered to the participants. Thus, we aimed to determine VO_{2max} values with Astrand Bicycle ergometer test, SpO_2 values with an oximeter, respiratory parameters with respiratory function test, and running distances with 20m shuttle run test. The basal levels of SpO_2 measurement and respiratory function test were also determined by making measurements five minutes or longer before the exercise. Later, all measurements were repeated three times on separate days, without a mask, with a surgical mask, and with an N95 mask.

The following steps were applied in each measurement. At first, the VO_{2max} measurement was measured with the astrand bicycle ergometer. Then, a respiratory function test was performed with spirometer 10 seconds after the end of the test. Thirdly, SpO_2 measurement was performed with an oximeter. Then, a 40-minute rest was given the participants to ensure that they recover physiologically. Finally, a 20-meter shuttle run test was applied.

There was a 48-hour rest period was given between the measurements without a mask, with a surgical mask, and with an N95 mask, and the measurements were carried out at the same time of the day. At every stage of the measurements, a personalized spirometer mouthpiece and a new mask were given to each participant, and the participants were taken to the laboratory one by one. Before the measurements of the next participant, we waited for 20 minutes and the laboratory was ventilated during this period. The devices used during the measurement were also disinfected during this period and hygiene rules were applied to each participant.

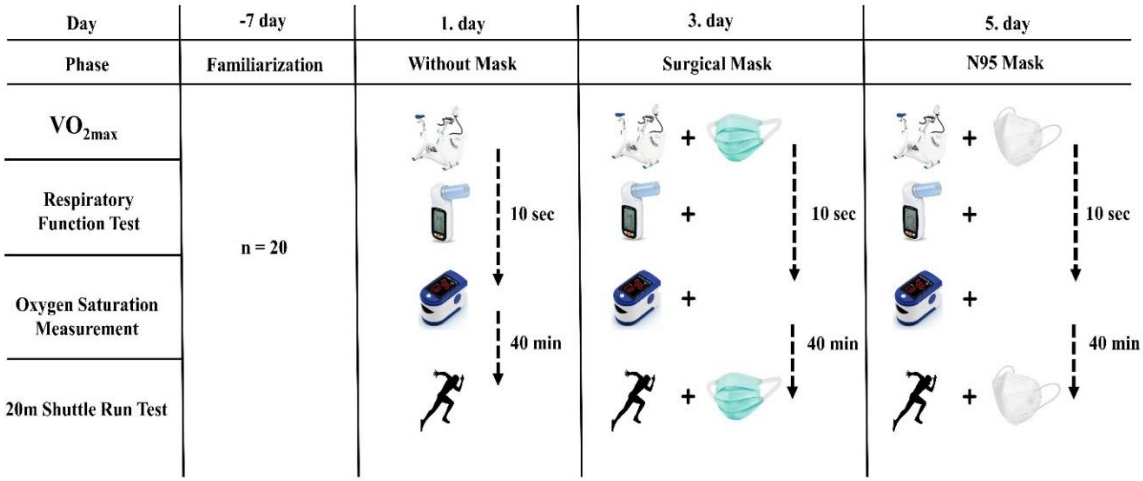

Figure 1. Experimental design

Ethical Approval

For the study, the ethics committee approval was obtained from E-95860085-050.02.04-29965 University's Non-Invasive Clinical Research Ethics Committee (No: 2021/29). All participants gave written informed consent before participating in compliance with the Declaration of Helsinki Principles ethical standards.

Data Collection Tools

Respiratory Function Test

Mikrolab 3300 brand spirometer device was used to measure the respiratory parameters of the participants. The measurements were performed four times in total before the study to determine the basal levels and after the astrand bicycle ergometer was applied without a mask, with a surgical mask, and with an N95 mask. Forced vital capacity (FVC-l), forced expiratory volume in the first second (FEV_1-l/s), peak expiratory flow rate (PEF-l/s), and FEV_1 / FVC% measurements were taken. Measurements were carried out when the participants sat comfortably, with clips on their noses.

Maximum Oxygen Consumption (VO_{2max})

The Astrand bicycle ergometer (Monark Ergomedic 839E, Sweden) measurements were performed using a computer connected to the polar clock and the ergometer to control the load. The measurements were performed three times in total without a mask, with a surgical mask, with N95 mask. The participants were asked to cycle for six minutes until the heart rate was consistently the same for two consecutive minutes, or until the difference between the two readings was at least four beats after three-minute warm-ups. The speed indicator is set on 50 rpm. Since the participants were male individuals, they started the test with a resistance of 150

watts (900 kpm). There was no change in resistance during the test, as the participants' pulses were not below 120 beats/min in the first two minutes of the test and did not exceed 170 beats/min in the first three minutes or less (Günay et al., 2013). The measurement results were recorded as (l/min - ml/kg/min) in the computer environment to which the bicycle ergometer was connected.

Oxygen Saturation Measurement (SpO_2)

Pulse oximetry determines the percentage of oxygenated hemoglobin in arterial blood, and the parameter measured is known as SpO_2. Finger type pulse oximeter was used in this study. The measurement was performed four times in total, without a mask, with a surgical mask, and with an N95 mask to determine the basal levels before the training and after the astrand bicycle ergometer measurement.

20m Shuttle Run Test

Although the shuttle run test is a basic test that aims to determine the VO_{2max}, the evaluation was based on the total distance running, since we measured the estimated VO_{2max} values in the 20m shuttle running test with an astrand bicycle ergometer. Participants ran a distance of 20m marked by round-trip lines. The running speed was adjusted with a calibrated cassette with the signal intervals increased by 0.5 km/h per minute. The measurements were performed three times in total without a mask, with a surgical mask, and with an N95 mask. The participants were informed that they should start their run with the first signal sound and reach the other line until the second signal sound. The test sessions were not terminated when the participant missed one signal and reached the second but they were terminated when the participant missed the second signal. The test result was recorded as the running distance.

Data Analysis

The data were analyzed with SPSS 24 package program. The normality distribution was examined with the Shapiro-Wilk Test. In repeated measurements, the Friedman Test, one of the nonparametric tests, was used to determine the difference between the measurements. $p<0.05$ was accepted as statistically significant.

RESULTS

The mean age of the participants was 21.7±2.86 years, their mean height was 179.50±6.69 cm, their mean body weight was 70.65 ± 7.90 kg. The participants' mean resting FVC value before exercise was 5.22±0.34 liters; their mean FEV_1 value was 4.49±0.29 l/s; their mean PEF value was 9.68±0.64 l/s; their mean FEV_1/FVC value was 84.29±1.51%. Their mean SpO_2 value was 97.70±0.47%; their mean heart rate was 73.50±5.56 beats/min.

Table 1. Comparison of respiratory parameters after measurements without mask, with surgical mask, and with N95 mask

Variables		N	X̄±Sd	X^2	p
FVC (l)	No mask	20	4.96±.47 [a]	15.600	0.00
	Surgery Mask	20	4.71±.49 [a]		
	N95 Mask	20	4.48±.51 [b]		
FEV_1 (l/s)	No Mask	20	4.28±.37 [a]	14.400	0.00
	Surgery Mask	20	4.14±.44 [ab]		
	N95 Mask	20	3.96±.38 [b]		
PEF (l/s)	No Mask	20	9.34±.63 [a]	21.100	0.00
	Surgery Mask	20	9.06±.60 [b]		
	N95 Mask	20	8.66±.57 [cb]		
FEV_1/FVC (%)	No Mask	20	83.42±1.89 [a]	14.400	0.00
	Surgery Mask	20	82.88±1.78 [ab]		
	N95 Mask	20	81.75±1.53 [b]		

p<0.05 a.b.c; different letters indicate statistical significance.

A statistically significant difference was found between FEV_1 values and FEV_1/FVC ratios between the measurements with no mask and N95 mask in favor of the measurements with no mask (p<0.05). A statistically significant difference was found between FVC measurements with no mask, surgical mask, and N95 mask in favor of the measurements with no mask and a surgical mask (p<0.05). A statistically significant difference was found between PEF values between the measurements with no mask, a surgical mask, and an N95 mask in favor of the measurements with no mask (p<0.05).

Table 2. Comparison of some parameters after measurements without mask, with surgical mask, and with N95 mask

Variables		N	X̄±Sd	X^2	p
VO_{2max} (ml/kg/min)	No mask	20	44.63±6.07 [a]	24.700	0.00
	Surgery Mask	20	42.57±4.76 [a]		
	N95 Mask	20	39.31±4.54 [b]		
VO_{2max} (l/min)	No mask	20	3.17±.41 [a]	21.700	0.00
	Surgery Mask	20	3.01±.32 [a]		
	N95 Mask	20	2.79±.25 [b]		
Shuttle Run Distance (m)	No mask	20	1669.00±272.33 [a]	34.300	0.00
	Surgery Mask	20	1248.00±119.01 [b]		
	N95 Mask	20	924.00±153.08 [c]		
Heart Rate (beats/min)	No mask	20	149.50±9.59 [a]	26.000	0.00
	Surgery Mask	20	156.05±7.61 [a]		
	N95 Mask	20	167.55±9.53 [b]		
O_2 Saturation (SpO_2)	No mask	20	96.90±.64 [a]	17.815	0.00
	Surgery Mask	20	96.15±.67 [b]		
	N95 Mask	20	96.00±.56 [b]		

p<0.05 a.b.c; different letters indicate statistical significance

When the table is examined, it was found that there was a statistically significant difference between the use of heart rate, VO_{2max} (ml / kg / min) and VO_{2max} (l / min) both without masks and surgical masks and N95 mask use in favor of measurements without mask and surgical mask (p <0.05). It was found that there was a statistically significant difference in SpO_2 in favor of non-mask measurements compared to both the measurements with a surgical mask and N95 mask (p<0.05). A statistically significant difference was determined between the measurements without ask, with surgical mask, N95 mask in favor of measurements with no mask compared. The measurements with surgical masks were also higher than the measurements with N95 masks (p<0.05).

DISCUSSION

During the COVID-19 pandemic, the necessity of using masks in daily life by not only for healthcare professionals but also for ordinary people has been widely discussed (Chan et al., 2020). Mask usage is recommended for the public as an additional measure to protect public health, especially in droplet-borne diseases (Eikenberry et al., 2020). In addition to the use of masks in protection from the pandemic, various studies are carried out on exercise programs to strengthen immunity, and they stated that physical activity can improve the immune system by increasing immune cells (Nieman & Wentz, 2019). Therefore, it is recommended that individuals do medium-intensity exercise in the process of coping with COVID-19 (Aktug & Demir, 2020; Doğan & Cengizhan, 2021; Rahmati-Ahmadabad & Hosseini, 2020).

The effect of using masks during doing these exercises in the pandemic period is still a matter of debate. A study conducted on whether to wear a mask in gyms to avoid the COVID-19 pandemic stated that wearing a mask while doing sports cause deterioration of physical performance and increases the risk of health problems (Silveira et al., 2020). After exercising for a while, hyperventilation and sweating leave masks completely wet and can restrict airflow when oxygen demand is at its highest level. This situation deepens the respiratory movements. There is still a lack of information about the effectiveness of masks in reducing the risk of transmission in community settings such as gyms (World Health Organization, 2020c). There is no definite information about what kind of masks can be used when a mask is used during exercise and what kind of effects this mask causes. In our study, respiratory parameters, VO_{2max} level, running performance, heart rate, SpO_2 measurements were taken, and it was found that the use of surgical masks and N95 masks negatively affected these values (Table 1, Table 2). It was determined that this negative effect was greater in the use of N95 masks. Disposable surgical masks are intended to prevent transmission from the user to the patient, hand-face contact, and face-to-face contact of large droplets. N95 masks, strictly apply the filtration requirements of small particles in the air with their respirators and achieve more effective outcomes than surgical masks in reducing exposure to viral infections (Shiu et al., 2019). The tight fit of N95 masks prevents the inhalation of small aerosols in the air by preventing leaks, while the looseness of the surgical masks prevents the passage of large particles only (Bartoszko et al., 2020). In the study, the measurement values decreased more in the use of N95 masks compared to the surgical mask this finding can be related to these features of the N95 mask. Findings support this situation, especially in international studies.

Shui et al., (2022) examined the physiological effects of surgical mask and N95 mask wear in exercise during the Covid-19 pandemic. In conclusion, it was stated that the wear of surgical mask caused some negative effect on cardiopulmonary function and this effect was more severe in N95 mask. He also recommended taking care to exercise while wearing a surgical or N95 mask. Fikenzer et al., (2020) investigated the effect of mask use on VO_{2max} and respiratory parameters in their study with 12 healthcare professionals. In the study, the measurements were conducted using a bicycle ergometer and spirometer with no mask, with surgical masks, and with N95 masks. In the study, it was determined that the use of surgical masks and N95 masks had a negative effect on VO_{2max} values, the measurement values were 39.7 ml/kg/min with no mask, 37.9 ml/kg/min with surgical masks, and 34.5 ml/kg/min with N95 masks. The respiratory parameters such as FVC, FEV_1, PEF values were found to decrease with the use of surgical masks while they decreased more with the use of N95 masks. In the study, the use of

N95 masks caused a 13% decrease in VO_{2max} values and a 23% decrease in ventilation (Fikenzer et al., 2020). The use of N95 masks and surgical masks negatively affected ventilation, cardiopulmonary exercise capacity, and comfort in healthy individuals, and these results are important for debate about wearing masks during work or exercise (Melissant et al., 1998).

In our study, a decrease of 5.04% in FVC, a decrease of 3.27% in FEV_1, a decrease of 2.99% in PEF, and a decrease of 0.64% in FEV_1/FVC were observed after the use of surgical masks. After using the N95 mask, a decrease of 9.67% in FVC, a decrease of 7.47% in FEV_1, a decrease of 7.28% in PEF, a decrease of 2.00% in FEV_1/FVC were found. The studies investigating increased upper airway obstruction caused by resistance in the mouth show that increased respiratory resistance creates certain effects on the lung function parameter (Melissant et al., 1998). It has been stated that these changes in breathing are associated with increased respiratory resistance (Lee & Wang, 2011). Increased respiratory resistance when the body is under stress causes ventilation to be limited (Kyung et al., 2020). The effect of mask usage on respiratory parameters in our study may be related to this situation.

In our study, SpO_2 values decreased by 0.77% after the use of surgical masks and by 0.92% after the use of the N95 mask. Limitation in ventilation is oxygen saturation, early diagnosis data of hypoxia, which means the insufficiency of tissue oxygenation. Moreover, ventilation is the source of vital problems such as insufficient oxygen in the inhaled air, an insufficient amount of air taken into the lungs, respiratory problems due to decreased airway resistance, decreased diffusion capacity, and circulatory failure (Özdal et al., 2014). It can be suggested that limiting breathing with the mask and re-inhaling the carbon dioxide in the mask during hyperventilation may cause a decrease in the SpO_2 percentage (Özel & Özer, 2017). Pifarré et al., (2020) applied a six-eight meth-intensity loading protocol to eight people with and without a mask. Heart rate, O_2, CO_2 concentration, and SpO_2 measurements were compared in the study. A decrease of 20.9% was observed in O_2 use in measurements with no mask while the decrease was 18.3% with a mask before starting exercise, and 17.8% with a mask after masked exercise. While the saturation value in basal SpO_2 measurements was 97.6%, it decreased by 92.1% after exercise with mask usage. Heart rate values increased from 75.7 beats/min to 112.8 beats/min after mask usage. It was also found that the use of masks reduced the O_2 concentration by 3.7% and increased the CO_2 concentration by 20%. They concluded that the use of masks during exercise causes hypoxic and hypercapnic breathing with increased effort (Pifarré et al., 2020). Barbieri et al. (2020) examined the effects of masks on 18 people with a 20-minute cycling exercise protocol at 60% intensity. They found the SpO_2 value as 98.09% before exercise and 96.81% after exercise in measurements with no mask while they found the same value as 98.19% before exercise and 96.16% after exercise (Barbieri et al., 2020).

Akgül et al., (2021) administered a one-hour brisk walking program with and without a surgical face mask on the participants in their study and measured blood pressure, heart rate, and SpO_2 values before and immediately after two walks. They determined that there was no statistically significant difference between heart rate and blood pressure values during brisk walking with and without surgical mask usage, while the decrease in SpO_2 values was statistically significant (Akgül et al., 2021). Andre et al., (2018) conducted a similar study with 10 people; they administered an exercise protocol for the lower extremity with and without a mask. At the end of this study, there was a significant decrease in the total duration of masked exercise sessions.

It was determined that SpO_2 decreased by 0.8% in the exercise with mask usage compared to the exercise without mask usage. For all these reasons, the use of masks during resistance exercises was not recommended (Andre et al., 2018). Kyung et al., (2020) applied for a low impact exercise program with N95 masks to 97 people with COPD. They found significant differences in respiratory frequency, SpO_2, and carbon dioxide exhausted levels of the individuals using no mask and the individuals using N95 masks (Kyung et al., 2020).

In our study, there was a 25.22% decrease in the 20m shuttle running test values after the use of surgical masks while the decrease was 44.63% after the use of N95 masks. In a similar study, it was determined that participants who applied the maximal exercise with increasing intensity using masks covered a shorter distance compared to those who applied the same exercise with no mask (Özel & Özer, 2017). The reason for this is that the mask restricts breathing and thus causing the athletes to have difficulty in a shorter time (Özel & Özer, 2017). Epstein et al., (2021) investigated some physiological parameters and the burnout time of individuals using a bicycle ergometer test in a study conducted with 16 individuals without a mask, surgical mask, and N95 mask. According to the findings, the fatigue time of individuals without masks was 18.9 minutes, individuals with surgical masks were 18.3 minutes and individuals with N95 masks were 18.5 minutes. The findings of the study showed that wearing masks during aerobic exercise had only minimal and statistically inconsistent effects on physiological parameters. They associated the minimal decrease in the study with a slight but significant increase in CO_2 partial pressure, which became more pronounced with the N95 mask as the intensity of physical activity exercise with the mask increased (Epstein et al., 2021). In our study, the effect of the use of the mask on the values of the 20m shuttle run can be related to this situation.

In our study, 4.38% increase in heart rate values occurred after the use of surgical masks while the increase after the use of the N95 mask was 12.07%. It has been suggested that the primary effect of mask usage on physical performance in healthy individuals is to decrease pulmonary function and to activate an afferent motive that affects the increase of fatigue effect of auxiliary respiratory muscles (Amann et al., 2011; Blain et al., 2016). Increased respiratory resistance during the use of N95 and surgical masks, compared to the situation with no mask usage, causes the respiratory muscles to work more and higher oxygen consumption (Fikenzer et al., 2020). Lee and Wang, (2011) found that the use of N95 mask increased inspiratory and expiratory flow resistance as 126% and 122%, respectively (Lee & Wang, 2011). Increased resistance in respiration enables a significant portion of cardiac output to be directed to the respiratory musculature through vasoconstriction (Harms et al., 1998). Increased respiratory resistance can increase and prolong inspiratory activity, and leads to negative intra-chest pressure for longer periods. Cardiac load increases due to this prolonged time, negative intra-thoracic pressure, and left ventricular pressure resulting in increased myocardial oxygen consumption (Cheyne et al., 2020; Convertino et al., 2005). Prolonged exposure to increased CO_2 levels can also often cause fatigue, difficulty in concentration, and an increase in heart rate and blood pressure (Redlich et al., 1997). Wong et al., (2020) examined the effects of mask usage during exercise, in a study involving 23 participants, using a stepped treadmill (10% incline) protocol set at a six-minute four km speed. They reported that exercising at the submaximal level with face masks caused restricted ventilation, heavier breathing, and higher physiological responses. While the heart rate in the group using masks was 128.4 beats/min and the perceived effort rate was 12.7, the heart rate in the group not using masks was 124.4 and the perceived effort rate

was 10.8. The effect of the use of the mask in our study on heart rate values may be related to this situation (Wong et al., 2020).

In our study, the VO_{2max} (ml/kg/min) values decreased by 4.81% after the use of surgical masks while they decreased by 11.92% after the use of the N95 mask. As the oxygen demand for the tissues increases during sports activities, the amount of oxygen delivered to the body through the respiratory system should also increase. Circulatory and respiratory systems have to balance this situation to meet the need of tissues, to tolerate excess carbon dioxide and metabolic heat (Fox et al., 1999). Umutlu et al., (2021) investigated the effects of wearing a surgical mask on metabolic, cardiovascular and pulmonary gas exchange responses during incremental walking testing in sedentary individuals in another study conducted on 14 people. As a result of the study, it was stated that wearing a surgical face mask during incremental walking increased pulmonary ventilation in sedentary individuals while causing a decrease in oxygen delivery, which in turn led to a decrease in exercise performance due to restricted breathing conditions (Umutlu et al., 2021). Respiration increases to provide the gas exchange that increases with exercise and to maintain the rate of gases (Bayar & Bayar, 2003). The use of N95 masks during aerobic activity is associated with increased CO_2 pressure in expiration at rest and any effort level. With the surgical mask, this effect is mild and only increases significantly during heavy training. The reason for this increase can be explained by the respiration of the inhaled air remaining in the mask and may contribute to mild hypercapnia (Epstein et al., 2021). The high level of VO_{2max}, which is the determinant of aerobic capacity, allows athletes to maintain body homeostasis and exercise for a long time under different loads (Wagner & Secher, 2008).

CONCLUSION

As a result of our study, it was observed that respiratory parameters, VO_{2max} level, running performance, heart rate, and SpO_2 values were negatively affected by the use of surgical masks and N95 masks, and this adverse effect was greater for N95 masks. During the pandemic period, exercises performed especially in closed areas during the pandemic period increase the possibility of transmission of the disease, so we recommend doing exercises in open areas without a mask when there are fewer people and wearing a surgical mask if the population density is high. We also recommend that N95 masks not to use during exercise, but those who feel safe with N95 masks and want to exercise at the same time should keep the duration and intensity of the exercise low compared to doing exercises without masks.

Conflict of interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Researchers Contribution Rate Statement: Research Design-ZBA; Sİ, Data Collection-NEP; ZK; GY, Statistical analysis- ZBA, Preparation of the article- ZBA; Sİ; NEP; GY; ZK.

Ethics Statement
Committee Name: Niğde Ömer Halisdemir University's Non-Invasive Clinical Research Ethics Committee
Date: 12/03/2021
Issue No: 2021/29

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