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Running and facemasks during COVID-19 Pandemic: A randomized crossover trial

Impacto del uso del tapabocas en corredores en tiempos de COVID – 19: un ensaño cruzado aleatorizado

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ABSTRACT

Introduction: Coronavirus disease 2019 (COVID-19) required the use of facemasks during some sport activities. **Objective:** The aim of the study is to evaluate the effects of using two different types of facemasks compared with no mask on recreational runners. **Materials and methods:** Randomized crossover clinical trial on runners asked to run on a treadmill for a 15-minute test, measuring oxygen saturation, heart rate, and shortness of breath every 3 minutes. Each participant completed these tests three times on different days, and the order in which they used different facemasks, or no masks was randomized. **Results and discussion:** 18 participants were included and randomized to the order of running in the three groups or modalities: no mask, surgical mask, and polyester reusable mask. For oxygen saturation (SaO_2), there were statistically significant differences at minutes 9, 12 and 15, with the greatest difference at minute 15: the mean SaO_2 (min 15) in the no mask group was 92%, that in the surgical mask group was 91%, and that in the polyester mask group was 85% (p= 0.0012). No differences in heart rate were observed among the groups. **Conclusions:** The polyester reusable cloth mask group exhibited the greatest decrease in oxygen saturation during the tests compared to the other groups. We avoid a major impact in oxygen saturation, we recommend a surgical mask for moderate intensity running in closed or crowded places and no mask for high intensity running in open spaces where social distancing can be consistently guaranteed.

Keywords: COVID-19; Masks; Oximetry; Running; Shortness of Breath.

RESUMEN

Introducción: la enfermedad por coronavirus SarsCov-19 (COVID-19) requirió el uso de mascarillas durante algunas actividades deportivas. **Objetivo:** el objetivo del estudio es evaluar los efectos del uso de dos tipos diferentes de máscaras faciales en comparación con el no uso de máscara en corredores recreativos. **Materiales y métodos:** ensayo clínico cruzado aleatorizado en corredores a los que se les pidió que corrieran en una banda eléctrica para una prueba de 15 minutos, midiendo la saturación de oxígeno, la frecuencia cardíaca y la dificultad respiratoria cada 3 minutos. Cada participante completó estas pruebas tres veces en días diferentes, y se aleatorizó el orden en que usaron diferentes mascarillas o ninguna mascarilla. **Resultados y discusión:** se incluyeron 18 participantes y se aleatorizaron por orden de carrera en los tres grupos o modalidades: sin mascarilla, mascarilla quirúrgica y mascarilla reutilizable de poliéster. Para la saturación de oxígeno (SaO_2), hubo diferencias estadísticamente significativas en los minutos 9, 12 y 15, con la mayor diferencia en el minuto 15: la SaO_2 media (min 15) en el grupo sin máscara fue del 92 %, que en el grupo con máscara quirúrgica fue del 91 %, y que en el grupo de máscara de poliéster fue del 85 % (p= 0,0012). No se observaron diferencias en la frecuencia cardíaca entre los grupos. **Conclusiones:** el grupo de máscaras de tela reutilizables de poliéster exhibió la mayor disminución en la saturación de oxígeno durante las pruebas en comparación con los otros grupos. Evitamos un impacto importante en la saturación de oxígeno, recomendamos mascarilla quirúrgica para carreras de intensidad moderada en lugares cerrados o concurridos y sin mascarilla para carreras de alta intensidad en espacios abiertos donde se puede garantizar el distanciamiento social de manera consistente.

Palabras clave: COVID-19; Correr; Dificultad para respirar; Mascarillas; Oximetría.

INTRODUCTION

The pandemic associated with the SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) virus has caused a worldwide health emergency (Velavan & Meyer, 2020).

The virus is primarily transmitted through the respiratory droplets expelled during various actions performed by people with active infection, such as during talking, sneezing, breathing, and/or coughing (Morawska & Milton, 2020; Prather *et al.* 2020). It was established that the use of masks is one of the most effective means to prevent the transmission of respiratory infections (Luo *et al.* 2020; WHO, 2020). Additionally, specific risk scales during daily activities were developed for SARS-CoV-2 infections, and these scales include the scale created by the Texas Medical Association (TMA), which classifies the practice of physical activity in gyms as high risk with a score of 8/10 (Mehta *et al.* 2021). Consequently, in some countries, norms were established for the practice of sports, including the mandatory use of facemasks during the practice of exercise.

Facemasks have been found to interfere with many physiological and psychological aspects associated with the performance of tasks (Guardiola Vera & Butragueño Revenga, 2020). Physiological research has shown that the use of facemasks affects ventilatory mechanics, respiratory rate response, tidal volume, and expired oxygen (O_2) and carbon dioxide (CO_2) fractions (Chandrasekaran & Fernandes, 2020; Guardiola Vera & Butragueño Revenga, 2020). Additionally, physical activity performance linearly decreases by up to 30% with increasing inspiratory resistance, which promotes hypoventilation that may result in an early transition from aerobic to anaerobic respiration (Guardiola Vera & Butragueño Revenga, 2020).

Some studies have concluded that the use of facemasks during physical activity may decrease oxygen saturation (SaO_2); for example, Pifarré *et al.* (2020), observed in a population of 8 participants that the use of facemasks reduces oxygen availability by approximately 14% and increases aspirated CO_2 levels by up to 30%. On the other hand, research by Epstein *et al.* (2021) concluded that the use of surgical and N95 face masks has minimal physiological effects but is associated with discomfort. Similarly, Shaw *et al.* (2020) found no detrimental effect of wearing a reusable or surgical face mask during vigorous physical activity on exercise performance.

Despite the previously published articles evaluating sports performance with the use of facemasks, there is no consensus in the literature regarding the effect of these devices during physical activity, and no research has been conducted on this topic in the running population. Therefore, this research aimed to evaluate the impact of facemask use on SaO_2, heart rate (HR), and shortness of breath in recreational runners from the health sector.

MATERIALS AND METHODS

A randomized crossover clinical trial was conducted involving recreational runners who were previously healthy and affiliated with the health sector of a university hospital. The participants were assigned to one of three groups, with each runner serving as their own control. The groups were differentiated based on the type of face mask used: no mask, a surgical mask, or a reusable cloth mask made of anti-fluid material with two layers of 100% polyester fabric. The order in which each runner used or did not use a face mask during the running tests was randomized using a table of random numbers. As a result, each participant completed a different sequence of running trials, wearing either the polyester mask, the surgical mask, or no mask at all. This study was approved by the Ethics Committee/IRB of the institution where the research was conducted.

Participants. Recreational runners aged 18 to 60 years who were working or studying at hospital university were invited to participate. All participants provided written informed consent before enrollment. To be included they should have moderate aerobic physical activity of 150 minutes per week or vigorous aerobic physical activity of 75 minutes per week, (WHO, 2010; Wicker & Frick, 2017). Also, those who had an expected ability to run for 15 minutes between 8.5 and 12 km/h (5.3 - 7.5 mph). Participants with any recent injuries or chronic conditions such as respiratory, cardiovascular, or any other conditions that could limit their ability to run or affect their performance or response to the use of face masks were excluded. Anyone who had a positive COVID-19 test or that had been in contact with a confirmed COVID-19 case within the previous 14 days was also excluded from the study.

Sample size calculations were done with oxygen saturation variable, assuming that the best group would have 90% mean SaO_2 and the worst group 80% mean Sa02 at certain point of the test (80 % power, 5 % alpha error). According to these calculations, 18 participants were included in each group, 9 men and 9 women, for a total sample size of 54.

Types of masks. Polyester cloth reusable mask: double layer of a 100% polyester cloth. Surgical mask: standard surgical mask.

Physical test. Each runner was subjected to 3 physical tests, each separated by a period of at least 24 hours. The tests lasted 15 minutes; the tests were divided into 3 initial minutes of warm-up with a progressive increase in speed, from 8.5 to 9.5 km/h, each minute, which was followed by 6 minutes of running at 10 km/h and 6 minutes of running at 12 km/h. The tests were performed on a programmed treadmill in an open space, with no other people exercising. Depending on the group assignment, the subject used one of the facemasks or no mask. The participants were asked to avoid exertional exercise on the same day prior to the test.

Physiological parameters measured. Physiological parameters were measured before the start of each physical test and subsequently every 3 minutes until its completion. SaO_2 and HR were measured with a pulse oximeter on the middle finger of the right hand because measurement on this finger correlates best with the arterial oxygen saturation (Basaranoglu *et al.* 2015). Shortness of breath was evaluated with a visual analog score from 0-10, where 0 was no shortness of breath and 10 was maximum shortness of breath, similar to the perceived exertion score (Borg, 1990; Pianosi *et al.* 2016), which requires a subjective measurement of the perception of shortness of breath. The data obtained were compiled in the hospital electronic platform BD-Clinic.

Statistical analysis.

Exploratory data analysis: The distribution of the data was evaluated with the Shapiro-Wilk test. Continuous variables are presented as the mean and standard deviation if the distribution was normal or as the median and interquartile range if the distribution did not meet the normality criteria. Categorical variables are presented as proportions.

Bivariate analysis: Comparisons between continuous variables were performed with the Kruskal-Wallis test using Stata Statistical Software: Release 13 (College Station, TX: StataCorp LP). Differences were considered statistically significant when the p value < 0.05. Categorical variables were compared with the X^2 or Fisher tests as appropriate. There were no sample size calculations because this began as an exploratory clinical trial.

RESULTS AND DISCUSSION

A total of 18 participants were included, with a median age of 25 (22-30) years old and an equal gender distribution. Considering that every participant had 3 physical tests, the total sample size was 54. Regarding the completion of the physical tests, 17 participants completed the test in the group without a mask, 15 in the group with a surgical mask and 13 in the group with a reusable polyester mask (P=0.259). The demographic characteristics of the participants and finishers in each group are shown in Table 1.

As shown in Table 2 and Figure 1, shortness of breath during the exercise test was higher in the groups with facemasks, and it was always the highest in the polyester reusable mask group. Additionally, when comparing the shortness of breath between the three groups after the test began a statistically significant difference was observed. But when comparing between the surgical mask group and the polyester reusable mask group, no statistically significant difference was observed.

Regarding the SaO_2 measurements, it was observed that the SaO_2 vs. time curve tended to decrease in all the groups (Figure 2); However, a significant difference between the groups was observed starting at minute 9 (Table 3). There was also a significant difference in SaO_2 between the group with no mask and the surgical mask group at minute 15 (p= 0.043).

The heart rate showed an increasing trend over time in the three tests, with no differences observed among the groups (Table 4).

In terms of the discussion, the main findings of this study were that shortness of breath and oxygen saturation were significantly different depending on the type of mask used or the absence of a mask. This was especially important for the reusable polyester mask test where the greatest effect was observed. These findings support the hypothesis that the use of masks alters performance during physical activity in runners. This hypothesis was based on the theory by Chandrasekaran & Fernandes (2020), who proposed that wearing a facemask during exercise increases carbon dioxide respiration or compromises oxygen consumption, decreasing arterial oxygen saturation and causing resistance to breathing, hindering respiratory work. Additionally, physiological studies report that the use of facemasks increases inspiratory and expiratory resistance, decreases peak expiratory flow, forced vital capacity, forced expiratory volume measured in one second, and maximum ventilation, and reduces gas exchange by up to 37%. (Lee & Wang, 2011; Fikenzer *et al.* 2020).

Table 1. Demographic characteristics of participants and distribution of finishers.

Variable	**n (%)**
Age**	25 [22-30]
Sex	
Female	9 (50)
Male	9 (50)
Participants who completed the test	
Without mask group	17 (94.44)
Surgical mask group	15 (83.33)
Polyester mask group	13 (72.22)
Time of withdrawal of participants who did not complete the test (min)	
Without mask group*	10
Surgical mask group*	9.86 ± 2.37
Polyester mask group*	10.6 ± 1.34
a Data are provided as the mean*, median** or percentage n (%)	

Table 2. Shortness of breath across groups during the test.

Variable	Without mask*	Surgical mask *	Polyester reusable mask *	P Value**
Previous (0 min)	0 [0 – 0]	0 [0 – 1]	0 [0 – 1]	0.1724
Warming up (3 min)	0 [0 – 1]	2 [1 – 2]	2.5 [1 – 5]	0.0021
6 min	1 [0 – 1]	3 [2 – 4]	4 [3 – 6]	0.0001
9 min	1 [0 – 2]	3.5 [3 – 5]	6 [4 – 8]	0.0001
12 min	3 [2 – 5]	6 [4 – 6]	7 [6 – 9]	0.0003
15 min	4 [2 – 6]	6 [5 – 8]	9 [8 – 9]	0.0002

a Data are provided as the median [IQR]*
b From 3 groups Kruskal-Wallis** for continuous variables. P values <0.05 were considered statistically significant

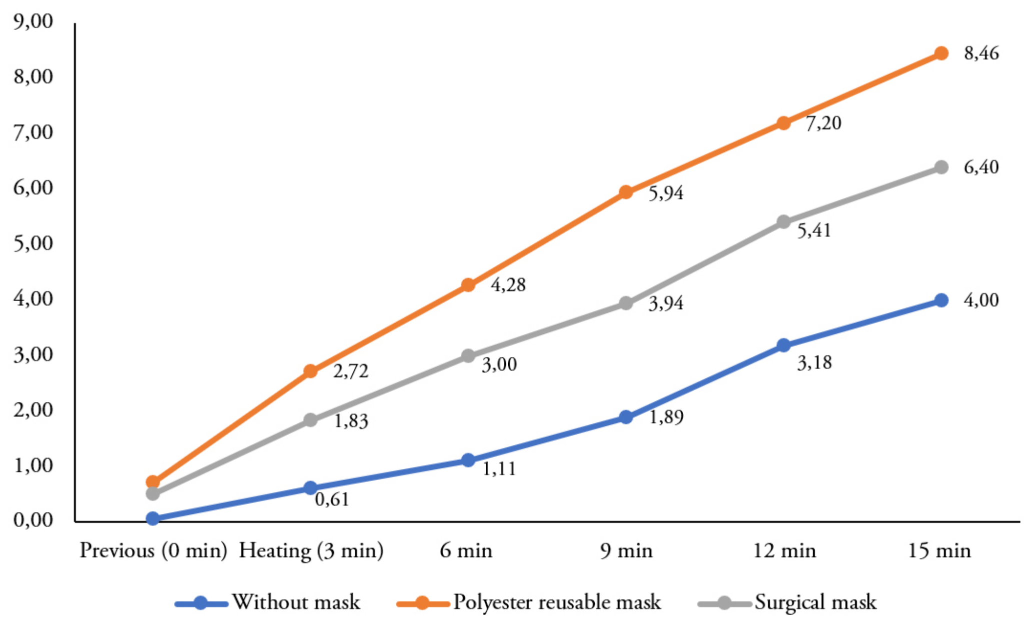

Figure 1. Mean sensation of shortness of breath by group as the test goes on. This shortness of breath is measured in a 0-10 scale.

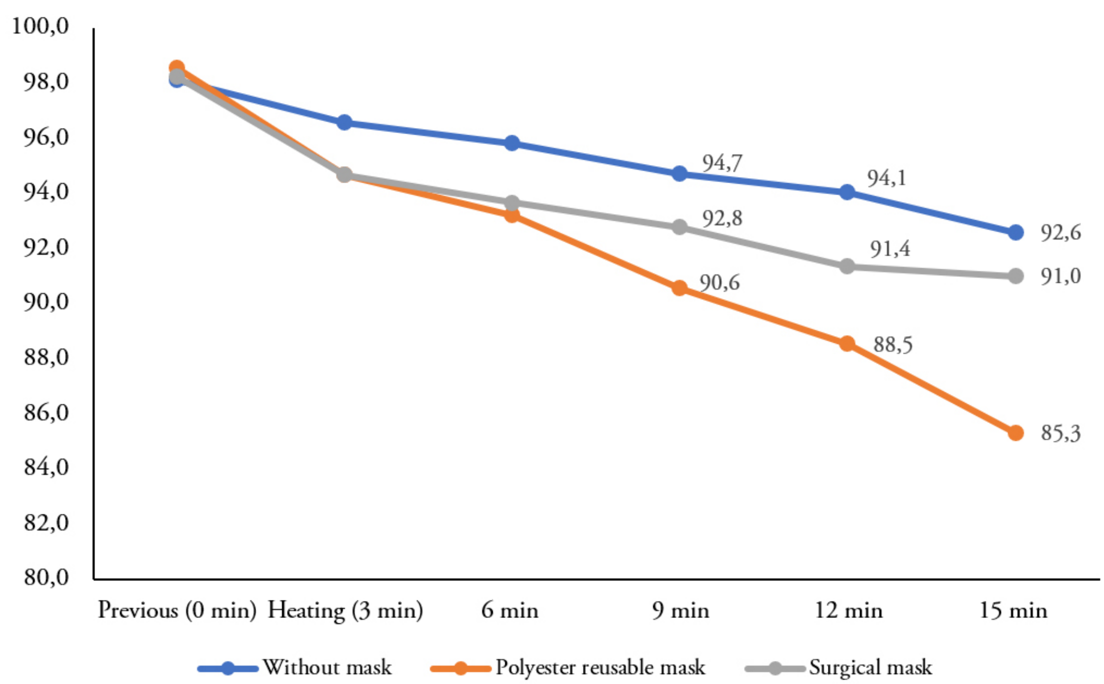

Figure 2. Mean oxygen saturation by group as the test goes on.

Table 3. Oxygen saturation vs. time

Variable	Without mask*	Surgical mask *	Polyester reusable mask *	P Value**
Previous (0 min)	98 [98 – 99]	98.5 [98 – 99]	99 [98 – 99]	0,2064
Heating (3 min)	97 [95 – 99]	95.5 [92 – 97]	95.5 [93 – 97]	0,1414
6 min	96 [93 – 98]	94 [92 – 96]	93.5 [91 – 97]	0,076
9 min	95 [93 – 97]	94 [91 – 95]	90 [87 – 96]	0,03
12 min	94 [92 – 97]	92 [90 – 95]	88 [85 – 91]	0,0054
15 min	92 [90 – 96]	91 [88 – 94]	85 [82 – 86]	0,0012
a Data are provided as the median [IQR]* b From 3 groups Kruskal-Wallis** for continuous variables. P values <0.05 were considered statistically significant				

Table 4. Heart rate vs time

Variable	Without mask*	Surgical mask *	Polyester reusable mask *	P Value**
Previous (0 min)	81 [72 – 87]	83.5 [78 – 90]	77.5 [66 – 92]	0,441
Heating (3 min)	133 [110 – 153]	141 [116 – 150]	130.5 [115 – 150]	0,829
6 min	144.5 [134 – 172]	152.5 [131 – 162]	143 [130 – 158]	0,5922
9 min	156 [143 – 160]	159.5 [145 – 174]	158.5 [140 – 175]	0,6334
12 min	167 [155 – 180]	157 [130 – 174]	153 [139 – 168]	0,204
15 min	160 [138 – 175]	162 [150 – 173]	150 [130 – 171]	0,5183
a Data are provided as the median [IQR]* b From 3 groups Kruskal-Wallis** for continuous variables. P values <0.05 were considered statistically significant				

Some authors as Shaw *et al.* (2020), Epstein *et al.* (2021), and Shein *et al.* (2021) found that the use of facemasks does not alter oxygenation or ventilation and that there were no episodes of hypoxemia or hypercapnia. In contrast, Mapelli *et al.* (2021) described a worsening of cardiorespiratory parameters both at rest and during high-intensity exercise secondary to the flow resistance provided by the masks; however, the difference was not significant. Therefore, it was concluded that the use of masks during physical activity was safe (Shaw *et al.* 2020; Epstein *et al.* 2021; Mapelli *et al.* 2021; Shein *et al.* 2021).

Those results differed from the preset study, maybe because in past publications, the use of a polyester reusable mask was not taken into account and the physical tests to which the participants were subjected to had a different duration; additionally, the tests conducted in this research had the longest durations, allowing us to observe a statistically significant difference in SaO_2 15 minutes after the start of the test when comparing the use and nonuse of a surgical mask.

It is considered that the use of a facemask has effects on both ventilatory mechanics and gas exchange, which may be closely related to the type and intensity of physical activity. As suggested by Porcari *et al.* (2016), who found variations in SaO_2 that may be due to the nature of the physical effort, it was found that interval exercise allows the subject to have rest periods where SaO_2 values can recover even when a mask is on (Safe, 2021). Therefore, this study encourages the development of new research where the duration and type of physical activity are considered.

Limitations. A limitation of the study is that not all the participants could finish all the tests due to shortness of breath or physical conditioning. However, as it was a crossover study, we could manage to have the same physical condition for participants in each group, and this can therefore be attributable to the type of mask because the test was always the same.

CONCLUSION

This study shows that face masks significantly impact respiratory function during physical exercise, with the greatest reductions in oxygen saturation and the highest levels of shortness of breath observed in the polyester reusable mask group. Surgical masks had a lesser but still notable effect, particularly after prolonged exercise. These findings challenge prior studies suggesting that masks do not affect oxygenation, likely due to differences in mask type, test duration, and exercise intensity.

Perspective. The results suggest that polyester reusable cloth masks should be avoided during running, as they are associated with a greater impact on shortness of breath and reduced oxygen saturation. For individuals running in crowded or enclosed spaces, we recommend using surgical masks, particularly for moderate physical activities such as running at intermediate speeds. However, for high-intensity physical activities, such as long-duration or sprint running, it is preferable to run without a mask in open, solitary environments where social distancing can be reliably practiced.

With the widespread availability of COVID-19 vaccines, running without a mask in open spaces is now considered safe, especially for vaccinated individuals. Future studies should explore the long-term effects of mask-wearing during exercise and research an alternative mask designs that balance protection with optimal respiratory function during physical exertion.

Conflict of interest: Authors do not declare conflicts of interest.

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