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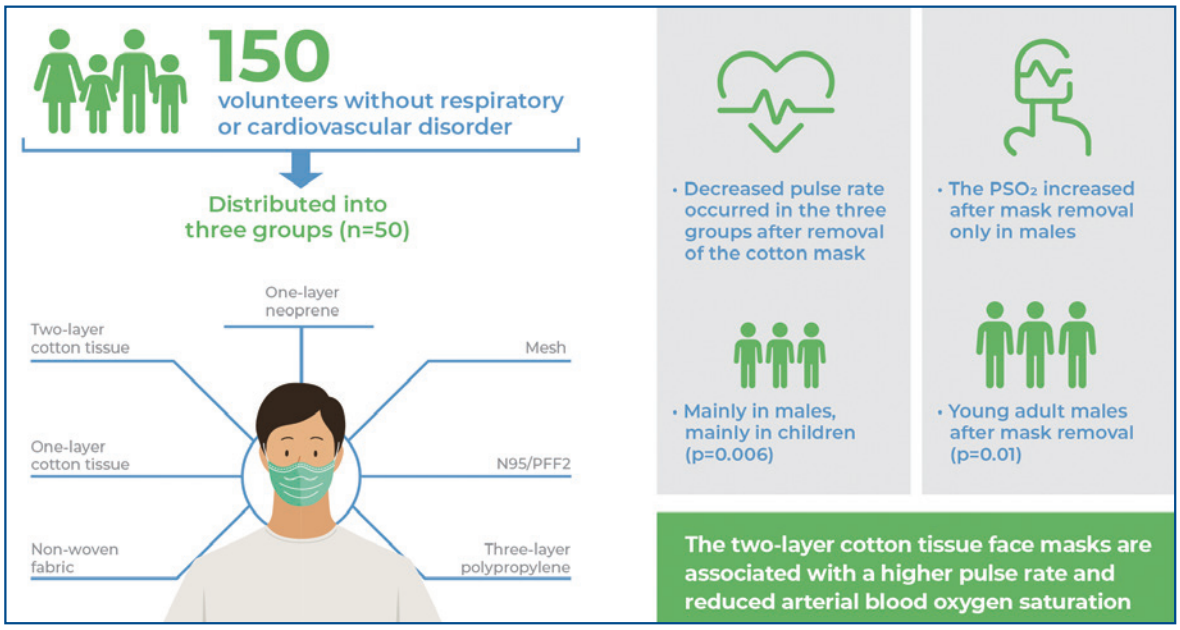
ORIGINAL ARTICLE

# Effects of face mask on pulse rate and blood oxygenation

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## In Brief

This study was conducted on a group of 150 volunteers (children, young adults, and older adults) of both sexes. The results showed that face masks were associated with an increased pulse rate and reduced arterial blood oxygen saturation without any associated clinical disorders. These effects were more pronounced in adult men, who tend to have lower tolerance to breathing and ear discomfort caused by the mask, compared to women and older adult volunteers.

## Highlights

- Face masks are associated with ear discomfort.
- Face masks increase the pulse rate.
- Face masks reduce arterial blood oxygen saturation.
- Face masks are less tolerated by young men.

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# Effects of face mask on pulse rate and blood oxygenation

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## ABSTRACT

**Objective:** The World Health Organization and Centers for Disease Control and Prevention recommend the use of face masks in public. This study aimed to evaluate the effects of face masks on pulse rate and partial blood oxygen saturation in patients without cardiorespiratory disorders. **Methods:** A total of 150 volunteers of both sexes were divided into three groups (n=50) according to age (children, young adults, and older adults). The partial blood oxygen saturation and pulse rate were measured for each volunteer using a digital oximeter while wearing a facial mask and remaining at rest. The masks were removed for two minutes, and partial blood oxygen saturation and pulse rate were remeasured. The materials and types of masks used were recorded. The *t*-test for paired samples was used to compare the mean values obtained before and after removing the masks. **Results:** The most frequently used mask was a two-layered cloth (64.7%). A decrease in pulse rate was observed after removing the face mask in males, particularly in children (p=0.006) and young adults (p=0.034). Partial blood oxygen saturation levels increased in young adult males after mask removal (p=0.01). **Conclusion:** The two-layer cotton tissue face masks are associated with a higher pulse rate and reduced arterial blood oxygen saturation without associated clinical disorders, mainly in adult men with a lower tolerance to breathing and ear discomfort.

**Keywords:** Facial masks; Heart rate; Oxygen saturation; Respiration; SARS-CoV-2; Coronavirus infections; Age factors

## INTRODUCTION

SARS-CoV-2 has become a highly contagious pandemic, with respiratory, pleural, cardiac, vascular, intestinal, and neuronal manifestations, as well as other unproven adverse effects.[1,2] The World Health Organization, Center for Disease Control and Prevention, and Brazilian Health Ministry have recommended the use of face masks in public spaces where a social distancing of greater than one meter is not possible.[3] A study by Beder et al. found an increase in pulse rate (PR) and a decrease in partial blood oxygen saturation ($PSO_2$) one hour after the use of surgical masks in a cohort of 53 surgeons.[4] However, another study involving ten health workers did not find a significant association between the use of N95 masks and changes in vital signs.[5] No published research was found on the general population who routinely used face masks. As these masks can retain heat and moisture, it is possible that part of the exhaled $CO_2$ is accumulated near the nose, consequently interfering with breathing.[6,7] However, data on heart rate related to mask use is scarce in the literature.

## OBJECTIVE

To evaluate the effect of face mask use on partial blood oxygen saturation and pulse rate in patients at rest and without any associated cardiovascular or respiratory disorders.

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none.

## METHODS

All volunteers were invited to participate in this study after signing an informed consent document. Children were also informed about the purpose of this study and were included after their acceptance and signature by their legal guardians.

A total of 150 participants of all ethnicities and both sexes were included. This study included only volunteers without respiratory or cardiovascular disorders who were not taking any medications. The participants were divided into three age groups, each with 50 participants (25 males and 25 females): Group 1 consisted of participants between 4 and 9 years old, Group 2 included participants between 20 and 60 years old, and Group 3 consisted of participants over 80 years old.

The $PSO_2$ and PR of each participant were measured using a digital oximeter (Oxygen Check Multilaser® HCO23) during two periods: first, while wearing the face mask for more than five minutes, and second, after removing the mask for two minutes while being at a distance of more than two meters from any other person or potentially contaminated objects. The material and type of mask were also recorded.

The results were analyzed using Epi Info version 7.2.2.6 and PASW Statistics 18 software. Normality was checked using the Kolmogorov–Smirnov test, and the *t*-test for paired samples was used to compare the means obtained before and after mask removal. Results were considered statistically significant at a significance level of 95% or greater, with a corresponding $p<0.05$.

The study was approved by the Research Ethics Committee of the *Universidade Federal de Minas Gerais*, Brazil (CAAE: 31095820.4.0000.5149 # 4.066.291).

## RESULTS

The skin color of the 150 participants was white in 58%, of mixed ethnicity in 23.3%, black in 18%, and Asian in 0.7%. Table 1 shows the types of masks used by the volunteers during the study. The results showed a decrease in PR in all three groups, which was observed after removal of the two-layered cotton mask. Pulse rate reduction after mask removal occurred mainly in males, with statistically significant differences observed in Groups 1 and 2 (Table 2). $PSO_2$ levels increased only in men after mask removal, with significant differences observed in Group 2 (Table 3). No participant reported any clinical symptoms such as shortness of breath, facial discomfort, or anxiety during mask use.

**Table 1.** Characterization of the sample according to the mask material used and its association with the volunteer's pulse frequency (mean+standard deviation of mean)

| Facial mask | Volunteers n (%) | With mask | Without mask | p value* |
|---|---|---|---|---|
| Two-layer cotton tissue | 97 (64.7) | 86.24±16.38 | 83.27±15.79 | 0.006 |
| One-layer cotton tissue | 22 (14.7) | 85.82±19.33 | 81.86±13.78 | 0.14 |
| Non-woven fabric | 10 (6.7) | 78.30±10.66 | 77.20±8.28 | 0.58 |
| Three-layer polypropylene | 9 (6) | 76.33±18.17 | 74.56±14.74 | 0.39 |
| N95/PFF2 | 7 (4.7) | 87.14±20.67 | 89.29±15.03 | 0.52 |
| Mesh | 4 (2.7) | 84.75±32.92 | 81.75±30.82 | 0.29 |
| One-layer neoprene | 1 (0.7) | 71.00 | 71.00 | - |

* p value referred to paired Student *t* test; N95/PFF2, mask with three layers of polypropylene and one layer of polyester.

**Table 2.** Pulse rate per minute (mean+standard deviation of mean) in each volunteer age group and sex

| Facial mask type | Volunteers n (%) | With mask | Without mask | p value* |
|---|---|---|---|---|
| Group 1 | 50 (33.3) | 97.54±13.46 | 94.02±11.78 | 0.06 |
| Male | 25 (16.6) | 102.36±12.23 | 95.6±12.29 | 0.006 |
| Female | 25 (16.6) | 92.72±13.11 | 92.44±11.27 | 0.92 |
| Group 2 | 50 (33.3) | 82.06±16.99 | 79.20±15.05 | 0.034 |
| Male | 25 (16.6) | 80.00±17.73 | 77.20±16.72 | 0.21 |
| Female | 25 (16.6) | 84.12±16.32 | 81.20±13.2 | 0.06 |
| Group 3 | 50 (33.3) | 75.26±13.20 | 73.66±11.27 | 0.07 |
| Male | 25 (16.6) | 78.68±11.99 | 76.80±11.66 | 0.13 |
| Female | 25 (16.6) | 71.84±13.69 | 70.52±10.15 | 0.3 |

* p value referred to paired Student *t* test.
Group 1: 4-9 years old; Group 2: 20–60 years old; Group 3: over 80 years old.

**Table 3.** Partial arterial blood oxygen saturation (mean+standard deviation of mean) in each volunteer age group and sex

| Facial mask type | Volunteers n (%) | With mask | Without mask | p value* |
|---|---|---|---|---|
| Group 1 | 50 (33.3) | 97.22±1.52 | 96.88±2.19 | 0.32 |
| Male | 25 (16.6) | 97.16±1.34 | 96.68±1.99 | 0.23 |
| Female | 25 (16.6) | 97.28±1.72 | 97.08±2.39 | 0.73 |
| Group 2 | 50 (33.3) | 95.82±2.18 | 96.34±2.00 | 0.01 |
| Male | 25 (16.6) | 95.48±1.98 | 96.24±1.96 | 0.01 |
| Female | 25 (16.6) | 96.16±2.35 | 96.44±2.08 | 0.43 |
| Group 3 | 50 (33.3) | 94.9±2.46 | 95.44±1.97 | 0.11 |
| Male | 25 (16.6) | 94.88±2.02 | 95.28±2.05 | 0.26 |
| Female | 25 (16.6) | 94.92±2.87 | 95.6±1.91 | 0.25 |

* p value referred to paired Student *t* test.
Group 1: 4-9 years old; Group 2: 20–60 years old; Group 3: over 80 years old.

## DATA AVAILABILITY

The authors have full control of all the data in this work, which are available for verification upon request.

## DISCUSSION

According to literature, the most commonly used types of face masks by health professionals and the general population are surgical masks and masks with filtration, including N95, FFP2, and FFP3.[8] However, in this study, a handmade two-layered cotton tissue mask was most commonly used, despite studies indicating that it was not an effective filter for respiratory droplets.[9-11]

Despite the physical barriers to free breathing, in this study, masks were not associated with any clinical manifestations. The slight decrease in $PSO_2$ observed in young adult men had no clinical relevance according to the volunteers, who complained only of minor ear discomfort due to short elastic bands and allergic reactions to the mask and elastic band material.[12,13] On the other hand, respiratory difficulties reported by health professionals using N95 masks in previous studies seems to be related to the high number of synthetic material layers.[14,15]

The results of this study suggested that PR and $PSO_2$ disorders should be considered when using masks, considering that the volunteers had no cardiovascular or respiratory disorders, and this study did not induce any stress or adverse effects. The observed differences between males and females in this study may be related to sex differences, considering that adult women are more tolerant of physical discomfort than men.[16,17] Males usually had greater sympathetic autonomic nervous system activity, and their response to breathing impairments was faster and more relevant.[18] The findings of this study are consistent with those of a previous study that found reduced $PSO_2$ only in males using face masks.[19]

## CONCLUSION

Two-layered cotton tissue face masks were associated with a higher pulse rate and reduced arterial blood oxygen saturation without clinical disorders, mainly in adult men who have lower tolerance to breath and ear discomfort.

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## AUTHORS' CONTRIBUTION

Pedro Alves Soares Vaz de Castro and Bruno Rodarte Freire: designed the study, participated in all steps of this work, wrote and drafted the manuscript, took responsibility for all aspects of this work and article, revised the manuscript, and are responsible for the submission of this article for publication. Andy Petroianu: designed the study, took responsibility for all aspects of this work and article, revised the manuscript, and submitted this article for publication.

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