

SPECIAL ARTICLE

## COVID-19 and mask in sports



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### KEYWORDS

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Hypercapnia;  
Sport;  
Masks

### Abstract

**Introduction:** Due to the mandatory use of a mask, and the authorization to do outdoor sports in Catalonia, we aimed to assess the physiological impact of the hypercapnia hypoxia generated by the masks during aerobic sports practice.

**Methods:** Eight subjects (2 women, 6 men) were assessed at baseline with and without a mask, and immediately after a 21-flex test performed following the Ruffier protocol with a mask. Measures of HR (heart rate), concentration of O<sub>2</sub> and CO<sub>2</sub> inside the mask and SatO<sub>2</sub> were assessed. The test was carried out in ambient air in squares in the city of Barcelona.

**Results:** A decrease in O<sub>2</sub> was recorded, and when comparing the, baseline 20.9%, baseline mask 18.3%, post-exercise 17.8% ( $p < 0.001$ ). An increase in CO<sub>2</sub> in the three preconditions (464, 14162, 17000 ppm;  $p < 0.001$ ). Basal saturation O<sub>2</sub> was  $97.6 \pm 1.5\%$  and post exercise  $92.1 \pm 4.12\%$  ( $p 0.02$ ).

**Conclusions:** The use of masks in athletes causes hypoxic and hypercapnic breathing as evidenced by increased effort during exercise. The use of masks during a short exercise with an intensity around 6–8 METS, decreases O<sub>2</sub> by 3.7% and increases the CO<sub>2</sub> concentration by 20%.

### Introduction

In the context of the COVID-19 pandemic and due to the authorization of sports practice in Catalonia, that has generated various health problems among the athletes. We

present some initial results that allow us to give guidelines that balance the risk of contagion and that of hypercapnic hypoxia generated using protective masks. Speculation and uncertainties are the order of the day<sup>1</sup>; clear doubts, motivates the present study.

**Objectives:** (a) Provide urgent information on the safety of the use of masks for the prevention of COVID-19, by athletes. (b) Assess the impact of the use of masks on inhaled air during an aerobic exercise of the order of 1.25 W/kg (6–8 METS), the oxygen deficiency generated by its use, as well

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**Table 1** shows the changes in O<sub>2</sub> and CO<sub>2</sub> in the 3 conditions, basal with and without mask, and post exercise with mask.

	Basal without mask	Basal with mask	Mask post-exercise	<i>p</i>
O <sub>2</sub> , %	20.9	18.3 ± 0.24	17.8 ± 0.43	<0.001
CO <sub>2</sub> , ppm	464 ± 117	14 162 ± 2100	17 000 ± 2684	<0.001
Saturation O <sub>2</sub> , %	97.6 ± 1.5	–	92.1 ± 4.12	0.02
Heart rate, bpm	75.7 ± 17.1	–	112.8 ± 4.1	<0.001

as the possible toxicity associated with the increase CO<sub>2</sub> breathed.

## Material and methods

Eight subjects were assessed at baseline with and without a mask, and immediately after a 21-flex test performed following the Ruffier protocol with a mask, with determination of the accumulated height as a function of time. Of 21 push-ups<sup>2</sup> in a public park. With determination of SaO<sub>2</sub>Hb, heart rate (HR), watts (W), O<sub>2</sub> and CO<sub>2</sub>. The power achieved has been calculated in kilograms per second (Kp-m/s) and has been converted into W and W/kg; and the interval has also been estimated in METS.

The subjects studied had this baseline characteristics: mean age: 48.9 (19–66) years old; height: 168 (159–176) cm; BMI: 22.1 (19.1–28.9). Medical history: HT (1 case), psychiatric (1 case), COVID-19 positive (1 case discharged), smoking (1 case), emphysema (1 case) and 4 without medical history.

Pulse Oximeter model FS20C TEMPI-TEC. MultiRae gas analyzer from Rae Systems® (portable chemical detector) with analysis of oxygen, carbon dioxide and carbon monoxide. It was strictly protocolized to avoid any risk of contagion.

Statistical analysis was performed with IBM SPSS® version 19 software, the T test for paired samples and the ANOVA of repeated means depending on the type of analysis used.

## Results

The 8 subjects (2 women, 6 men) were calculated to have performed the test<sup>2</sup> with a performance of 82.81 ± 27.3 W (1.23 ± 0.37 W/kg) (i.e. between 6 and 8 METS) (Table 1).

In two cases, the CO<sub>2</sub> level of 2% (20 000 parts per million or ppm) has been reached. This represents the threshold of toxicity for many subjects.

Subjects, when wearing a mask, at rest showed a minimal decrease in capillary hemoglobin saturation O<sub>2</sub> (97.6 ± 1.5%). At the end of the test they showed a decrease of 5.5 points (saturation O<sub>2</sub> 92.1 ± 4.12%; *p* ≤ 0.02).

Regarding the heart rate during the test, have been: 75.7 ± 17.1 bpm at rest vs. 112.8 ± 4.1 bpm; *p* ≤ 0.001 at the end of the test at 45". The heart rate recovery at one minute post effort was: 81 ± 17.5 bpm; and at 3 min 78.9 ± 23.6 bpm (*p* = 0.56).

## Discussion

The results of our study show that there is a significant decrease in O<sub>2</sub> and increase in CO<sub>2</sub> when performing an aerobic exercise with a mask.

To date, we do not know of other studies that assess the use of protective masks related to sport, with which we can contrast our results, but we do have different points of view with supporters and detractors of their use in the context of the pandemic from COVID-19.<sup>3</sup> There are other studies on the effect of contamination and hypercapnic hypoxia and its possible metabolic implications in moderate hypercapnia.<sup>4,5</sup> In the case of hypoxia and severe hypercapnia, there are affectations at the neuro-vegetative level,<sup>6</sup> with diverse symptoms typical of hypercapnia.<sup>7</sup>

We consider it of general interest to be able to communicate some initial results that confirm the hypoxic and hypercapnic impact due to the protection with masks on the intensity levels of aerobic exercise. We provide real first figures on the range of the rarefied air generated by the masks. We visualize a cut zone in the figure of 2% of hypercapnia; this topic should be object of analysis and consensus among the specialists.

Knowing the size of the O<sub>2</sub> (0.15 nm) and CO<sub>2</sub> (0.33 nm) molecules and the size of the SARS-CoV-2 that is between 50 and 200 nm, it can be deduced that, seeing the considerable filtering impact of masks, their effect will be effective in preventing/limiting the penetration of SARS-CoV-2 by air. The effects of oxygen deficiency can be assessed in isolation, when compared with the Saturation O<sub>2</sub> data reported for acute exposure at different altitudes above sea level.<sup>8</sup>

In relation to the limitations of our study, we can mention (a) a small number of subjects in the sample; (b) study that has been carried out outside the physiology laboratory environment (closed at this stage of the pandemic); (c) it is limited to investigate the intensity only in the range of 6–8 METS; (d) also does not provide data on the different types of masks and different prototypes for the protection of the nose, mouth and respiratory tract. And finally, the analysis of the gaseous content of the mask-subject interface is simply that, and therefore it is not an ergo-spirometric analysis, but the study of the gaseous composition that the subject will inhale.

## Conclusions

The use of masks in a resting situation decreases the availability of oxygen by 14% on average and increases aspirated CO<sub>2</sub> levels by 30 times. The use of masks during a short exercise with an intensity around 6–8 METS, decreases O<sub>2</sub> by 3.7% and increases the CO<sub>2</sub> concentration by 20%. In some model

of mask during exercise, 20 000 ppm of CO<sub>2</sub> (2%) is reached and it can be uncomfortable and symptomatic for some of the subjects.

### Conflict of interest

Volunteers subjected to stress test in a level 0 confinement situation in the Barcelona Epicenter, COVID-19.

There are no conflicts of interest affecting the signatories of this publication.

Research data available on the blog Ergometria i canvi climàtic: COVID 19 & mask in sports-dades.<sup>9</sup>

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