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SPECIAL ARTICLE

COVID-19 and mask in sports

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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 O2 and CO2 inside the mask and SatO2 were assessed. The test was carried out in ambient air in squares in the city of Barcelona.
Results: A decrease in O2 was recorded, and when comparing the, baseline 20.9%, baseline mask 18.3%, post-exercise 17.8% (p < 0.001). An increase in CO2 in the three preconditions (464, 14162, 17000 ppm; p < 0.001). Basal saturation O2 was 97.6 ± 1.5% and post exercise 92.1 ± 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 O2 by 3.7% and increases the CO2 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; 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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as the possible toxicity associated with the increase CO₂ 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 in a public park. With determination of SaO₂Hb, heart rate (HR), watts (W), O₂ and CO₂. 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. MultiRa 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.

Table 1 shows the changes in O₂ and CO₂ in the 3 conditions, basal with and without mask, and post exercise with mask.

|                      | Basal without mask | Basal with mask    | Mask post-exercise | p     |
|----------------------|--------------------|--------------------|--------------------|-------|
| O₂, %                | 20.9               | 18.3 ± 0.24        | 17.8 ± 0.43        | <0.001|
| CO₂, ppm             | 464 ± 117          | 14162 ± 2100       | 17000 ± 2684       | <0.001|
| Saturation O₂, %     | 97.6 ± 1.5         | –                  | 92.1 ± 4.12        | 0.02  |
| Heart rate, bpm      | 75.7 ± 17.1        | –                  | 112.8 ± 4.1        | <0.001|

Discussion

The results of our study show that there is a significant decrease in O₂ and increase in CO₂ 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. There are other studies on the effect of contamination and hypercapnic hypoxia and its possible metabolic implications in moderate hypercapnia. In the case of hypoxia and severe hypercapnia, there are affectations at the neuro-vegetative level, with diverse symptoms typical of hypercapnia.

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 O₂ (0.15 nm) and CO₂ (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 O₂ data reported for acute exposure at different altitudes above sea level.

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 CO₂ levels by 30 times. The use of masks during a short exercise with an intensity around 6–8 METS, decreases O₂ by 3.7% and increases the CO₂ concentration by 20%. In some model...
of mask during exercise, 20000 ppm of CO₂ (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.³

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