Apunts Sports Med. 2020;55(208):143–145

apunts
SPORTS MEDICINE
www.apunts/org

SPECIAL ARTICLE

COVID-19 and mask in sports

Fernando Pifarré[a], Diego Dulanto Zabala[b], Gonzalo Grazioli[c], Ignasi de Yzaguirre i Maura[a,*]

[a] *Unitat de Medicina i Esport, Generalitat of Catalunya, Barcelona, Spain*
[b] *Basurto University Hospital, Bilbao, Spain*
[c] *Àptima Center Clínic, Terrassa, Spain*

Received 28 May 2020; accepted 4 June 2020
Available online 6 June 2020

KEYWORDS
COVID-19;
SARS-CoV-2;
Hypoxia;
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_2 and CO_2 inside the mask and $SatO_2$ were assessed. The test was carried out in ambient air in squares in the city of Barcelona.
Results: A decrease in O_2 was recorded, and when comparing the, baseline 20.9%, baseline mask 18.3%, post-exercise 17.8% ($p < 0.001$). An increase in CO_2 in the three preconditions (464, 14162, 17 000 ppm; $p < 0.001$). Basal saturation O_2 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 O_2 by 3.7% and increases the CO_2 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[1]; 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

* Corresponding author.
E-mail addresses: ignasi.yzaguirre@gencat.cat, 14521iym@comb.cat (I.d.Y.i. Maura).

https://doi.org/10.1016/j.apunsm.2020.06.002

Table 1 shows the changes in O_2 and CO_2 in the 3 conditions, basal with and without mask, and post exercise with mask.

	Basal without mask	Basal with mask	Mask post-exercise	*p*
O_2,%	20.9	18.3 ± 0.24	17.8 ± 0.43	<0.001
CO_2, ppm	464 ± 117	14 162 ± 2100	17 000 ± 2684	<0.001
Saturation O_2,%	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_2 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[2] in a public park. With determination of SaO_2Hb, heart rate (HR), watts (W), O_2 and CO_2. 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[2] 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_2 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_2 (97.6 ± 1.5%). At the end of the test they showed a decrease of 5.5 points (saturation O_2 92.1 ± 4.12%; $p \leq 0.02$).

Regarding the heart rate during the test, have been: 75.7 ± 17.1 bpm at rest vs. 112.8 ± 4.1 bpm; $p \leq 0.001$ 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_2 and increase in CO_2 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.[3] There are other studies on the effect of contamination and hypercapnic hypoxia and its possible metabolic implications in moderate hypercapnia.[4,5] In the case of hypoxia and severe hypercapnia, there are affectations at the neuro-vegetative level,[6] with diverse symptoms typical of hypercapnia.[7]

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_2 (0.15 nm) and CO_2 (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_2 data reported for acute exposure at different altitudes above sea level.[8]

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_2 levels by 30 times. The use of masks during a short exercise with an intensity around 6–8 METS, decreases O_2 by 3.7% and increases the CO_2 concentration by 20%. In some model

of mask during exercise, 20 000 ppm of CO_2 (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.[9]

References

1. Reynolds G. Exercising Outdoors With a Face Mask. New York Times [Internet]; 2020. Available from: https://www.nytimes.com/2020/04/10/well/move/coronavirus-exercise-outdoors-mask-running-cycling.html
2. Guillet R, Genéty J, Brunet-Guedj E. Sports medicine manual; 1985. p. 110–1.
3. Toresdahl BG, Asif IM. Coronavirus disease 2019 (COVID-19): considerations for the competitive athlete. Sports Health. 2020;12:221–4.
4. de Yzaguirre I, Vives J, Gutiérrez JA, Brotons D, Tramullas A. Ergometría y cambio climático. Apunt Med l'Esport. 2010;45:219–25.
5. Yang WY, Zhang ZY, Thijs L, Bijnens EM, Janssen BG, Vanpoucke C, et al. Left ventricular function in relation to chronic residential air pollution in a general population. Eur J Prev Cardiol. 2017;24:1416–28.
6. de Yzaguirre y Maura I, Grazioli G, Domènech Feira-Carot M, Dulanto Zabala D, Sitges Carreño M, Gutiérrez Rincón JA. Impacto del aire enrarecido de una cueva mediterránea en humanos, a nivel cardiovascular. Apunt Med l'Esport. 2016;51(190):40–7.
7. de Yzaguirre i Maura I, Escoda i Mora J, Cornet JB, Rincón JAG, Zabala DD, Cardona RS. Adaptación al aire enrarecido de las simas y cuevas. Estudio de laboratorio. Apunt Med l'Esport. 2008;43:135–41.
8. Botella De Maglia J, Compte Torrero L. Saturación arterial de oxígeno a gran altitud. Estudio en montañeros no aclimatados y en habitantes de alta montaña. Med Clin (Barc) [Internet]. 2005;124:172–6, http://dx.doi.org/10.1157/13071480.
9. de Yzaguirre I. Ergometria i canvi climàtic [Internet]. VilaWeb; 2020. Available from: https://blocs.mesvilaweb.cat/ignasiblume17/2020/05/30/covid-19-mask-in-spor-dades/