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Early View

Research letter

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Facemasks do not lead to abnormal gas exchange during treadmill exercise testing in children

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Take home message

No episodes of oxygen desaturation or carbon dioxide retention were observed in this cross-sectional study assessing children with exercise-induced symptoms wearing a surgical facemask during a submaximal treadmill exercise test.

To the Editor:

Facemasks help reducing the spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) during the COVID-19 pandemic. The United Nations Children's Fund and World Health Organisation recommend their use in children as from six years old.[1] However, many parents worry about health effects of facemasks in children, especially during exercise. They fear that facemasks might cause breathing difficulties, impair oxygen (O2) uptake and cause carbon dioxide (CO2) retention.[2] Parents of children with underlying respiratory problems are particularly concerned, and some request medical certificates to exempt their children from wearing facemasks during sports at school.

Studies in adults have shown that it is safe to wear facemasks even during intense physical exercise [3-6], but data for children are lacking. The few paediatric studies included healthy children observed at rest or during mild physical exercise.[7,8] We thus aimed to assess whether wearing a surgical facemask during intense physical exercise leads to abnormal gas exchange in children with underlying respiratory problems.

We conducted a cross-sectional study nested in the Swiss Paediatric Airway Cohort (SPAC), a multicentre observational cohort study of children referred to paediatric respiratory outpatient clinics for investigation of respiratory problems including wheeze, cough and exercise-induced symptoms.[9] The study is hosted in Bern and has ethical approval (KEB 2016-02176).

Between December 2020 and October 2021, children with exercise-induced symptoms (EIS) performing an exercise-induced asthma (EIA) test on a treadmill were recruited at the Lucerne Children's Hospital, one of the SPAC centres. We obtained informed consent from caregivers. All children had to wear a surgical mask during the EIA test, which was performed according to the American Thoracic Society guidelines.[10] Briefly, the children exercised during six (if aged <12 years) to eight (if aged ≥ 12 years) minutes on a treadmill at a heart rate of 80-90% of the predicted maximum (220 – age in years). The forced expiratory volume in one second (FEV1) was measured before and at 2, 5, 10 and 15 minutes after exercise. Oxygen saturation (SpO_2) was measured before and after exercise with a fingertip oximeter. Capillary blood gas analysis was performed immediately after exercise to assess gas exchange. Measurements were done in all children, including those who prematurely interrupted the exercise test because of breathing difficulties or exhaustion. We summarised categorical data using counts and percentages and continuous data using medians, interquartile range (IQR) and range. Differences between medians were assessed with the Wilcoxon signed rank test.

We included 25 participants. Median age was 14 years (range 9 – 16 years), 76% (19) were girls. Median heart rate attained during the exercise test was 185 beats per minute (range: 175 – 200). Four participants terminated exercise prematurely because of shortness of breath, burning sensation in the throat and chest or dizziness and nausea. One participant reported shortness of breath and throat/chest tightness, and one reported cough during the exercise, but completed it. Two participants had chest tightness, one had shortness of breath and throat tightness, one dry cough, one dizziness and one tachypnea, at the end of the exercise.

Fifteen children (60%) had a drop in FEV_1 of 10% or more, suggestive of an exercise-induced airway obstruction. Median FEV_1 was thus lower after exercise (2.27 L) than before (2.83 L, $p<0.001$) (Table 1). The clinicians who interpreted the exercise test and considered the full clinical picture diagnosed EIA in eleven children (44%). Other diagnoses included induced laryngeal obstruction (ILO), dysfunctional breathing (DB) and insufficient fitness level. We observed no episodes of oxygen desaturation after exercise. The lowest SpO_2 value was 93%. We also found no difference in SpO_2 before and after exercise ($p=0.096$). Capillary blood gas analysis revealed lactic acidosis in most participants (n=19, 76%), but CO_2 retention was not observed in any child. The highest pCO_2 value (5.67 kPa) was well below the upper limit of normal (6.0 kPa).

Table 1: Physiological parameters in children wearing a surgical facemask during exercise-induced asthma (EIA) test on a treadmill (N=25).

	Before EIA test			**After EIA test**			**p-value**
	Median	IQR	Range	Median	IQR	Range	
Lung function							
FEV1 (litres)[a]	2.83	2.07 – 3.01	1.53 – 4.10	2.27	1.92 – 2.65	1.14 – 3.39	< 0.001
Drop in FEV1[b] (%)	-	-	-	11	7 – 18	0 – 43	-
Oxygen saturation							
SpO2 (%)	98	97 – 99	95 – 99	97	96 – 98	93 – 99	0.096
Capillary blood gas							
pH	-	-	-	7.30	7.25 – 7.34	7.15 – 7.40	-
pCO2 (kPa)	-	-	-	4.54	4.22 – 4.99	3.90 – 5.67	-
Bicarbonate (mmol/l)	-	-	-	16.1	14.7 – 18.8	12.7 – 21.3	-
Lactate (mmol/l)	-	-	-	7.9	5.9 – 10.6	3.0 – 13.6	-

[a] After EIA test FEV1: lowest FEV1 value recorded within 15 minutes after exercise; [b] difference between the pre-exercise FEV1 value and the lowest FEV1 value recorded within 15 minutes after exercise expressed as a percentage of the pre-exercise value; FEV1: Forced Expiratory Volume in one second; IQR: Interquartile range; p-value compares the median values before and after the EIA test.

This cross-sectional study does not provide any evidence that wearing surgical facemasks during submaximal treadmill exercise testing leads to oxygen desaturation or CO2 retention in children with EIS. Although exercise-induced airway obstruction occurred in around two-thirds of the children, none had abnormal gas exchange.

As no similar studies have been performed in children, we cannot compare our data to others. Lubrano et al conducted a study among 47 0-12 year old healthy children wearing surgical masks during play activities and a 12-minute walk test (in > 2 years old).[8] During the first 60 minutes of evaluation, there was no significant change in SpO2 and partial pressure of end tidal carbon dioxide (PETCO2). Studies conducted in adults found that wearing of masks could reduce performance, but did not affect gas exchange in healthy individuals undergoing moderate to vigorous exercise [3,4,6] or in patients with severe lung impairment after a 6-minute walk test.[5]

Our data do not allow us to state whether the wearing of facemasks can lead to breathing difficulties or exacerbate breathing problems. It is thought that masks can increase airflow resistance with subsequent increased breathing effort, resulting in a feeling of discomfort frequently associated with their use.[4, 6,7] Further limitations of our study include the small sample size, the short period of exercise, the assessment of surgical masks only and the absence of a control group without facemasks. However, it was not feasible to conduct a controlled study as it was recommended at that time to perform EIA tests with a mask to minimise the risk of SARS-CoV-2 transmission.

In conclusion, this first study assessing the impact of surgical facemasks on oxygen saturation and CO2 retention in children with EIS undergoing submaximal treadmill exercise testing did not reveal evidence of abnormal gas exchange. Even if these findings are reassuring and may help promote the use of surgical masks among children, controlled studies with a larger number of children are needed to confirm our preliminary findings.

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Conflicts of interest

All authors have nothing to disclose

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