Review of “Experimental Assessment of Carbon Dioxide Content in Inhaled Air with or without Face Masks in Healthy Children: A Randomized Clinical Trial”


One-minute summary

- This study primarily examined the amount of carbon dioxide (CO₂) inhaled by 45 healthy children less than 18 years old wearing either a surgical mask or a filtering face piece 2 (FFP2) mask (equivalent to N95 respirator).

- Inhaled mean CO₂ % by volume (95% confidence intervals [CI]), after 3 minutes:
  - Pretest (no mask): 0.27 (0.235–0.300; n=45)
  - Post-test (no mask): 0.28 (0.247–0.316; n=39)
  - Surgical mask: 1.31 (1.197–1.427; n=45)
  - FFP2 mask: 1.39 (1.279–1.504; n=45)

- Age was associated with CO₂ content in inhaled air (y=1.9867-0.0555x; r=-0.39; p=0.008), with CO₂ content of inhaled air decreasing with age.

- The mean (standard deviation [SD]) CO₂ parts per million (ppm) inhaled after 3 minutes for the surgical mask was 13,120 (384) and for the FFP2 was 13,910 (374). The authors state that these values are 6 times larger than allowable limits set by the German Federal Environmental Office (2,000 ppm or 0.2% by volume) in enclosed spaces. The authors concluded that children should not be forced to wear face masks. Please see PHO reviewer’s comments for our concerns with the quality and validity of the measurements used in the study and the authors’ conclusions.
Additional information

- The mean (SD) age of children was 10.7 (2.6) (range: 6–17), with 25 boys and 20 girls.

- For baseline CO₂ measurements without a face mask, a 3-minute continuous measurement was taken. For each mask, nine minutes of measurement were made: 1) 3 minutes for joint inhaled and exhaled air, 2) 3 minutes for inhalation, and 3) 3 minutes for exhalation. Ambient air had a CO₂ % by volume maintained below 0.1% (0.074%; 95% CI 0.073–0.075). The sequence of masks was randomized, with randomization blinded and stratified by age of children.

- Gender and ambient CO₂ amount was not associated with CO₂ content in inhaled air.

- Mean CO₂ % by volume (95% CI) after 3 minutes:
  - Surgical mask, joint inhaled and exhaled: 2.65 (2.504–2.796; n=45)
  - FFP2 mask, joint inhaled and exhaled: 2.68 (2.561–2.793; n=45)
  - Surgical mask, exhaled air: 3.85 (3.641–4.053; n=44)
  - FFP2 mask, exhaled air: 3.85 (3.682–4.011; n=45)

- The authors acknowledge that a limitation of the study was the children may have been apprehensive and were not occupied with an activity in a laboratory setting.

PHO reviewer’s comments

- The use of face masks in children is an important part of a layered approach to preventing Coronavirus Disease 2019 (COVID-19) transmission, particularly in indoor environments.

- The gas measurement apparatus was G100 (manufacturer: Geotech), which is reported in the supplementary materials as an incubator analyzer. This instrument has not been validated for use in this type of study.

- The authors used two types/brands of surgical and FFP2 masks; however, no results by type were reported, or if there was a significant difference within each mask category. The authors did not report on fit-testing for the FFP2 mask.

- The authors state that mask-wearing complaints from children may be attributed to CO₂ being inhaled; however, the authors did not test this hypothesis. The authors commented on hypercapnia as a possible outcome in the Discussion, but did not measure changes in physiological parameters such as respiratory rate, blood gas levels, lung function or heart function. Thus, the clinical significance, if any, of these results are unclear.

- The research protocol accompanying the paper does not match the methods and results reported in the paper. In the protocol, the authors state that additional parameters will be measured, including: oxygen (O₂) levels, humidity of room, breathing frequency, height of children, weight of children, blood oxygenation, pressure in mask, and pulse rate. Details on how exhaled and inhaled air is differentiated are not provided. The authors do not explain this discrepancy in protocol and actual work reported. The inclusion of these measurements would assist in interpreting the results presented.
• The authors do not discuss the purpose of the cited German Federal Environmental Office’s recommended limit of 0.2% for closed rooms or the appropriateness of comparing this environmental recommendation to inhaled concentrations of CO₂. CO₂ limits for indoor air are typically not based on adverse health outcomes (short, medium, long-term effects); they are typically set to be a proxy indicator for ventilation.

• In two similar studies reported in the protocol, one had similar results as those reported by the authors; however, the other reported much lower inhaled CO₂ % by volume (lower by a factor of 2–5). In a cohort study of 47 healthy children, Lubrano et al. (2021) reported there was no significant difference in median pressure of end-tidal CO₂, O₂ saturation, pulse rate or respiratory rate in children wearing surgical masks, compared to children not wearing surgical masks. After a walking test for 12 minutes while wearing a mask, there was a significant increase in median pulse rate and respiratory rate in those wearing a mask, compared to no activity for the 60 minutes before the walking test. For the walking test, there was no significant difference for median pressure of end-tidal CO₂ or O₂ saturation.

References


Citation


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