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Effects of surgical and FFP2/N95 face masks on cardiopulmonary exercise capacity: the numbers don't add up

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To the Editor:

We were interested to see the work of Fikenzer et al.,[1] evaluating the effects of surgical masks and FFP2/N95 face masks on exercise performance. While at first glance, the results are intriguing, there are numerous flaws in this work that draw the validity of the study into question. In the interest of brevity, we will focus on the FFP2/N95 face mask condition although the reasoning outlined below equally applies to the surgical mask condition.

There are several robust relationships in pulmonary and exercise physiology that can be used to evaluate data quality. The first of these is the linear relationship between power output and oxygen consumption which is the basis of estimating oxygen consumption without measuring expired gas (see [2] for example). Fikenzer et al., show an average peak oxygen consumption of 3248 ml/min at a power output of 277 watts without masks for an overall efficiency of 11.7 mlO_2/watt. While wearing a FFP2/N95 face mask subjects averaged a 14 watt decrement in peak power output, which based on the efficiency in these subjects, would

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Conflict of Interest
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be expected to reduce oxygen consumption by ~160 ml. This corresponds to a 5% difference, yet the reported oxygen consumption is reduced by 426 ml/min or 13%. Thus, these data are not internally consistent and even less likely if masks significantly impact the work of breathing as the authors suggest.

A second robust relationship is the linear relationship between cardiac output during exercise and oxygen consumption (slope ~ 5.5 L/L) [3–5]. Fikenzer et al., show no significant change in heart rate (Omnibus F = 0.11) or cardiac output between conditions (Omnibus F = 0.34), further calling the reported reduction in oxygen consumption with FFP2/N95 face mask into question.

Finally, expired ventilation was reported to be 25% less with the FFP2/N95 face mask than the unmasked condition, leading the authors to suggest that masks limit ventilation. However, there was essentially identical arterial PCO_2 (Omnibus F = 0.72) between FFP2/N95 face mask and unmasked conditions while the pH and arterial PO_2 were similar. As PCO_2 reflects alveolar ventilation [6], the lack of difference in PCO_2 across conditions is not consistent with the reported reduction in ventilation. Rather, these data show that alveolar ventilation and gas exchange during exercise are unaffected by facemasks and fail to support the authors' conclusion of a respiratory/ventilatory limitation to exercise.

Unfortunately, these data suggest that ventilation was grossly underestimated during maximal exercise as well as during spirometry due to one of two potential problems. First, there could have been a leak in the system. The authors tested their system for leaks by the "absence of any acoustic, sensory or visual indication of leakage (e.g., lifting of the mask, whistling or lateral airflow)" during forced expiration but this is an inadequate technique. Second, the mask material may affect the measurement of ventilation. Regardless of the precise source, the data suggest the effects of measurement error and not the underlying impact of wearing facemasks on the respiratory system.

When viewed in conjunction with problems in the statistical analysis, such as the fact that a Type I error is highly likely given the number of statistical comparisons, and the lack of the full description of the metabolic system or its calibration, these fundamental inconsistencies in the data strongly call into question the results of this study. To the uncritical eye, this study may raise concerns that could undermine public health efforts to ensure mask adherence, particularly among those engaging in physical activity. Given the numerous problems noted above, however, the data do not support such concerns. Rather the data show that arterial blood gases, heart rate, cardiac output and blood pressure are not significantly different between masked and unmasked conditions. This study should in no way serve as a basis for avoiding mask use during exercise.

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