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Short Communication

Effects of wearing a FFP2 mask on indirect calorimetry measurements: A pilot study

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Summary

Background & aims: During the coronavirus disease 2019 (COVID-19) pandemic the use of Indirect calorimetry (IC) during nutritional rehabilitation program requires special precautions due to possible contagions for patients and health professionals. We evaluated in a sample of healthy subjects the agreement between oxygen consumption (VO₂ mL/min), carbon dioxide production (VCO₂ mL/min), respiratory quotient (RQ) and resting energy expenditure (REE kcal/24 h/day) measured by IC with and without a filtering facepiece mask.

Materials: 10 subjects with a mean (SD) age of 43 (10) years and a body mass index of 25.2 (5.8) kg/m² underwent indirect calorimetry both with and without a class 2 filtering facepiece mask (FFP2), in random order. The limits of agreement (LOA) and the concordance correlation coefficient (CCC) were used to evaluate the interchangeability of the measurement conditions.

Results: The LOA between REE measured with and without FFP2 (-111 to 189 kcal/day) were comparable to those for repeated IC tests without wearing masks and CCC (0.95) showed substantial agreement.

Conclusions: We observed high agreement between REE measured by IC with and without FFP2 mask. These procedures are interchangeable in clinical practice.

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1. Introduction

Measuring resting energy expenditure (REE) by indirect calorimetry (IC) plays a central role in the management of the nutritional rehabilitation program. IC is required to establish a correct nutritional diagnosis and to prescribe the optimal energy intake for a specific patient energy requirements, both in adults and in children and specifically in presence of diseases that can impair REE, making common predictive formulas unreliable [1].

On 9 March 2020, the government of Italy declared a national quarantine. The lockdown measures have included the temporary closure of all non-essential activities, and increased measures aimed to increase personal hygiene, symptom monitoring, early diagnosis, patient isolation, and the suspension of all non-deferred medical visits, including nutritional assessment and indirect calorimetry in order to guarantee social distancing.

In phase 2 of these epidemic, clinical activities are opening and new standardized procedures are needed to protect both patients and health professionals. Concerning REE measurement, an increasing number of queries has been raised related to the use and safety of IC, beside ordinary cleaning procedures [2]. Manufacturing companies have released comprehensive cleaning and disinfection manuals to ease and promote adequate infection prevention procedures. Specifically, the canopy needs validated cleaning and
disinfection procedures for any reusable parts and a high bacterial/viral efficiency filter connected to the patient canopy expiratory port protecting the device from any contaminated flow and finally, many instruments are provided of electropneumatic devices to guarantee that no air flows from the device to the patient.

However, all these best practice guidelines [3] do not foresee that the patient may wear a mask during the procedure, thus increasing the level of biological risk for both the patient and the healthcare personnel and requiring an higher level of individual protection devices.

The aim of the present study was to evaluate the agreement between REE measured by IC with and without a filtering facepiece mask in a sample of healthy subjects.

2. Materials and methods

2.1. Subjects

A convenience sample of 10 subjects (7 women and 3 men) with a mean (SD) age of 43 (10) years was consecutively recruited among the University personnel and IC exams were conducted during 3 days at the International Center for the Assessment of Nutritional Status (ICANS). All subjects underwent a clinical history and a physical examination. Acute and chronic organ diseases were reasons for exclusion. Participants were healthy volunteers who were enrolled in a nutritional study that included indirect calorimetry among other investigations. The whole study protocol had been approved by the local Ethical committee of the University of Milan (report #21/2020) and all volunteers provided their fully informed written consent prior to participate in the study. This manuscript reports only the results relative to indirect calorimetry, whereas the full study results will be reported separately.

2.2. Anthropometry

Weight and height were measured according to standard guidelines [4]. Body mass index (BMI) was calculated as weight (kg)/[stature(m)]^2.

2.3. Indirect calorimetry

2.3.1. Measured REE

An open-circuit ventilated-hood system IC (Q-NRG, Cosmed, Roma, Italy) [5] was used to measure oxygen consumption (VO2), carbon dioxide production (VCO2) from ventilation gases in spontaneous breathing, to calculate REE. The IC was calibrated according to the manufacturer’s instructions: calibration of the flowmeter was performed using a certified 3 L calibration syringe, while calibration of zero, span and delay alignment of the gas analyzers was performed using a certified calibration gas.

All subjects received in random order two consecutive VO2 (mL/min), VCO2 (mL/min) measurements both with and without a class 2 filtering facepiece (FFP2) mask.

Each measurement was done by one trained dietitian early in the morning (between 09:00 and 10:00) and after twelve hours’ fast. Subjects lay awake completely at rest supine on a bed in a thermally neutral environment (24 °C).

Gas exchange was measured by transparent ventilated canopy equipped with antibacterial filter and disposable veil. To avoid gas leakages, the subject’s head was carefully wrapped with veil. Canopy hood underwent high-level disinfection, immediately after each use, with a soft cloth strayed with a cleaning solution for 30 s followed by air drying.

A 15-min resting period was observed before starting the measurements in order for the subjects to acclimatize themselves to the canopy and instrument noise.

For each measurement period, respiratory gas samples were taken for at least 10 min and the data collected during the first 5 min were discarded, as recommended [6]. A 5-min steady state was defined as the first five consecutive stable 1-min readings with a coefficient of variation < 10% for VCO2 and VO2 [7]. After steady state was achieved, the FFP2 mask status was switched, and the second measurement period was begun always discarding the first 5 min of measurement.

2.3.2. Calculations

Respiratory quotient (RQ) was calculated as the ratio VCO2/VO2 during steady state. To calculate REE modified Weir equation was applied [8] using the mean VO2 and VCO2 during steady state:

$$\text{REE (kcal/day)} = [3.941 \text{VO2 (mL/min)} + 1.106 \text{VCO2 (mL/min)}] \times 1.44$$

2.4. Statistical analysis

Values of continuous variables are reported as mean and standard deviation (SD). The proportion of subjects who reached the steady state was recorded as well as the time to complete each set of measures. The duration of the studies was then compared among mask status by paired T-test. Bland and Altman’s method was used to calculate the limits of agreement (LOA) between measurements taken with (wmVO2, wmVCO2 and wmREE) and without mask (nmVO2, nmVCO2 and nmREE). For each measurement of interest, bias was defined as the difference between the values obtained with and without mask. Pitman’s test was used to evaluate proportional bias [9]. Lin’s concordance correlation coefficient (CCC) was calculated as further measure of agreement [10]. The strength of the agreement was graded as poor when <0.90, moderate between 0.90 and 0.95, substantial between 0.95 and 0.99 and almost perfect when >0.99.

3. Results

Table 1 gives the measurements of the study subjects.

All subjects could equally reach a steady state of VO2 and VCO2 with and without mask. Provided that the measures in the first 5 min were always discarded, the consecutive 5 minutes steady state conditions were achieved in similar times, 11.9 (2.2) and 11.4

| Characteristics and measurements of the study cohort. | mean (SD) |
|-------------------------------------------------------|-----------|
| Sex (F/M)                                              | 7/3       |
| Age (years)                                            | 43 (10)   |
| Weight (kg)                                            | 65.7 (17.2)|
| Height (m)                                             | 1.61 (0.05)|
| BMI (kg/m²)                                            | 25.2 (5.8)|
| Steady state wm (min)                                  | 11.9 (2.2)|
| Steady state nm (min)                                  | 11.4 (2.7)|
| wmVO2 (mL/min)                                         | 199.23 (39.2)|
| nmVO2 (mL/min)                                         | 193.21 (37.12)|
| wmVCO2 (mL/min)                                        | 182.25 (36.46)|
| nmVCO2 (mL/min)                                        | 179.05 (34.05)|
| wmREE (kcal/day)                                       | 1419 (276)|
| nmREE (kcal/day)                                       | 1380 (266)|

Abbreviations: SD = standard deviation; VO2 = measure oxygen consumption; VCO2 = carbon dioxide production; REE = resting energy expenditure; wm = with mask; nm = without mask.
Table 2  
Agreement between IC with and without FFP2 mask for the assessment of gas exchanges and energy expenditure.

|                | Fixed bias mean (SD) [LOA] | Proportional bias | CCC [95% CI] |
|----------------|-----------------------------|-------------------|--------------|
| VO₂ (mL/min)   | 6.01 (9.86) [-13.31, 25.34] | r = 0.213         | 0.95 [0.84, 0.99] |
| VCO₂ (mL/min)  | 3.19 (16.19) [-28.54, 34.92] | r = 0.153         | 0.89 [0.63, 0.97] |
| REE (kcal/day) | 39 (77) [-111, 189]         | r = 0.194         | 0.95 [0.82, 0.99] |

Abbreviations: SD — standard deviation; LOA — limits of agreement; CCC — concordance correlation coefficient; 95%CI — 95% confidence interval.

Fig. 1. Plots of the limits of agreement (LOA) and concordance correlation coefficient (CCC) of measurements taken with and without the mask. In LOA graphs, continuous lines are means and limits of agreement and dashed lines are correlation plots (Pitman’s test). In CCC graphs, dashed lines are reduced major axes and continuous lines are the lines of perfect concordance.
interest with and without mask. Intra-subject variability: VO₂ and VCO₂ values tended to be higher differences with and without fi/C₀eration indirect calorimeter within the mean interval of 5 min

wmREE and wmVO₂ showed a substantial (CCC = 0.95, 0.99) agreement with the respective reference measurements. Lower CCC values were found for wmVCO₂ and wmRQ.

4. Discussion

This study was performed to assess whether wearing a FFP2 mask during indirect calorimetry may affect measured REE. All patients reached steady state of measured gas exchanges and showed a high agreement between VO₂, VCO₂ and REE in a similar time estimated with and without FFP2 mask. No previous studies investigated this issue that in COVID-19 era has become of great interest in the clinical practice of nutritional rehabilitation program.

We used Lin’s CCC because it is one of the less biased measures of agreement [10], and the REE CCC value of 0.95 showed substantial agreement. The variability we observed among the tests with different mask status can be explained by the inherent variability of IC exams, because the LOA are comparable to those previously reported for repeated IC tests without wearing masks [5]. Mean intra-subject variability for VO₂ and VCO₂ of our new generation indirect calorimeter within the mean interval of 5 min is −3 ± 14 and −3 ± 12 mL/min, respectively [5]. In our study, the differences with and without filter mask were in line with this intra-subject variability: VO₂ and VCO₂ values tended to be higher with the filter mask but were not statistically significant.

Our work provides useful information for the management of IC during the COVID-19 pandemic but has some limitations. Specifically, the main limitations of this study stay in the limited sample number and in the selection of subject in a wide range of BMI, but without significant comorbidities potentially affecting the IC performance.

5. Conclusion

In conclusion, wearing a filtering facepiece did not affect REE measured by IC. Not wearing the mask may expose the health personnel and other patients to infective hazard, thus we recommend wearing a mask during indirect calorimetry because this practice does not affect REE estimates. Our data support the use of a mask as the standard practice during COVID-19 pandemic.

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Author contributions

SB and AB were responsible of the conception and design of the study. DO and RDA acquired the data. AL and AB performed analysis. SB and AB provided interpretation of data. SB, AB, and AL drafted the article. AB, AL and AF revised it critically for important intellectual content. All authors gave final approval of the version to be submitted.

Declaration of competing interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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