ize the spirometric criteria of airway reversibility in COPD.

Helmi Ben Saad MD PhD
Laboratory of Physiology
Faculty of Medicine of Sousse
University of Sousse
Sousse, Tunisia

Dr Ben Saad has disclosed no conflicts of interest.

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Promoting the Inclusion of Lung Volumes in the Reversibility Evaluation—Reply

In reply:

We greatly appreciate the thoughts Dr Ben Saad has shared with us about hyperinflation and our research. We think his research on lung volume reversibility¹ complements ours.² The question of whether residual volume change was more sensitive than FEV₁ or FVC change is a problematic one because all thresholds for responsiveness are arbitrary and can be manipulated by setting them higher or lower. What we found was that residual volume change correlated poorly with FEV₁ and FVC, which led us to conclude that we were describing a novel group of responders.

The research of Dr Ben Saad¹ shows that there were more residual volume responders in the hyperinflated group but not the control, which suggests that there are probably differences between hyperinflated people and those that are not hyperinflated. This makes us wonder whether we should use obstructed patients to help guide us to what expected change is and not use healthy subjects.³

Ultimately, we think the more we expand our knowledge about lung volumes the better off we will be understanding obstructive lung diseases. We think residual volume changes add important information about obstructive lung diseases.

Conor T McCartney MD
Department of Internal Medicine
St. Louis University
St. Louis, Missouri

**Gregg L Ruppel MEd RRT RPFT
FAARC
Ravi P Nayak MD**
Department of Internal Medicine
Division of Pulmonary, Critical Care, and Sleep Medicine
St. Louis University
St. Louis, Missouri

The authors have disclosed no conflicts of interest.

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A Shout Instead of a Whisper: Let's Get the Graphics Right

To the Editor:

In July of 2013, Mark Siobal and colleagues wrote a paper on volumetric capnography in *RESPIRATORY CARE*.¹ In a subsequent letter to the Editor,² I pointed out an error in their Figure 8. In that figure, the quantity V_{Dalv} is represented as the shaded areas between the volume curve and the CO₂ axis. Although the vertical axis is labeled simply CO₂, there are horizontal lines labeled P_{aCO₂}, P_{ACO₂}, etc, implying that the vertical axis represents pressure. The problem is that if the vertical axis is pressure, then the areas on the graph have the wrong dimensions; they are not volumes. Unfortunately, Mr Siobal failed to heed my advice and, in his most recent paper on the same subject,³ has made the same error 7 more times (Figs. 4, 5, 6, 14, 15, 18, and 19; most of which explicitly label the vertical axis as P_{CO₂} in mm Hg). Figure 6 is particularly egregious because its legend says "From reference 106, with permission." Checking that reference,⁴ we see it repeatedly shows the vertical axis labeled as *Exhaled FCO₂* (carbon dioxide fraction), not P_{CO₂}, for volumetric CO₂ curves.

Here is the significance of the error. The dimensions of any area on an x-y plot are the dimensions of the vertical axis times the dimensions of the horizontal axis. For example, if the y axis has the dimension of length (L) and the x axis also has the dimension of length, then any area on the graph has the dimensions

of length squared (L^2). Similarly, if the graph was, say, flow versus time, then the area under the flow curve would have units of volume; flow $\times$ time (T) = (volume/time) $\times$ time = volume, which has dimensions of length cubed (L^3). Now, if a volumetric CO_2 graph has its vertical axis labeled as P_{CO_2} (a pressure) and its horizontal axis labeled as volume, then any area has units of pressure $\times$ volume = (force/area) $\times$ volume = (force/ L^2) $\times$ L^3 = force $\times$ L, which has dimensions of mass (M) $\times$ acceleration $\times$ distance, or ML^2T^{-2} , representing *work*, not *volume*.⁵

The correct labeling for the volumetric CO_2 graph shows the fractional concentration of CO_2 on the vertical axis (F_{CO_2} not P_{CO_2}).⁶ Area in units of a fraction times volume yields the units of volume, as required. This was illustrated as early as 1948 in a paper by Fowler,⁷ where the vertical axis is labeled “ CO_2 concentration” expressed as a fraction. Fletcher et al⁴ seem to have written the original article describing volumetric CO_2 monitoring. They showed several graphs of volume versus fraction of CO_2 . Tusman et al⁸ even state explicitly, “The advantage of using fractions of carbon dioxide compared with partial pressure is that each area represents a volume of carbon dioxide, real or theoretical.”

You may think this issue is a trivial matter, not worth mentioning. But if you are a clinician who is struggling with inconsistencies in the literature, a researcher trying to analyze actual raw data, an educator trying to make a simulation with a spreadsheet, or an engineer trying to design software for a monitor, this kind of error could be quite confusing.

**Robert L Chatburn MHHS RRT-NPS
FAARC**

Respiratory Therapy Department
Cleveland Clinic
Cleveland, Ohio

Mr Chatburn has disclosed relationships with IngMar Medical and DeVilbiss/Drive Medical.

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A Shout Instead of a Whisper: Let's Get the Graphics Right— Reply

In reply:

After politely conceding to his original objections back in 2013, and thanking him for “his compulsion for accuracy and obsession to detail,”^{1,2} I am now amused and a bit annoyed by Mr Chatburn’s letter, which expresses his incessant intellectual banter and expert opinion on how the axis of the volumetric capnogram should be labeled in a peer-reviewed publication.³

In the pure technical sense, Mr Chatburn is absolutely correct in that fractional CO_2 is essential to the accuracy of the volumetric CO_2 calculation and for the calculation of areas representing the dimension of volumes of CO_2 . However, I would like to point out to Mr Chatburn that there are numerous examples of journal articles, presentations at educational meetings, ventilator graphics, and volumetric capnography monitors that depict or display the vertical axis of the volumetric capnogram in the manner that appears throughout my paper³ in Figures 4, 5, 6, 13, 14, 15, 18, and 19.

Certainly, a scientist or engineer studying, designing, or building a volumetric capnography device would understand this and

create the appropriate calculations. However, for the rest of us folks, it makes more sense to view the vertical axis labeled P_{CO_2} because that is how it is normally seen in the real world.

Maybe it would help if Mr Chatburn could imagine that everywhere P_{CO_2} appears in the vertical axis of the figures in question, inside invisible brackets next to P_{CO_2} is the equation, $[P_{CO_2} = F_{CO_2} \times (P_B - 47)]$, where F_{CO_2} = fractional concentration of CO_2 , P_B = barometric pressure, and 47 = water vapor pressure at 37°C. I should hope this might be enough to justify my author’s prerogative instead of being seen as an egregious and confusing violation of depicting dimensionless and erroneous graphic illustrations.

To his credit, if not for Mr Chatburn’s scrutiny, I would have overlooked the error in the lower right corner of Figure 13 that was missed during the review and editing process. In place of the infinity symbol (∞) should have been the proportional to symbol ($\propto$).³ I am surprised that this missed Mr Chatburn’s scope of intense review and his quest for policing perfection and that I wasn’t reprimanded again for another error.²

Perhaps instead of shouting about getting the graphics right, Mr Chatburn should put some thought into the maxims of professional etiquette in constructive criticism.

Mark S Siobal RRT-ACCS FAARC

BSRC Program
Skyline College
San Bruno, California

Mr Siobal has disclosed a relationship with Aerogen.

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