

AEI Technologies Metabolic Cart Systems

The better Breath-by-Breath measurement system using a Mixing Chamber

Sampling at the mouth has come to be known as a “Breath-by-Breath measurement system”. This is a misnomer. Metabolic carts that use a mixing chamber also measure each and every breath.

AEI Technologies Metabolic Cart Systems utilize an active [air circulating fan] Mixing Chamber in sampling expiratory air. The advantages of the Mixing Chamber when compared with the “sampling at the mouth” method are overwhelming. While in theory the “sampling at the mouth” method seems advantageous, in practice this method of sampling cannot be implemented without significant disadvantages.

In AEI Technologies Metabolic Cart Systems the flow at the mouth is measured continuously about every 4 msec. From this we accurately determine exactly when the inspiratory breath starts and ends. We also record its magnitude over time - [integrated into volume]. The start of each new breath is a trigger to determine when to sample the gases in the mixing chamber. The gases are sampled at the start of every breath - (plus a small intra-breath delay time). These measurements are synced in time to their appropriate breath with the mixed volume delay plus the analyzer delay time. We record the O₂ and CO₂ concentrations for every breath and can then proceed to calculate VO₂ and VCO₂ precisely for every breath. Since we sample gases from the mixing chamber there is residual gas from the previous breath(s) in the mixing chamber resulting in a ‘averaging effect’ of the gas concentrations. This “averaging effect” is lowest when V_t value approaches the volume of the mixing chamber; i.e. at moderate to high exercise levels. Ideally, the mixing chamber should be sized to be close to expected Tidal Volume. The great benefit of this ‘averaging effect’ is that the data is much less noisy when compared to data taken without a mixing chamber.

In the basic “sampling at the mouth” method the gas sampling is required to be sampled much faster, usually the same rate as the flow sampling. Therefore, the time delays are about 100 times

shorter and much more difficult to accurately determine – thus resulting in greater inaccuracies. Also, the noise is much greater in the basic “sampling at the mouth” method requiring some type of averaging or integration – just like the ‘averaging effect’ in mixing chamber systems. The basic “sampling at the mouth” method seems accurate to many researchers because they use the Douglas Bag method for what many researchers refer to as Validation. The Douglas Bag method is a method for comparison purposes and it is NOT a measure of accuracy nor Validation! The ‘Douglas Bag method for comparison’ mainly looks at Volume measurements and does very little for looking at errors in gas measurements and humidity effects.

Therefore, because of these issues with sample at the mouth systems the mixing chamber systems are more accurate and have equivalent speed of response [AEI believes the speed of response is better in our mixing chamber systems].

Mixing Chamber advantages:

- Every breath is recorded
- O₂ and CO₂ data is accurately synchronized to each breath
- Very consistent data from one breath to the next
- VO₂ and VCO₂ calculations utilize simple textbook formulas
- Accurate VO₂ and VCO₂ data as validated by Douglas Bags and ‘First Principles’ Simulators
- AEI Technologies unique active mixing chamber utilizing a fan to circulate air in the mixing chamber improves the gas mixing and response time of breath to breath changes

Mixing Chamber disadvantages:

- A thicker sampling hose
- etO₂ and etCO₂ measurements are possible with additional analyzers

Sample at the mouth advantages:

- Direct measurement of etO₂ and etCO₂ possible
- Smaller diameter sampling hose

Sample at the mouth disadvantages:

- Large variability of data from one breath to the next
- Data for every breath is recorded but is modified by averaging algorithms thus negating the breath-by-breath concept
- VO₂ and VCO₂ calculations utilize complex averaging algorithms and timing corrections thus making validation difficult when comparing with textbook formulas
- Less consistent data when compared to Mixing Chamber systems

References:

Accuracy and precision of CPET equipment: A comparison of breath-by-breath and mixing chamber systems, Casper Beijsta, Goof Schepb, Eric van Breda, Pieter F. F. Wijn & Carola van Puld, *J Med Eng Technol.* 2013 Jan;37(1):35-42.

Clinical Exercise Testing, editors Idelle M. Weisman and R. Jorge Zeballos, 2002, Pages 46 -47.

CPX/D Underestimates VO₂ in Athletes Compared with an Automated Douglas Bag System, Christopher J Gore, Robert J Clark, Nicholas J Shipp, Grant E Van Der Ploeg, Robert T Withers
Med Sci Sports Exercise 35 no8 Ag 2003.



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