

Comparison of Two Metabolic Simulators Used for Gas Exchange Verification in Cardiopulmonary Exercise Test Carts

This is a summary of the original article by Tjeu Souren. This summary is authored by Edward A. Rose, M.D., Medical Writer and a consultant for Vyaire Medical*.

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Objectives

Metabolic simulators (MS) are used to simulate human breaths to verify and calibrate cardiopulmonary exercise test (CPET) equipment. MS create breaths with set CO₂ and O₂ gas concentrations despite changes in breath rates and tidal volumes. CPET metabolic carts are calibrated using a MS as a standard, requiring the MS to be predictable. We evaluated two MS devices against two standard CPET systems.

Study methods

Two standard metabolic carts (Vyntus™ CPX and Vyntus™ ONE, both Vyaire Medical GmbH**, Höchberg, Germany) were used to test the Vacumed 17056 (Vacumetrics, Ventura, CA) and Relitech (Relitech Systems BV, Nijkerk, The Netherlands) metabolic simulators. Tests were performed in random order. Simulated breathing frequency was tested from 20 to 80 breaths per minute with tidal volumes (VT) was set to 2 and 3 L. At each set point, three sets of 40 breaths were measured for VT, oxygen consumption ($\dot{V}O_2$), carbon dioxide production ($\dot{V}CO_2$), and respiratory exchange ratio (RER).

Results

Both metabolic simulators performed within specifications according to settings used. VT, RER, ($\dot{V}O_2$, and ($\dot{V}CO_2$ results as obtained from both MS were all within acceptable limits at all settings. Tidal volumes produced by the Relitech MS were closer to the target VT for both CPET carts at all settings, but both MS were within acceptable ranges.

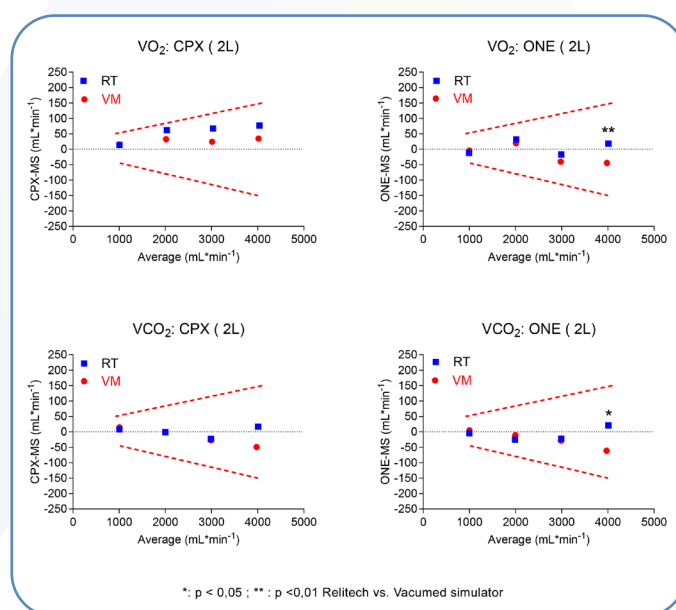


Figure 1. Shows example: VT 2-liter results for $\dot{V}O_2$ and $\dot{V}CO_2$. RT; relichte simulator, VM: Vacumed simulator.

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What is a metabolic simulator?

Both Relitech and Vacumed metabolic simulators follow a common design approach. Their user interfaces grant operators the flexibility to set varying stroke volumes ranging from 1 to 3 liters in 0.5-liter increments, along with an adjustable stroke frequency spanning from 10 to 80 strokes per minute. This versatility allows for simulated ventilation rates between 10 and 240 liters per minute and breathing rates up to 80 breaths per minute.

Both systems mix room air circulated with injections of pure CO₂ and N₂. The 100% CO₂ injection precisely mimics CO₂ production rates at different ventilation levels, while 100% N₂ dilutes ambient air O₂ to reach predetermined oxygen consumption rates. The precise regulation of injected CO₂ and N₂ during each exhalation is achieved through high-precision mass flow controllers (MFCs), ensuring a high level of precision in simulating metabolic rates for O₂ and CO₂, with an accuracy of less than 0.2%. The certification process for the metabolic simulator piston pump and MFCs is conducted initially and then re-certified every 2 years by the MFC manufacturer. These features collectively empower the metabolic simulators to produce $\dot{V}O_2$ and $\dot{V}CO_2$ with an accuracy of less than 0.5%, even when operating at high ventilation ranges.



Figure 2. Vyntus™ CPX with cart.

Conclusion

In this study, both Vyntus CPET carts were tested using simulated breaths produced by two standard metabolic simulators, creating comparable gas mixtures for O₂ and CO₂ over two different tidal volumes and a wide range of respiratory rates. Oxygen consumption, carbon dioxide production, and respiratory exchange ratio were consistently within manufacturers' specifications.

Take home message

- Maximal Cardio-Pulmonary Exercise Testing (CPET) is useful for the evaluation of the linked metabolic and physiological systems that may have been missed if relying solely on tests in resting condition.
- Based on this extended metabolic simulator testing, both Vyntus™ ONE and Vyntus™ CPX will deliver an comparable, accurate gas exchange assessment of subjects undergoing a maximal CPET.

For more details on the content of the study, please refer to the original article here.

Reference: Souren T, Rose E, Groepenhoff H. Comparison of Two Metabolic Simulators Used for Gas Exchange Verification in Cardiopulmonary Exercise Test Carts. *Frontiers in Physiology*. 2021:792.

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