# EVALUATION OF A NOVEL RESTING METABOLIC RATE MEASUREMENT SYSTEM

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**Introduction:**
Resting metabolic rate (RMR) is the rate at which a person burns calories while at rest. Between 70 and 80% of all calories are burned under resting conditions. Knowledge of metabolic rate is vital to nutritional assessment, weight loss planning and care of various medical conditions.

The primary method of metabolic rate measurement is indirect calorimetry. In indirect calorimetry, the rate at which oxygen is consumed and carbon dioxide is produced are measured directly and the caloric burn rate is calculated from the measured oxygen consumption and CO2 production. The relationship between oxygen consumed and calories burned is defined by the Wier equation [1,2]. The standard Wier equation defines the relationship between oxygen consumption (VO2), CO2 production and energy expenditure. Weir also showed that for a specific measurement technique, energy expenditure (caloric burn rate) could be measured without requiring carbon dioxide production measurements [1,2].

Testing of an indirect calorimeter based on Weir's "O2 only" method is described here. The test system (ReeVue, Korr Medical Technologies, Salt Lake City, UT) is less complex and much less expensive than the standard metabolic rate measurement instruments. Traditionally, metabolic measurements are large instruments that require frequent calibration of their oxygen and CO2 sensors. This type of system is often referred to as a "metabolic cart" because the size of the instrument and related computer and calibration equipment required a cart for transport within the hospital. We compared the REEVUE system against the Deltatrac metabolic cart (Datex-Ohmeda, Finland). The Deltatrac system represents an established clinical standard that has been validated clinically and in-vitro [3,4].

**Materials and Methods:**
The goal of this study was to compare the measurements reported by the two systems when analyzing the same expired gas. To make this comparison, the REEVUE and the Deltatrac systems were connected in series. A hose was used to connect the systems such that the exhaust gas from the REEVUE entered the air intake of the Deltatrac. The REEVUE received the subject's expired gas and the Deltatrac analyzed the exhaust. The Deltatrac was connected in the secondary position because it uses a gas dilution technique that could contaminate any measurement made using its exhaust. Because the REEVUE has no exhaust gas port, a modification was made to add an exhaust port and to ensure that all exhaled gas that entered the REEVUE exited through the REEVUE exhaust port.

Tests were conducted at the University of Utah Medical Center with approval of the institutional ethics committee. Thirty-five volunteers were recruited from among the students and staff of the university. Volunteers were asked to sit in a large reclining chair and relax. Each volunteer breathed into the standard disposable mouthpiece provided with the REEVUE system. The mouthpieces are equipped with one-way valves, which ensure that only expired gas enters the metabolic analysis system. A nose clip was used to prevent air leakage through the nostrils during the test.

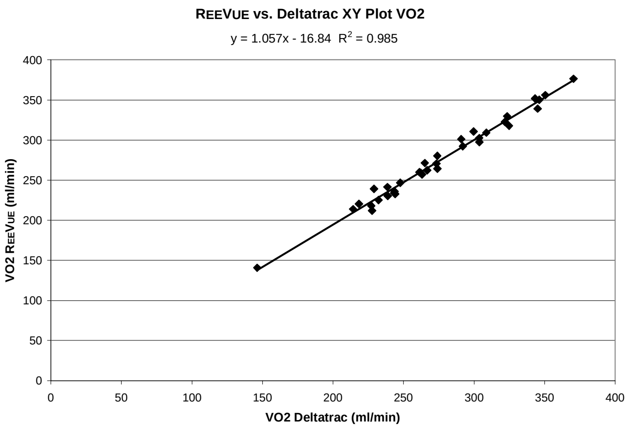
Each test lasted 10 minutes in which data from the two systems was compared. Data from the first three minutes of each test was discarded to allow for differences in measurement response time between the two systems. The oxygen uptake and energy expenditure measurements reported by each system during the remaining 7 minutes of the tests were averaged and compared.

Results were analyzed using regression analysis and Bland-Altman analysis. Bland-Altman analysis assumes that neither system is a "gold standard" and that the test is only a comparison between the two systems. In this analysis, the difference between the paired measurements is plotted against the average of the two data values. The 95% confidence interval is the expected range of the difference between measurements in which 95% of the tests will lie.

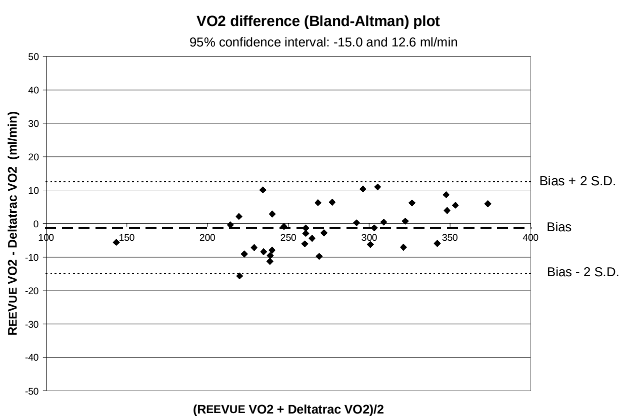
All measurements were corrected to standard temperature and pressure (STPD) conditions prior to comparison. Both systems automatically correct to STPD conditions. The Deltatrac required barometric pressure to be manually entered while the REEVUE has an internal barometric pressure sensor.

**Results:**
The average VO2, and resting energy expenditure (REE), reading for each subject was calculated. The average of

the differences in oxygen uptake (VO2) measurements was -1.22 ml/min (-0.68%). The standard deviation of the differences was 6.9 ml/min (2.7%). Regression analysis of the data shows that the correlation coefficient for the line relating VO2 measured by the REEVUE to the corresponding measurements on the Deltatrac was $r^2 = 0.985$. The factor and offset of the line were 1.056 and –17 ml/min respectively. The figure below shows the X-Y plot of the data.




The figure below shows the “Bland-Altman” plot of the VO2 data. The 95% confidence interval of the measurements is between –15.0 and 12.6 ml/min.

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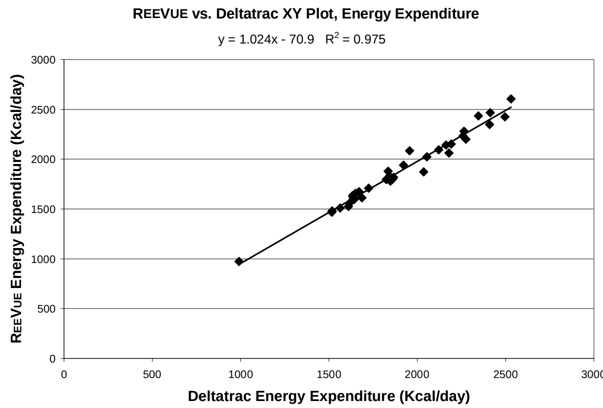
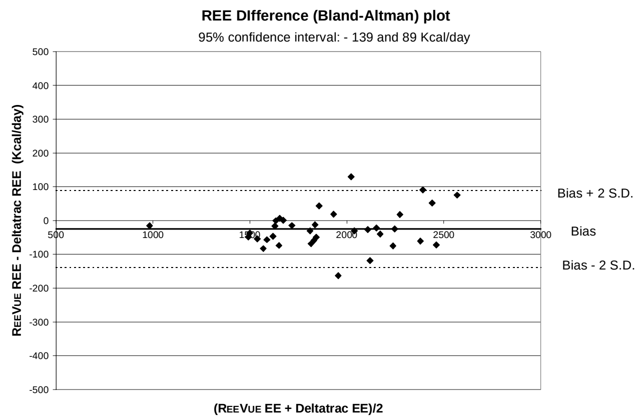
The average difference in energy expenditure (EE) is –24.7 kcal/day (1.45%) with a standard deviation of the difference of 57.1 kcal/day or 2.85 % of reading. Regression analysis of the energy expenditure data shows that the correlation coefficient for the line relating REEVUE measurements to the to the corresponding Deltatrac results was $r^2 = 0.975$. The factor and offset of the line were 1.02 and –71 Kcal/day respectively. The figure below shows the X-Y plot of the data.




The figure below shows the “Bland-Altman” plot of the energy expenditure data. The 95% confidence interval of the measurements is between -139 and 89 Kcal/day




**Discussion:**

These results show that the REEVUE system compares closely with the Deltatrac system. The Deltatrac is a commonly used system for metabolic rate measurement in the intensive care unit and for ambulatory patient testing.

The Deltatrac system measures carbon dioxide production as well as oxygen uptake. The REEVUE makes use of Weir’s method of calculating energy expenditure without the use of a carbon dioxide measurement. The data presented here showing that energy expenditure measurements are very similar for both systems shows that metabolic rate can indeed be calculated without carbon dioxide measurements.

It should also be noted that the Deltatrac required a calibration using a precision gas blend prior to each test session while the REEVUE is self-calibrating using only ambient room air for calibration.

Resting metabolic rate measurements must achieve a minimal level of reliability to be useful. The standard method of assessing caloric need in most clinical settings is calculation using an equation such as Harris-Benedict. Harris-Benedict calculations have been shown to correlate with actual energy expenditure at a level of $r^2 = 0.35$ [5]. When percent of fat free mass in considered, Resting energy expenditure calculations correlate with actual energy expenditure at a level of $r^2 = 0.33$ in a study by Foster et al. [5] and at a level of 0.79 in another study by Roza et al. [6]. A small handheld device is available for measuring resting metabolic rate. However a published validation study provided by the manufacturer shows this handheld system correlated against the gold standard at a level of only $r^2 = 0.66$ (r = 0.81) [7]. This implies that use of a handheld device is no better than making a calculation based on percent body fat according to Roza [6]. However, this study shows that measuring energy expenditure using the REEVUE correlates with the accepted clinical standard at a level of $r^2 = 0.975$ which is much more accurate than calculation of energy expenditure with the use of a body fat measurement or using a handheld device.

**Conclusion**:
The oxygen uptake and energy expenditure (Resting Metabolic Rate) measurements obtained using the REEVUE indirect calorimeter are statistically similar to those obtained using the Deltatrac.

References: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