MetaCheck Accuracy Validation Report

May 14, 2002

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Introduction:

The MetaCheck (Korr Medical Technologies, Salt Lake City, Utah) is an instrument designed to measure Resting Metabolic Rate (RMR) using indirect calorimetry. Indirect calorimetry is a method of calculating metabolic rate from the measured the amount of oxygen consumed by the body. Using the MetaCheck mouthpiece, the individual being tested breathes in room air and the gas the person breathes out, is conveyed to the MetaCheck through the breathing hose. The MetaCheck analyzes the volumetric flow and oxygen concentration of the expired gas to determine the amount of oxygen consumed by the body due to metabolism.

The accuracy of the MetaCheck device was tested using the nitrogen injection method as described in the medical and physiology literature. The references listed at the end of the report are examples of publications where this test method is described and/or applied to validate various indirect calorimetry systems.

Methods and Materials:

The accuracy of the MetaCheck was analyzed using the nitrogen injection method. In this method, a motorized piston or other device simulates patient breathing. A precisely measured flow of pure nitrogen (N_2) is added to the gas that is pumped into the MetaCheck. Injecting nitrogen simulates expired air, which has a lower concentration of oxygen than fresh air. By exactly measuring and controlling the flow of nitrogen, the amount of oxygen consumed can be exactly controlled and known. In these tests, breathing was simulated using a motorized dual piston ventilator (Model 608, Harvard Apparatus, South Natick, MA). Pure nitrogen was obtained from a tank of compressed nitrogen. The flow rate of the nitrogen was verified using a precision flow standard (VT Plus, BioTek Instruments, Winooski, VT)

Since the MetaCheck reports values in Standard Temperature and Pressure Dry (STPD) conditions, results were multiplied by the STPD factor as calculated by the MetaCheck. The MetaCheck barometric pressure, ambient temperature, and relative humidity measurements were verified using independent laboratory instruments to ensure that these reported values were sufficiently similar to actual ambient conditions.

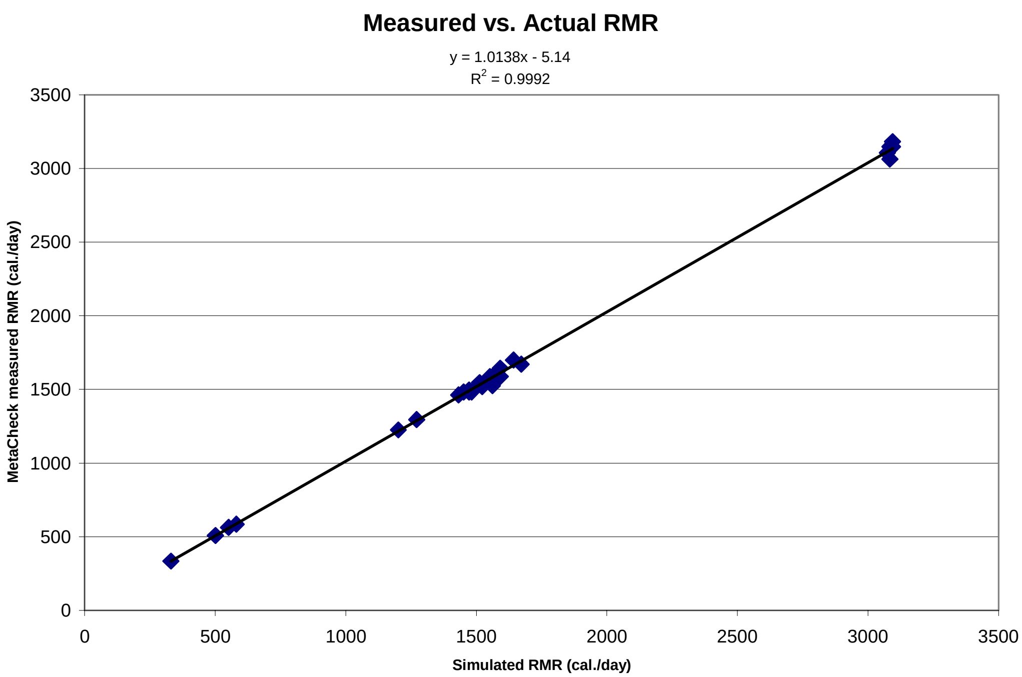
A wide range of breath rates were simulated by the motorized piston to ensure that the accuracy of the MetaCheck was not limited to a narrow range of breathing patterns. The simulated oxygen consumption rate relative to the ventilation was also varied over a wide range to ensure that accuracy was not limited to a narrow range of oxygen concentrations.

Results:

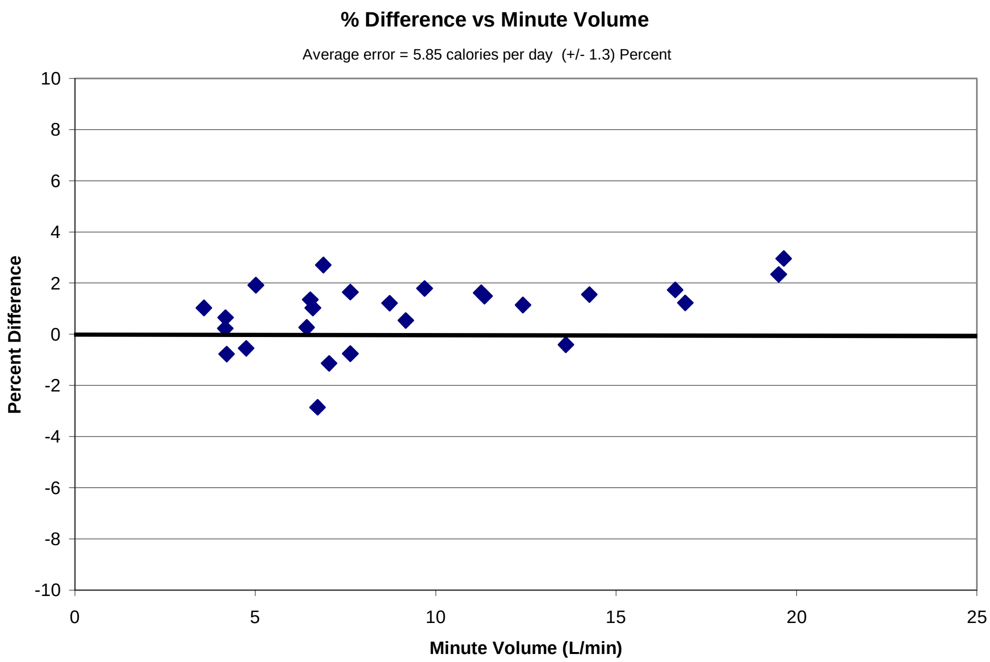
For each measurement the RMR measured by the MetaCheck and the simulated RMR was recorded. The percent difference was calculated as:

$$\%Difference = \frac{(RMR_{METACHECK} - RMR_{SIMULATED})}{RMR_{SIMULATED}} \, x \, 100\% \qquad [1]$$

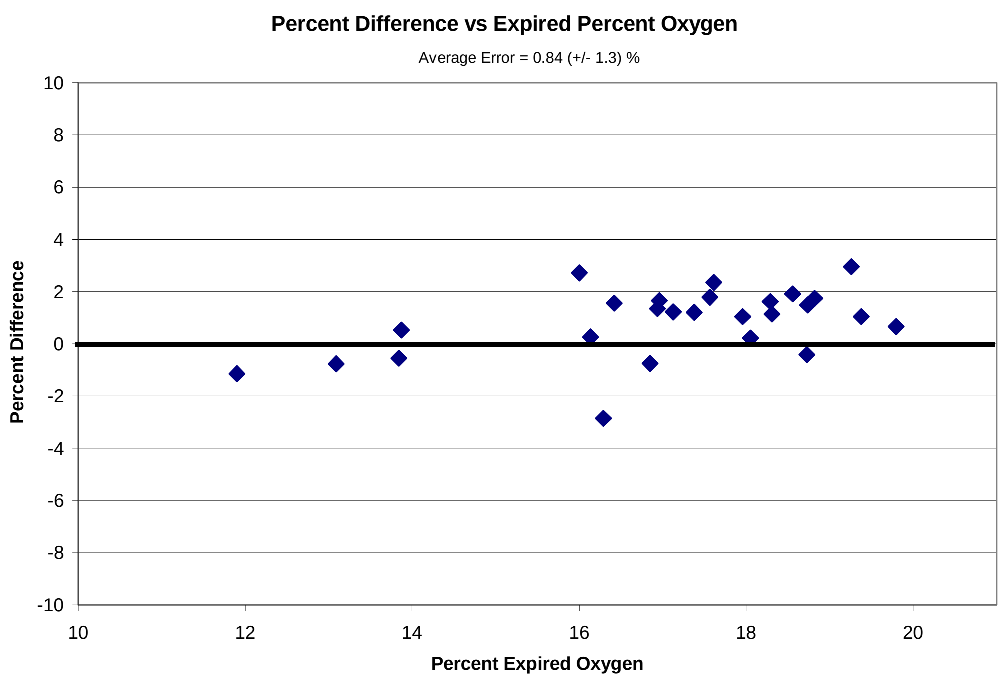
The average of the percent difference across all measurements was 0.84% (13.2 cal./day). The standard deviation of the error was 1.3% (25.8 cal./day). The Plot below shows the measured value plotted against the actual values. Regression analysis shows the correlation between the actual and measured values was $r^2 = 0.9992$ and the factor relating the two values were near a perfect 1.0 at 1.0088.



The plot below shows the percent difference of the measurements vs. the minute volume. Note that the percent difference is similarly low regardless of the simulated minute volume (minute volume is amount of air breathed in one minute).



The next plot shows the percent difference plotted against the concentration of oygen in the expired air. Note that the error is consistently low even at the extremes of oxygen concentration.



Inter-device Variability:

A set of five MetaCheck systems were tested to assess the variability of the results between systems. In this test, the N2 dilution technique was set up using two standard oxygen consumption and minute volume conditions. The table below shows the measured results:

Unit #	Simulated RMR	Measured RMR	error	% error
1	1392	1378	-13.9	-1.0%
2	1434	1399	-34.8	-2.4%
3	1469	1489	20.9	1.4%
4	1364	1336	-27.8	-2.0%
5	1434	1413	-20.9	-1.5%
1	2568	2561	-7.0	-0.3%
2	2624	2659	34.8	1.3%
3	2610	2610	0.0	0.0%
4	2575	2533	-41.8	-1.6%
5	2589	2589	0.0	0.0%

The average error across all units was 0.6% (9 calories per day) with a standard deviation of the error of 1.3% (24 calories per day). There is no significant difference between measurements made with different MetaCheck systems.

Long Term Stability

The MetaCheck was also tested to assess the stability of the measurements over multiple days. Simulate oxygen uptake rates were simulated at approximately the same in 10 separate tests distributed over a 22-day period. Simulations were done using the nitrogen dilution technique as discussed above. The table below lists the date of each test along with the simulated and measured oxygen consumption values.

Date	Simulated VO2 (ml/min)	Measured VO2 (ml/min)	Error (ml/min)	Percent Error
22-Apr	352	347	-5	-1.4%
24-Apr	326	326	0	0.0%

26-Apr	318	315	-3	-0.9%
30-Apr	336	337	1	0.3%
2-May	318	321	3	0.9%
6-May	323	327	4	1.2%
8-May	323	327	4	1.2%
9-May	342	344	2	0.6%
10-May	320	320	0	0.0%
14-May	339	342	3	0.9%

The average error was 0.9 ml/min (0.3%) with a standard deviation of the error of 3 ml/min (0.9%). Over the entire period of the tests, the worst case error was 1.4% of reading.

Discussion:

As can seen in the plots above, measurements reported by the MetaCheck are consistently within 2% of simulated values. This accuracy is as good as, or better than, accuracies reported in the medical literature when testing more complex indirect calorimetry devices that are used in clinical settings (see references below). The data further show that accuracy is not limited to a narrow range of breathing patterns or oxygen concentrations. The accuracy is also consistent over multiple different MetaCheck systems.
Testing over multiple days showed no degradation in performance. It appears that the MetaCheck maintains excellent accuracy over time.

References:

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