MetaCheck Clinical Accuracy Testing Using the Douglas Bag Method

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Introduction

The MetaCheck is an indirect calorimetry system that is designed to measure resting metabolic rate (RMR). The system operates by measuring the volume of oxygen consumed by the patient. Since every calorie consumed by the body requires a fixed amount of oxygen, oxygen consumed relates directly to calories burned.

The MetaCheck uses an oxygen sensor and a gas flow sensor to measure oxygen consumption. The MetaCheck system auto-calibrates these sensors before each use. The microcomputer in the MetaCheck device integrates the flow and oxygen signals to calculate the rate at which oxygen is consumed.

The “Douglas bag” is the “gold standard” method of validating the accuracy of oxygen consumption measuring devices, such as the MetaCheck. The Douglas Bag method uses a large, non-porous bag to collect all of the gas expired by the individual being tested. After the gas is collected, the volume, and oxygen concentration of the gas collected in the bag are analyzed. This analysis gives the total volume of oxygen in the bag. Based on the bag contents and amount of time over which the bag was filled, the rate at which oxygen was consumed can be calculated.

Methods

The MetaCheck system was calibrated using the standard automatic calibration before each test. Following auto-calibration, subjects breathed through a standard MetaBreather disposable airway adaptor connected to the MetaCheck system. Breathing was allowed to stabilize for at least 1 minute before data collection began.

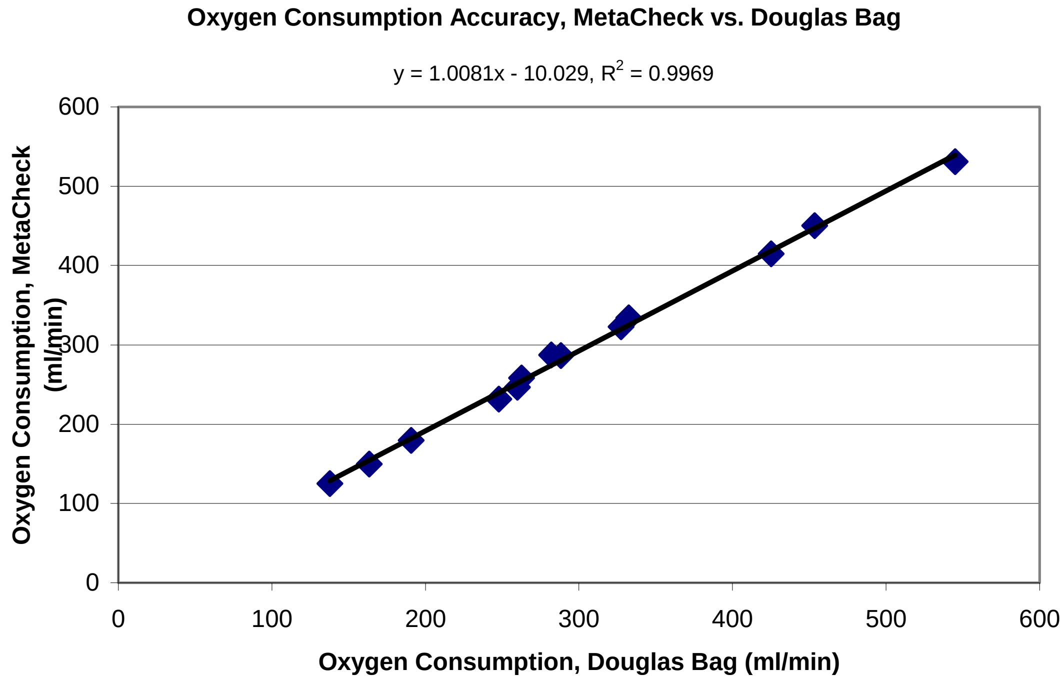
After stabilization, expired gas exiting the MetaCheck was collected in a 100 Liter Douglas Bag (Hans Rudolph P/N 112377, Hans Rudolph inc, Kansas City, MO). Oxygen consumption (VO2) for each breath along with the breath rate measured by the MetaCheck were stored digitally for each breath during the test. Expired gas was collected for at least 2 minutes and at least 20 Liters of gas was collected for each test. After the gas was collected, the bag was sealed. Average oxygen consumption for all of the breaths measured by the MetaCheck during data collection was calculated. The total time of data collection was recorded as well.

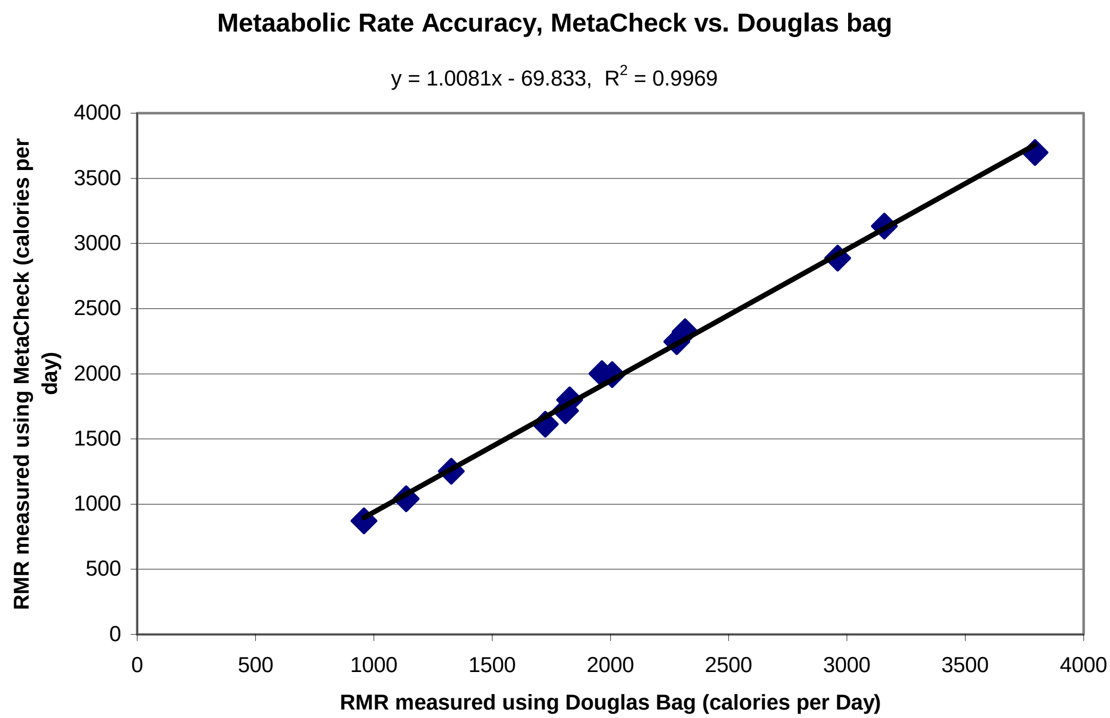
The volume and contents of the Douglas bag were analyzed following each individual's data collection. The volume was measured by drawing gas out of the bag by a vacuum pump at a fixed rate of 8 liters per minute through a precision flow measurement system (P/N RSS100-HR with Neonatal Fixed-orifice Flow Sensor P/N 101110, Hans Rudolph inc, Kansas City, MO). The gas was drawn out of the bag until a vacuum of –3 cm H_2O was observed indicating that the bag had been completely emptied. The flow measurement system was set to measure expired air at room temperature and ambient barometric pressure. The average oxygen concentration of the air in the bag was measured using a gas flow analyzer (VT Plus, BioTek Instruments, Winooski, VT). The average CO_2 concentration was measured using a CO_2 analyzer (model 8200 Cosmo+, Novametrix Medical Systems, Wallingford, CT). The volume of oxygen inspired by the subject was calculated using the measured ambient relative humidity and temperature. Further compensation was made to account for the difference in the rate of oxygen consumption to carbon dioxide production. The oxygen consumed during the test is the difference between oxygen consumed by the subject and the volume of oxygen that was collected in the bag. The total oxygen consumed divided by the collection time gives the rate or oxygen consumption measured by the Douglas Bag method. This rate of oxygen consumption can then be compared to the average oxygen consumption rate measured simultaneously by the MetaCheck. Oxygen consumption rates were converted to metabolic rates for purposes of presenting the data.

Results

A total of 13 comparisons were made using 8 subjects. Tests were repeated in some subjects at various levels of physical activity to produce a wider range of test conditions. Measured metabolic rates ranged from 959 to 3795 calories per day. The average difference between the MetaCheck and the Douglas bag method was –3.22% (-53 calories/day). The standard deviation of the error was 3.4% (46 calories/day). The data plots below show the relationship between Oxygen consumption and metabolic rates tested using the Douglas bag and the MetaCheck.

The line relating MetaCheck oxygen consumption measurements to the corresponding Douglas bag values has a slope of 1.0081 with an offset of –10 ml/min. The correlation coefficient between the two methods was $R^2 = 0.9969$.


Oxygen Consumption Accuracy, MetaCheck vs. Douglas Bag
y = 1.0081x - 10.029, R2 = 0.9969
Oxygen Consumption, MetaCheck (ml/min)
0
100
200
300
400
500
600
Oxygen Consumption, Douglas Bag (ml/min)


Metaabolic Rate Accuracy, MetaCheck vs. Douglas bag
y = 1.0081x - 69.833, R2 = 0.9969
RMR measured using MetaCheck (calories per day)
0
500
1000
1500
2000
2500
3000
3500
4000
RMR measured using Douglas Bag (calories per Day)

Discussion

This data shows very good agreement between the MetaCheck and the Douglas Bag method. The number of data points is small and further testing will be done in the future. However, the accuracy of this data and the range over which it was gathered, indicates that further testing should only reinforce these results. Linear regression shows a near perfect correlation between MetaCheck and Douglas bag measurements of $R^2 = 0.9969$ and a near perfect slope factor of 1.0081.

The accuracy of the MetaCheck system can be partially attributed the accuracy of the sensors. At the average expired oxygen level of 15.65% Oxygen, the "worst case" error attributable to oxygen sensor error would be 3.64% error. Since the oxygen sensor in the MetaCheck is specified to be better than 0.2%, the errors we observed may be attributable to oxygen sensor error. Competing devices claim an oxygen sensor accuracy of ±0.8%. Similar analysis of errors attributable to this level of oxygen sensor accuracy shows expected errors of 14.6% error in competing products.

Another source of error is gas flow measurement. Since the MetaCheck only measures flow in one direction, errors in flow measurement do not translate into significant errors. For example, in the MetaCheck, a 2% error in flow measurement can cause an error in oxygen consumption of no greater than 2%. In some competing devices, both inspired and expired gas flow is measured. In this method, even a 1% error in flow measurement may cause errors as high as 6.7% for the competing devices.