A Novel Approach Assessing Changes in Metabolic Fuel Usage by the Lumen Device

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Abstract

Background

Metabolic fuel is a well-known parameter which indicates the body's fuel preference in energy production. Respiratory Quotient (RQ) is the gold standard measurement for directly determining metabolic fuel usage. However, it requires the insertion of a catheter into the vein and artery for a blood sample. This invasive method makes the RQ measurement unfeasible and inaccessible. Respiratory Exchange Ratio (RER) is currently the preferred method for determining metabolic fuel usage. RER estimates the relative contribution of carbohydrate and lipids to overall energy expenditure, via carbon dioxide production and oxygen uptake, in an indirect manner. A very specific and well-documented physiological range for the overall RER of an average individual is between 0.67 to 1.3; 0.70 for fats, 0.8 for proteins and 1.00 for carbohydrates. This method is time-consuming (up to 40 minutes) and is only available in clinics as it requires professional technicians for both handlings and interpreting the system's output. As a result, the process is very cumbersome and expensive.

MetaFlow Ltd. (Lumen), an Israeli-based innovative company founded in 2014, has developed the Lumen device, a novel metabolic fuel breathalyzer that delivers metabolic status in real-time.

Objective

Compare estimation of changes in the metabolic fuel usage of an individual using the Lumen device versus the gold standard using indirect measurement with a calorimetric cart. In addition, the secondary objective focused on identifying changes in metabolic fuel usage in an individual following exercise, a change in diet, and consumption of carbohydrates.

Methods

Validation of Changes in Metabolic Fuel Usage Using Lumen Device Vs. Gold Standard

The studies were conducted in two separate and independent external institutes (Inst. 2 and Inst. 1). 31 healthy subjects arrived at the clinic after fasting for 12 hours. Their RER was measured using gold standard devices (ParvoMedics TrueOne 2400 and Quark RMR, Cosmed) and the Lumen device. Next, they drank a high carb shake and both measurements were taken again.

Validation of Changes in Metabolic Fuel Usage Following Low & High Carb Diet Using Lumen Device

Eight healthy subjects followed a low carb diet for three days. On the fourth day, they ate a high carb meal, followed by three days of a high carb diet. Their Lumen Level was then measured using the Lumen device after 12 hours of fasting on days 1, 4, and 7. Additionally, on day 4 subjects were measured 90 mins after a high carb meal.

Validation of Changes in Metabolic Fuel Usage Following Exercise Using Lumen Device

20 healthy subjects performed a running exercise at a maximum HR of 70 bpm for 60 mins. Measurements were taken using the Lumen device before and after the exercise at a resting HR.

Results

Validation of Changes in Metabolic Fuel Usage Using Lumen Device Vs. Gold Standard

- The Lumen Index was found to highly correlate with changes in the RER of a subject (Figure 1). In a repetitive ANOVA test, the Lumen method was found to differentiate between the different metabolic states of an individual in response to drinking a high carb shake (Figure 2).

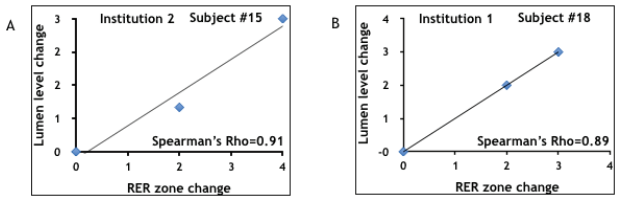

Figure 1.

Representative correlation between changes in the gold standard, RER zone, and changes in Lumen Level. (A) Inst. 2 (B) Inst. 1.

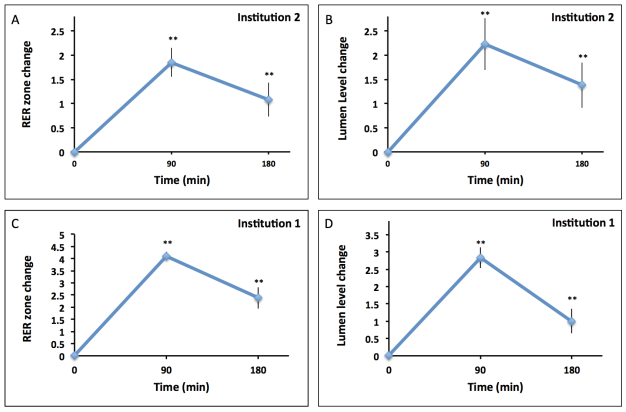

Figure 2.

Comparison between changes in the RER zone to Lumen Level following drinking a high carb juice. (A,a) Average of changes in RER zone after 12 hours fasting, 30 and 180 min following the third high carb juice (n=18 and n=13 at Inst. 2 and Inst. 1 respectively). (B,b) Average of changes in Lumen level after 12 hours fasting, 30 and 180 min following the third high carb juice (n=18 and n=13 at Inst. 2 and Inst. 1 respectively).

- ### Validation of Changes in Metabolic Fuel Usage Following Low & High Carb Diet Using Lumen Device

In an ANOVA repetitive measurement, the Lumen method was found to effectively differentiate between the different metabolic states of an individual following a low and high carb diet (Figure 3). Addtionally in a T-test analysis, the Lumen method was found to differentiate between metabolic states following a high carb meal. (Figure 4)

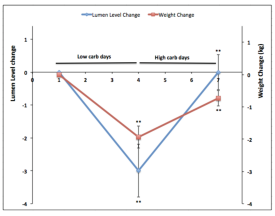

Figure 3.

Changes in the Lumen level and weight following low and high carb diets.

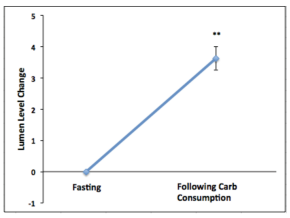

Figure 4.

Lumen level change following high carb

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Validation of Changes in Metabolic Fuel Usage Following Exercise Using Lumen Device

In a T-test analysis, Lumen method was found to effectively differentiate between the different metabolic states of an individual following exercise (Figures 5 and 6).

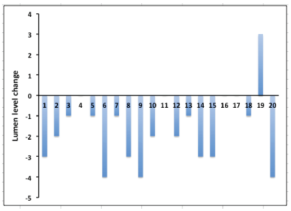

Figure 5.

Lumen level change following training exercise (n=20).

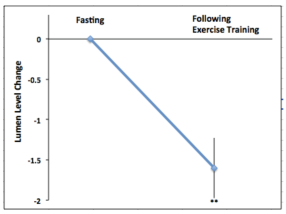

Figure 6.

Average of Lumen level change following training exercise.

Conclusion

The above studies conclude the validity of Lumen's technology as a device to measure changes in the metabolic fuel usage of an individual accurately in comparison to the gold standard. The studies concluded Lumen's ability to identify changes in the metabolic fuel usage of an individual following exercise, a change in diet and consumption of a high carb meal.

In a within-subject correlation, the changes in Lumen Level were found to highly correlate with changes in RER. In a between-subject correlation, the changes in Lumen Level were also found to be highly correlated with changes in RER ($p<0.01$).

Following a low carb diet, the body tends to use mainly fat storages as its primary fuel source, which is represented by a low RER. However, following a high carb meal, the body tends to use less of its fat storage, which is represented by a higher RER. Additionally, following a high carb meal, the body tends to use available carbs in the digestive system, represented by a higher RER.

When using the Lumen device to assess changes in metabolic fuel usage, the same trends as described in well-accepted literature are seen. The Lumen method was found to effectively differentiate between different metabolic states of an individual (figures 3 and 4) ($p<0.01$).

Following aerobic exercise, the body shifts towards the fuel usage of fats. This is well-known physiological responses that have been well documented. In a T-test analysis, the Lumen method was found to effectively differentiate between different metabolic states of an individual following a single bout of exercise ($p<0.01$).

These controlled studies demonstrated the potential of the Lumen device to assess changes in the body's metabolic fuel usage. The measurement results from the Lumen device were found to highly correlate with the gold standard measurement to metabolic fuel usage. In addition, the control studies demonstrated the potential of the Lumen device to asses changes in the body's metabolic fuel usage following exercise, a change in diet, and consumption of carbohydrates.

Glossary of Terms

HR	Heart Rate
BPM	Beats Per Minute
Fasting State	Following an overnight fast, the body uses the energy it needs from its energy storages, such as fat and glycogen in the liver.
Metabolic Cart	Form of RER or RQ measurement taken by lying down and breathing into a mask. Calculated by measuring the ratio of carbon doxide production to oxygen consumption.
Lumen Levels	A Lumen Level represents the metabolic fuel source the body is using for energy production.
Gold Standard	Respiratory Quotient (RQ) is the gold standard measurement for directly determining metabolic fuel usage that requires the insertion of a catheter into the vein and artery.
RER Zone	RER is the ratio between carbon dioxide production and oxygen consumption. If this ratio is between 0.7-1.0., 0.7 indicates the body is using only fats, and 1.0, only carbs. This range is divided into 7 zones.

Lumen's validation research is currently under review for IRB approval, and the names of the institutions included in this paper have been concealed until approval is granted. Throughout this paper, reference is made to two external medical institutes which will be referred to as Institution 1 and Institution 2.