BREATH ACETONE TESTING, KETOSIS, AND KETOGENIC DIETS

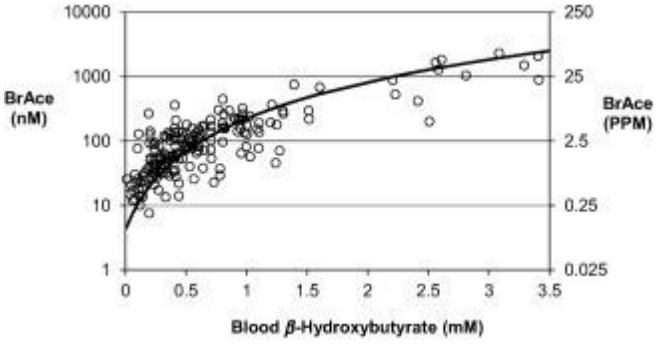
Summary

- Breath acetone levels are a real-time accurate measure of ketosis. Breath acetone levels significantly correlate with blood ketone levels.
- Breath acetone levels are closely correlated with the amount of fat lost during a carbohydrate restricted or ketogenic diet.
- Breath acetone levels indicate the amount of ketones produced during ketosis, but not the amount of excess ketones stored in the blood.

While the understanding of fatty acid metabolism has greatly increased in the last decade, there is still much to understand and there are many popular misunderstandings to correct. The basic enzymatic pathways and the organs in the body involved in these pathways have been clearly identified. However, the body's metabolic adaptation to long-term ketone production and fatty acid metabolism, and the specific factors impacting these processes, are not well understood. Much of this lack of knowledge is simply due to a small number of scientific and clinical studies.

This article will summarize our scientific knowledge to date, and also reveal exactly what is not yet known.

First, breath acetone levels (BrAce) significantly correlate with blood ketone (beta-hydroxybutyrate) levels (1.). The correlation of BrAce levels to blood ketone levels can be observed in Figure 1 below (reprinted from 1.)). The data were combined from 5 independent studies (2., 3., 4., 5., 6.). The relationship is linear to approximately 1.0 mmol/l of blood ketones, and then becomes non-linear. The correlation is statistically significant as an exponential function. Therefore, BrAce measurements can be an alternative to blood ketone measurements as an indicator of ketosis.



The advantages of breath testing vs. blood testing include:

1. Non-invasive breath sample vs. invasive blood sample
2. Less costly disposables
3. No costly chemical reagents

Second, BrAce levels significantly correlate with fat loss, while blood ketone levels correlate with fat loss to a lesser extent. This is because acetone levels closely correlate with fat metabolism, or beta-fatty acid oxidation. It is possible to predict the amount (pounds) of fat loss by measuring BrAce levels, but not with blood ketone levels (7.).

Third, BrAce levels indicate ketone production, but are not involved in the storage of ketones. Once acetone is produced, it is metabolized and eliminated, and is not stored in the body. Conversely, blood ketones can be used as fuel in many organs and tissues, especially the brain. Blood ketones can be converted back to the "fuel" form of ketones, i.e., acetyl CoA, while acetone cannot.

There are also individual variations in the efficiency of ketone metabolism. If this metabolism is slow to develop, blood ketones can build up in the bloodstream (8.). However, these higher blood ketone levels do not indicate a higher level of ketone production. Since acetone is not used as a fuel, acetone levels are a more accurate indicator of real-time ketone production.

Understanding how breath acetone is measured is critical to its use as a metabolic marker. Studies found in the scientific and clinical literature use gas chromatography, mass spectrometry, chemiresistive semiconductors, and UV or Near-IR spectroscopy (1.). These are scientifically validated techniques and instruments. However, the way that acetone is tested, or the instrument used for testing, can produce different results. An analogy would be the discrepancy between the scale that is used at home to measure weight vs. the scale in a doctor's office. The weight always seems to be higher at the doctor's office.

Breath sampling is also critical when determining BrAce levels. A normal, tidal breathing sample, a rebreathing sample into a breath bag, and the forced exhalation in the vital capacity breath manoever will each produce different acetone results. Vital capacity exhalation more closely correlates with blood ketone levels than the other two methods (9.).

Lastly, certain factors must also be controlled, such as exercise and fasting. However, once these factors are controlled, BrAce testing can be an indispensable window into the metabolism of fats and ketones.

The most significant gap in our understanding of metabolism and metabolic markers is what happens over time during a long-term ketogenic diet. There are very few

longitudinal studies, and the Virta studies indicate that metabolic adaptation may occur. (10.). Unfortunately, these studies use diabetic subjects, and therefore may not be indicative of a normal population.

In summary, the measurement of BrAce levels can be as useful, and in some instances superior, to blood ketone levels. This is dependent upon the use of scientifically validated instruments, consistent breath exhalation methods, and the monitoring of certain easily-controlled factors.

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