# Breath Hydrogen Tests

Breath hydrogen tests are very useful to help plan a low-FODMAP diet. The tests have been around for many years—decades, in fact. However, they were not regularly used in routine gastroenterology until recently, in part due to the increased awareness of the low-FODMAP diet. This section will address the principles behind the test, why and how they are done, how we interpret the results, and some issues surrounding their performance/role.

## THE BASIS FOR BREATH HYDROGEN TESTING

Hydrogen is a gas that is produced by bacteria in the bowel when they ferment carbohydrates. Bacteria in the bowel can do this when dietary carbohydrates are not absorbed in the small bowel, and, therefore, stay in the "poop" that then travels further along the digestive tract and arrive into the large bowel. Some of the hydrogen gas that is produced by the bacteria is expelled as flatus ("farts"), some is used to make other molecules (such as acetate, sulphides, and short-chain fatty acids), and some is readily absorbed across the lining of the large bowel into the bloodstream. The bloodstream then transports it up to the lungs, where it is exchanged from the blood into our airways and is then breathed out. The only source of hydrogen gas in the breath is bacterial fermentation in the bowel. The same applies to the gas called methane—in some people (about one in three people), bacteria in the large bowel avidly make methane from the hydrogen, so mainly methane and very little hydrogen is found in the breath.

The amount of hydrogen and methane gases breathed out from the lungs can be easily measured by taking a breath sample, blown into a breath-testing machine.

**Key Fact No. 1:** Hydrogen in the breath comes from bacterial fermentation in the bowel.

**Key Fact No. 2:** The concentration of hydrogen and methane in breath samples can be accurately measured.

If we minimize the intake of fiber and FODMAPs in food for twenty-four hours, most of us will not have any hydrogen in our breath samples, so when the amount of hydrogen in the breath is measured, it will be close to zero. This is because, when eating a diet made up of low-FODMAP foods and low fiber, there are few carbohydrates for the bacteria in the large bowel to ferment. If, after fasting for several hours, we consume some sugar mixed in water, and nothing else, then any rise in the breath hydrogen (or methane) after consuming that sugar drink means that the sugar is meeting bacteria in the bowel, which indicates that it was malabsorbed.

**Key Fact No. 3:** A rise in breath hydrogen and/or methane after ingesting a specific sugar implies that the sugar was not completely absorbed (in other words, malabsorbed).

## WHY IS THE TEST PERFORMED?

Performing hydrogen and/or methane breath tests with the appropriate testing machines allows us to answer the question, "Has a specific sugar consumed by an individual been completely absorbed?" If there is no increase in breath hydrogen and/or methane, then it has been completely absorbed. If there is an increase, then it has been incompletely absorbed (i.e., malabsorbed). Performing the test can help determine, for a patient experiencing gastrointestinal distress, which FODMAP sugars may or may not be at the root of it.

Some FODMAPs—oligosaccharides, fructans, and galacto-oligosaccharides, or GOS—are not absorbed in

all of us. The polyols like sorbitol are slowly absorbed in all of us and poor absorption of them occurs if the dose is high or if the contents move quickly through the small bowel (such transit varies over time in all of us). Recent studies have shown that breath tests are not helpful in defining who should avoid sorbitol. But breath hydrogen tests are useful to provide information as to whether free fructose (fructose in excess of glucose) and lactose are problematic FODMAPs for an individual. This is useful information, because it can help determine how extensive your individual low-FODMAP dietary restrictions must be.

For patients with IBS, breath hydrogen tests are not generally done to diagnose conditions called fructose malabsorption or lactose malabsorption (or intolerance), per se. The test results show us what your usual, or baseline, gut function is. It is like finding out what size feet you have so that we can fit the right-size shoe—we want to know whether you can or cannot completely absorb fructose, lactose, and sorbitol so that we can design a diet that is the right fit for you.

## HOW IS THE TEST PERFORMED?

### Preparation for the test

To prepare for a breath test, several things are important. The tests can be performed at different times of day, but they are often conducted in the morning, after an overnight fast. The breath-testing center should provide instructions about fasting, medication/supplement use, and lifestyle issues (e.g., smoking, use of perfumes/aftershave, diabetes). They will also provide you with a low-fiber, low-FODMAP diet to follow for one day prior to testing.

### The test itself

The procedure for the test itself may differ slightly between testing centers, but the general process is:

1. You will provide a breath sample by blowing into a bag or handheld machine.
2. You will consume a drink containing the test sugar. It is usually about a standard tumbler size and tastes sweet.
3. You will then be asked to give breath samples every 15 to 20 minutes for about 3 hours. The technician will record the results on the machine or collect the bags and set them aside to measure the gas at a later time.
4. When you finish, the technician will ask you if you have had any symptoms caused by the drink (e.g., has it caused bloating, pain, or diarrhea).
5. Your involvement in the testing procedure for that sugar is then complete. You will be able to get something to eat and drive yourself home.
6. If bags of samples were collected, the technician will then measure their content of hydrogen and methane on a special machine. All results will be compiled and sent to the physician who referred you for the test.

This procedure will be repeated for each sugar being tested. Often three or four different sugars will be tested, but only one can be tested on any one day. It is recommended to leave a gap of at least 2 days between tests so that the effect of one sugar cannot possibly be influencing the results from the next test. The results of all the sugars tested are then interpreted and reported by a doctor with expertise in doing so.

## The sugars tested

We recommend testing three sugars—lactulose, fructose, and lactose—and, in some circumstances, a fourth: glucose.

- **Lactulose** (at a dose of 15 g) is the first. This is a synthetic sugar that we know cannot be digested or absorbed by the human gut. (In fact, it is a commonly used as a laxative, but when used for breath testing, the dose used is below the recommended laxative dose.) There are two reasons to test this sugar first:
  - ***To see how vigorously your bacteria produce hydrogen.*** Most people have bacteria that make lots of gas and cause high levels in the breath. Some people have only low levels in the breath because the bacteria use hydrogen more in other ways (as discussed above). Some people do not produce hydrogen at all, but have methane in the breath. If the testing centers simultaneously measure methane and hydrogen, then the methane results can be used in place of hydrogen. The reason to find out how vigorously an individual produces hydrogen is so that we can properly interpret the results obtained in the future for the other sugar tests. Previously there was an idea that some people are "non-hydrogen-producers" (that is, their bacteria were not capable of producing hydrogen) and, therefore, breath tests for other sugars would not be suitable for them. Research has now shown that this is not correct and that it is all about dose. Further information about this follows in the section on interpreting the tests' results.
  - ***To determine how fast the sugar travels out of the stomach and down the small intestine.*** If your breath hydrogen rises quickly (e.g., after only 30 minutes), the testing time needed for fructose and lactose will be at maximum 2 hours, since the lactulose test has shown the transit time to be quick. Of perhaps more importance, if breath hydrogen rises after a longer time (e.g., 2 to 3 hours after taking the lactulose), then transit from the stomach to the end of the small bowel is slow (though still normal). If, in such a person, the time frame used for testing, e.g., fructose were only 2 hours (people often get impatient having this test and want to go as quickly as possible), then there is the risk that recording increase in hydrogen because of fructose malabsorption could be missed. In other words, the lactulose test predicts the time frame required for future sugar tests.
- **Fructose** is the second sugar tested. Usually, a dose of 35 g is used. This is more than the dose of lactulose. It is a dose approximately equal to a large fructose load in a meal. The dose is chosen because we want to identify people who can completely absorb a large load of fructose, because for them, dietary restriction of free fructose is not needed. The test is generally not very good for telling us what proportion of fructose is being malabsorbed. In other words, a positive test may mean only 10% (i.e., 3.5 out of the 35 g ingested) is not absorbed, or it might indicate that 80% (28 g out of the 35 g ingested) is not absorbed.
- **Lactose** is the third sugar tested. A large dose of lactose (50 g) is used to test how well the lactase enzyme is really working.
- **Glucose** is tested if the doctor suspects that small intestinal bacterial overgrowth (SIBO) might be present. Glucose is a sugar that is very rapidly absorbed in the upper small intestine. Even when the contents travel rapidly through the small intestine (i.e., there is rapid transit), glucose is still expected to be well absorbed. So, a breath hydrogen test showing a rise after consuming glucose nearly always means that there are too many bacteria in the small bowel (i.e., bacterial overgrowth is present).

## HOW ARE THE BREATH HYDROGEN TEST RESULTS INTERPRETED?

Let's look at some result examples to help understand how the doctors will interpret the tests. The results of some typical tests have been shown in the pictures on the next page. Breath hydrogen is measured in parts per million (ppm), and, in the following examples, the breath samples have been taken every 20 minutes. The four people being tested all have IBS symptoms.

Let's look at the **lactulose results** first.

- In ***Daisy and Matthew***, there are rapid rises in breath hydrogen after lactulose. The methane responses do not need to even be considered (hydrogen is a much better marker).
- ***Zoe*** has a small or 'blunted' rise and does not produce methane.
- ***Joel*** has no rise in breath hydrogen at all, but produces a significant response to methane (it is often not zero to start), so it may be possible to use methane in place of hydrogen in Joel.

These tests tell us that the intestinal bacteria of Daisy, Matthew, Zoe, and Joel all have different abilities to produce hydrogen (appearing in the breath), ranging from vigorous to minimal. The other important information that the lactulose test gives us is the length of time these people must stay during subsequent tests. Matthew will need to stay for no less than three hours to ensure we do not miss a rise in breath hydrogen after fructose or lactose, whereas with Daisy we can be confident that no rise in breath hydrogen within two hours of taking the fructose or lactose means that those sugars are completely absorbed. No need for Daisy to stay for three hours!

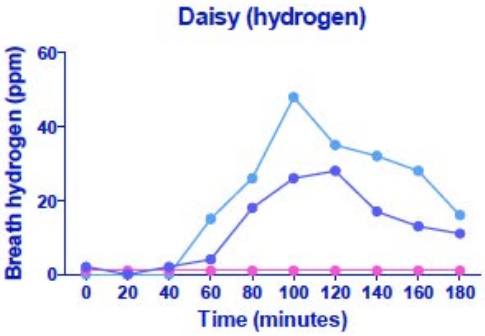
The **fructose and lactose** results for the patients are also shown.

- ***Daisy*** has lactose malabsorption (there is a clear rise in breath hydrogen after lactose) but can completely absorb fructose (there is no rise in breath hydrogen).
- ***Matthew*** has neither fructose nor lactose malabsorption.
- ***Zoe*** has a hydrogen response to fructose that is small, but we know that the response to lactulose was also small. Therefore, fructose malabsorption is present. Lactose is negative, but the ability to pick small degrees of malabsorption is impaired because of the small rise of breath hydrogen after lactulose. Hence, the lactose test is not informative (i.e., we cannot say if lactose is completely absorbed or not).
- ***Joel*** has no hydrogen response to either fructose or lactose, but, since there was no hydrogen response to lactulose, this test is not informative. However, if we look at the results for breath methane, it clearly shows a rise after fructose but not after lactose. Joel, therefore, has fructose but not lactose malabsorption.

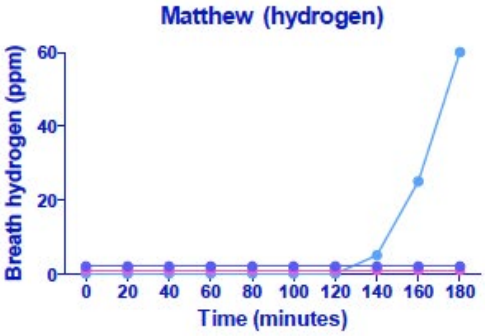
The results for sorbitol are interpreted in the same way.

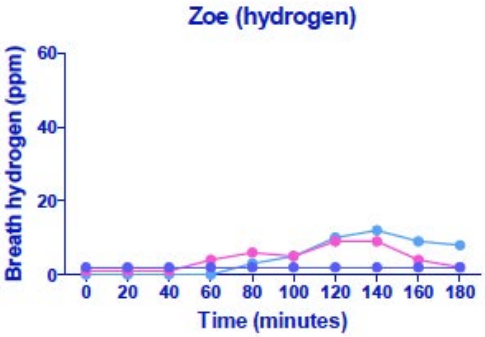
These test results are then used by the registered dietitian to plan the appropriate diet for each person, in relation to their IBS symptoms.

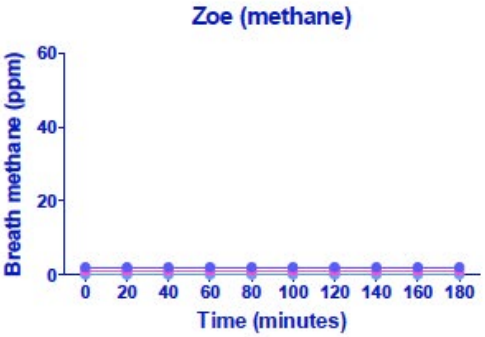
- All of the patients will be taught to restrict fructans, GOS, and polyols.
- ***Daisy*** will be taught a low-FODMAP diet that includes lactose restriction but does not restrict free fructose.
- ***Matthew*** will be taught a low-FODMAP diet, but will not restrict free fructose or lactose.
- ***Zoe*** will be taught a low-FODMAP diet that will include restriction of free fructose. Since it is uncertain whether lactose is being malabsorbed, the dietitian will advise restriction of lactose, but will use lactose early when the reintroduction challenge is to commence (see Chapter Four of *The Complete Low-FODMAP Diet*).
- ***Joel*** will be taught a low-FODMAP diet that will include restriction of free fructose but not of lactose.

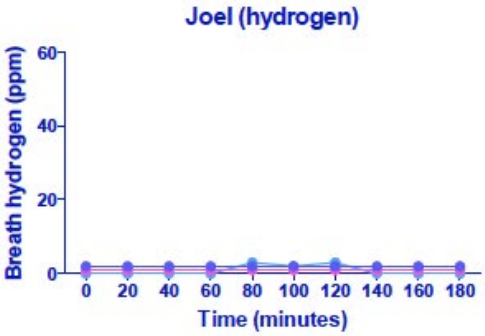


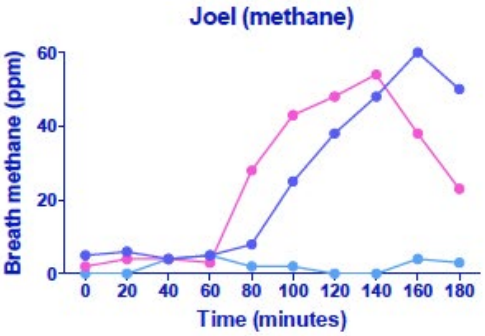

Lactulose
Fructose
Lactose



## THE SIGNIFICANCE OF SYMPTOMS TRIGGERED DURING OR FOLLOWING THE TEST

What is then done with the information about symptoms that are triggered during or after the test? In the days before FODMAPs were understood, doctors identified a difference between lactose "intolerance" and lactose "malabsorption":

- In lactose "intolerance," malabsorption was shown at the breath test but the lactose taken also triggered symptoms.
- In lactose "malabsorption," symptoms were not triggered despite a positive test result.

Lactose restriction was then recommended only for those with lactose "intolerance." We are now aware of the additive effects of different FODMAPs consumed in one meal or sitting. The effect of one specific FODMAP is usually irrelevant, because it is uncommon to have only one FODMAP food source at a time in a normal meal. The breath hydrogen tests can identify whether lactose or fructose are adding to the effects of other FODMAPs in that individual. Hence, whether or not symptoms are triggered after the testing of a single FODMAP, we still use the information from the breath hydrogen or methane results to plan a patient's low-FODMAP diet.

Our research group also performed a study to see how well symptoms that were reported by the patient during or after the fructose breath test matched (correlated) with actual fructose malabsorption. Symptoms experienced by the time the hydrogen test was completed were associated mostly (but not always) with fructose malabsorption (i.e., they mostly, but not always, occurred in those who had fructose malabsorption but not in those who did not). However, symptoms that developed over the next twelve or twenty-six hours had no association with fructose malabsorption (i.e., late symptoms occurred in the same proportion of those with and without fructose malabsorption).

Thus, while symptoms can develop during the test, they have little bearing on how the results are used. However, it is important to let people undergoing the test know that symptoms may be triggered by the sugars during the test!

## WHERE TO GET BREATH HYDROGEN TESTS

Breath hydrogen testing is becoming more readily available. Centers are now present in most major cities. You should contact your gastroenterologist to find out if one is available near you. If a testing center is not convenient or available to you, another option is to do it remotely. A kit can be sent to your home with instructions. You do the test and then return the bags containing your breath samples to the breath testing center. Unfortunately, the kits can be quite expensive.

## ARE BREATH HYDROGEN TESTS NECESSARY TO GO ON THE LOW-FODMAP DIET?

Remember that although the reason for doing the breath test is to determine whether fructose and lactose need to be restricted, the low-FODMAP diet may be instituted without the breath tests. It just means that the diet is started with restriction of all FODMAPs, including free fructose and lactose. If the fully FODMAP-restricted diet satisfactorily relieves IBS symptoms, then you may reintroduce food containing free fructose and lactose (and other FODMAPs) one by one to determine your tolerance. While not as "concrete" or practical as doing the diet with the information from the breath tests, it works just as well. In other words, breath testing is helpful but not essential for being successfully treated with the low-FODMAP diet.

# Publications in the medical literature

Barrett, Jacqueline S., Peter M. Irving, Sue J. Shepherd, Jane G. Muir, and Peter R. Gibson. "Comparison of the Prevalence of Fructose and Lactose Malabsorption across Chronic Intestinal Disorders." *Alimentary Pharmacology and Therapeutics* 30, no. 2 (2009): 165–74.

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Bate, John P., Peter M. Irving, Jacqueline S. Barrett, and Peter R. Gibson. "Benefits of Breath Hydrogen Testing After Lactulose Administration in Analysing Carbohydrate Malabsorption." *European Journal of Gastroenterology and Hepatology* 22, no. 3 (2010): 318–26.

A. Gasbarrini, Corazza, G. R., Gasbarrini, G., et al. (1st Rome H2-Breath Testing Consensus Conference Working Group). "Methodology and indications of H2-breath testing in gastrointestinal diseases: the Rome Consensus Conference." *Alimentary Pharmacology and Therapeutics* 29, Suppl 1 (March, 2009): 1–49.

P. R. Gibson, Newnham, E., Barrett, J. S., Shepherd, S. J., Muir, J.G. "Fructose malabsorption and the bigger picture." *Alimentary Pharmacology and Therapeutics* 25 (2007): 349–63.

Yao C. K., Tan H-L, van Langenberg D. R., Barrett J. S., Rose R.,Liels K., Gibson P. R., Muir J.G. "Dietary Sorbitol and Mannitol: Food Content and Distinct Absorption Patterns Between Healthy Individuals and Patients with Irritable Bowel Syndrome." *Journal of Human Nutrition and Dietetics* 2013 Aug 3. doi: 0.1111/jhn.12144.