Breath Hydrogen Tests

food intolerance management plan

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 'poo' 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 of the hydrogen is readily absorbed across the lining of the large bowel into the blood stream. The blood stream then transports it up to the lungs, where it is exchanged from the blood into our airways, and it is then breathed out. The only source of hydrogen gas in the breath can be from bacterial fermentation in the bowel. The same applies to the gas called methane – in some people (about 10% of the population), the bacteria in their 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 will be coming 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 minimise the intake of fibre and FODMAPs in food for 24 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 eating a diet that is made up of low FODMAP foods means there will be no short chain carbohydrates for the bacteria in the large bowel to ferment. If after fasting for several hours we consume some sugar mixed in water, but nothing else, then any rise in the breath hydrogen (or methane) after consuming that sugar drink will mean that the sugar is meeting bacteria in the bowel…. and this has occurred because it was malabsorbed.

Key Fact No. 3:

A rise in breath hydrogen (and/or methane) after the ingestion of a specific sugar implies that the sugar is not being completely absorbed (ie. it is 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 a rise in breath hydrogen (and/or methane), then it has been incompletely absorbed (i.e., malabsorbed).

We want to know how completely the sugars, called fructose and lactose, and the polyols, sorbitol, are absorbed in intestine. The other main FODMAPs - the oligosaccharides, fructans and galacto-oligosaccharides or 'GOS') – are poorly absorbed in all of us. Therefore, they will always give us a rise in breath hydrogen (and/or methane) and, as such, it is pointless testing them. So breath hydrogen tests are useful to provide information as to whether free fructose (fructose in excess of glucose), lactose and sorbitol are problem FODMAPs for an individual. As you can

now understand, this is useful information as it can help determine how extensive the FODMAP dietary restriction you require needs to be as an individual.

In other words, we do breath hydrogen tests to find out whether fructose and/or lactose and/or sorbitol are FODMAPs for an individual who has IBS symptoms. It is not done to find out if you have a condition called 'fructose malabsorption' or a condition called 'lactose malabsorption or intolerance' *per se*. The test results show us what your usual/baseline gut function is. It is like finding out whether you have big feet or little feet so that we can fit the right sized shoe – we want to know whether you can or cannot completely absorb fructose, lactose and sorbitol so that we can design the diet that is the right fit for you.

How is the test performed?

Preparation for the test

To prepare for the 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 centre will provide instructions about fasting, medication/supplement use and lifestyle issues (e.g., smoking, perfumes/aftershave, diabetes). They will also provide you with a diet to follow for the day prior to testing. This diet will be low fibre and low in FODMAPs.

The test itself

The procedure for the test itself may differ slightly between testing centres, but the general process will be:

1. A breath sample is taken by blowing into a bag (or a hand-held machine).
2. A drink containing the test sugar is consumed. It is usually about a standard tumbler size, and is sweet to drink.
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 aside to measure the gas at a later time).
4. When you finish, the technician will ask you if you have any symptoms caused by the drink (e.g., has it caused bloating, pain or diarrhoea).

5. Your involvement in the testing procedure for that sugar is then complete. You will be able to get something to eat and to drive yourself home.
6. If bags of samples were collected, the technician will then measure the content of hydrogen and methane on a special machine. All results will be compiled and sent to the person who referred you for the test.

This procedure will be repeated for each sugar being tested. Often three or four different sugars are tested, but only one sugar can be tested on one day. It is recommended to have a gap of at least 2 days between sugars 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 the doctor expert at these tests.

The sugars tested

We recommend testing four sugars, lactulose, fructose, lactose and sorbitol, and, in some circumstances a fifth, 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 centre 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, the person would not be suitable to test with other sugars. Our research studies have shown that this is not correct and that it is all about dose. Further information about this is following in the section below on interpreting the test’s results.

- *To determine how fast the sugar travels out of the stomach and down the small intestine.* If, for example, your breath hydrogen rises quickly, for example after only 30 minutes, the testing time needed for fructose and lactose will only need to be done for 2 hours maximum, since the lactulose test has shown the transit time to be quick. Of perhaps more importance, if breath hydrogen rises after a longer time, for example 2 to 3 hours of taking the lactulose, it means that 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 in the future for testing eg. fructose was 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 big fructose load in a meal. The big dose is chosen because we want to identify people who can *completely* absorb a load of fructose, because if they do, then dietary restriction of free fructose is not needed. The test is generally not very good in 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 might indicate that 80% (28 g out of the 35 g ingested) is not absorbed.

- *Lactose* is the third sugar tested. A big dose of lactose (50 g) is used to really test out how well the lactase enzyme is working.

- *Sorbitol* is tested next. This has only recently been added to breath hydrogen testing. Our research studies have shown that two out of every five people can completely absorb sorbitol (used to be thought everyone malabsorbed it). Currently, a dose of sorbitol of 10 g (the amount found in one apple and one pear eaten together) is used.

- *Glucose* is tested if the doctor suspects that small intestinal bacterial overgrowth 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 will nearly always mean 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 following. Breath hydrogen is measured as '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 able to use methane in place of hydrogen in Joel.

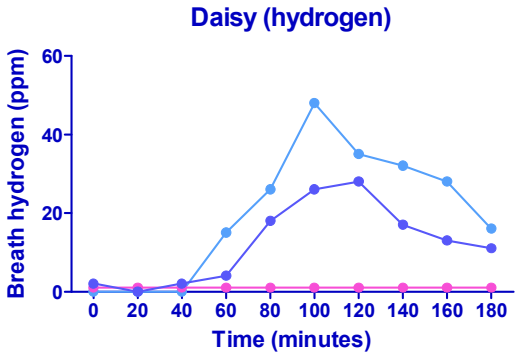
These tests tell us that the intestinal bacteria of Daisy, Matthew, Zoe and Joel all have different abilities to produce hydrogen (appearing in the breath), ranging from from vigorous to minimal. The other important information that the lactulose test gives us is the time these people must stay during 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, we can be confident in Daisy that no rise in breath hydrogen within two hours of taking the fructose or lactose will mean that those sugars are completely absorbed. No need for Daisy to stay for 3 hours!

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

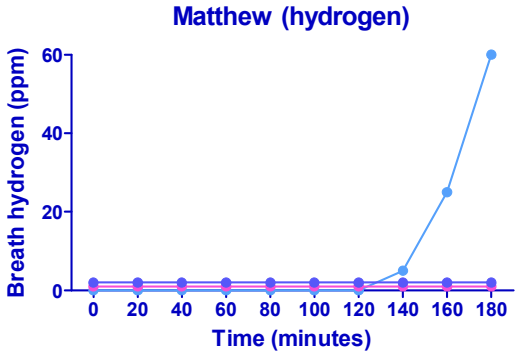
- *Daisy* has lactose malabsorption (there is a clear rise in breath hydrogen after lactose) but can completely absorb fructose (there is not rise in breath hydrogen).
- *Matthew* has neither fructose nor lactose malabsorption.
- *Zoe* has a hydrogen response to fructose that is small, but we know that 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 lactose. Joel, therefore, has fructose but not lactose malabsorption.

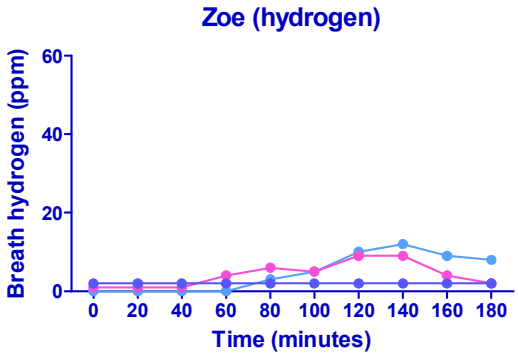
The results for sorbitol are interpreted in the same way.

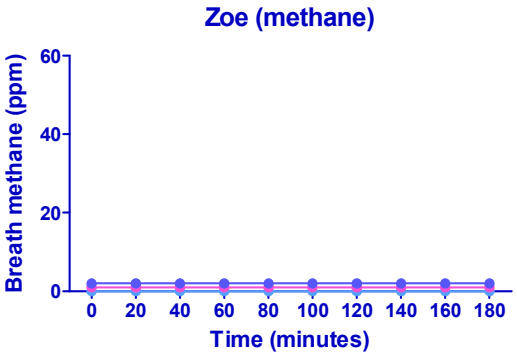
Breath hydrogen results from 4 different people. See the text for interpretation

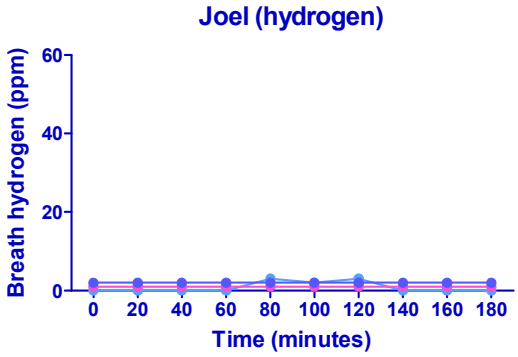


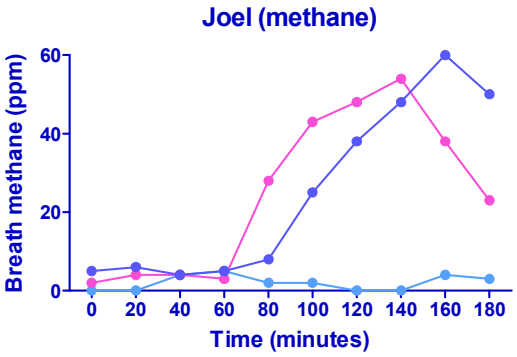
Lactulose
Fructose
Lactose











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

- *All* of them will be taught to restrict fructans, GOS and polyols.
- *Daisy* will be taught the *low FODMAP diet* that includes lactose restriction, but free fructose will not be restricted.
- *Matthew* will be taught the *low FODMAP diet*, but will not include restriction of free fructose or lactose.
- *Zoe* will be taught the *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 re-introduction trial is to commence (see Chapter 4).
- *Joel* will be taught the *low FODMAP diet* that will include restriction of free fructose but not of 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':

- lactose 'intolerance' is where malabsorption was shown at the breath test but the lactose taken also triggered symptoms; and
- lactose 'malabsorption' alone is where symptoms were not triggered despite a positive test result.

Lactose restriction was then only recommended for those with lactose 'intolerance'. We are now aware of the additive effects of different FODMAPs taken in the one meal or sitting. The effect of one specific FODMAP is usually irrelevant because it is not common to have only one FODMAP food source at a time in a normal diet. The breath hydrogen tests can identify whether lactose or fructose are adding to the mix of other FODMAPs in that individual. Hence, if symptoms are triggered after the testing of a single FODMAP, or not, it will not alter how we use the information from the breath hydrogen or methane results in the planning of the *low FODMAP* dietary design.

Our research group also performed a study in which we wanted to see how well symptoms that were reported by the patient during or after the fructose breath test matched well (correlated) with actual fructose malabsorption. Symptoms experienced by the time the hydrogen test was completed were associated mostly (but not all) with fructose malabsorption (i.e., they occurred in those who has fructose malabsorption but not in those who did not). However, symptoms that developed over the next 12 or 26 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 it is noted that 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 are that symptoms can be triggered by the sugars during the test!

Where to get breath hydrogen tests

Breath hydrogen testing is becoming more readily available across Australia. Centres are now present in most capital cities. You should contact your local gastroenterologist to find out if they are available near you. If a testing Centre 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 send the bags containing your breath samples back to the breath testing centre. 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, lactose and sorbitol need to be restricted, the *low FODMAP diet* can be instituted without the breath tests. It just means that the diet is started with restriction of all FODMAPs, including free fructose and lactose - the 'whole Monty" you might say! If the full FODMAP restricted diet has satisfactorily relieved IBS symptoms, then the reintroduction of food containing free fructose and lactose will occur, to determine your tolerance. While not as 'concrete' or practical as doing it with the knowledge of 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

- Gasbarrini A, Corazza GR, 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. Aliment Pharmacol Ther. 2009 Mar 30;29 Suppl 1:1-49.
- Gibson PR, Newnham E, Barrett JS, Shepherd SJ, Muir JG. Fructose malabsorption and the bigger picture. Aliment Pharmacol Therap 2007; 25:349-63.
- Bate JP, Irving PM, Barrett JS, Gibson PR. Benefits of breath hydrogen testing following lactulose administration in analyzing carbohydrate malabsorption. Eur J Gastroenterol Hepatol 2010; 22(3): 318-326
- Barrett JS, Irving PM, Shepherd SJ, Muir JG, Gibson PR. Comparison of the prevalence of fructose and lactose malabsorption across chronic intestinal disorders. Aliment Pharmacol Therap 2009; 30:165-174.