

Technical Bulletin

GLUCOSE/INSULIN METABOLISM

The patented FIA™ test for *glucose/insulin metabolism*, which does not exist commercially anywhere but at SpectraCell, is a unique biochemical test to assess carbohydrate metabolism and the intracellular function of insulin. This test does not measure a single micronutrient, but rather, the function of an entire system of handling carbohydrates — similar in concept to the FIA™ *fructose intolerance* test.

WHAT IS INSULIN?

- Insulin is a polypeptide (protein) hormone that is produced by beta cells in the islets of langerhans glands, located in the pancreas. Insulin is a general maintenance type of hormone with multiple roles.
- The primary function of insulin is to allow the transport of glucose (blood sugar) into cells. Only liver cells (hepatocytes), brain cells and red blood cells do not use insulin to facilitate the transport of glucose. Therefore, insulin is necessary to provide carbohydrate fuel (glucose) for nearly all cells.
- Insulin allows the transport of amino acids into cells, providing basic building blocks that are essential for cell functions and survival.
- Insulin has anabolic functions on cells, meaning that it stimulates glucose oxidation (getting energy from “burning” glucose), protein synthesis, RNA synthesis, fatty acid synthesis, and glycosaminoglycan synthesis.
- Insulin inhibits the manufacture of glucose by cells which can prevent the breakdown of protein and amino acids.
- When present in the blood stream, insulin prevents the mobilization of fat from stores, lowers blood sugar levels, and increases glycogen levels in muscles and liver.
- Insulin activates fat formation and helps to improve nitrogen retention (i.e., protein and amino acid synthesis).
- Insulin is released by pancreatic beta cells into the blood stream when blood levels of glucose, amino acids or other hormones increase. Insulin is relatively short-lived in the blood stream and is broken down within minutes to hours.
- Insulin forms a hormonal partnership with glucagon which generally has opposite effects on metabolism than on insulin.
- Insulin attaches to specific receptors on cell membranes — activating a series of events that require calcium, manganese, chromium, zinc and cyclic nucleotides. A cascade of events then occur inside the cells to support glucose and amino acid transport, and biosynthetic activities.
- Cells have the ability to change numbers and activity of insulin receptors, thus modulating how cells respond to insulin.
- Other hormones, especially high levels of cortisol and corticosteroids, suppress insulin function by inhibiting insulin receptor presence and/or receptivity.
- Insulin is part of a constantly changing, dynamic system designed to maintain blood sugar and amino acid levels within tolerable limits to the brain. Insulin prevents blood sugar from getting too high which would damage brain cells - causing coma or death.

INSULIN DEFICIENCY SYMPTOMS

- When insulin function is impaired, glucose cannot be transported into the cells fast enough to support regular cellular metabolism. The result is a form of cellular starvation in which fat is mobilized, and amino acids are broken down to manufacture glucose intracellularly. This results in ketone body formation, small organic acids, in addition to more anaerobic metabolism — forming excess lactate which can acidify cells and the blood to harmful levels. Diabetes mellitus is the name given to a lack of insulin function.
- Type I diabetes, also known as *juvenile diabetes*, affects younger individuals. Type I diabetes is

usually insulin-dependent, meaning that insulin must be administered by injection during the course of the day.

- Type II diabetes, also known as *mature-onset diabetes*, occurs as people age. A more gradual decrease in insulin function, along with fluctuating levels, leads to obesity and hyperlipidemia. Most Type II diabetics are non-insulin-dependent.
- Antibodies may form against insulin which will manifest as diabetes. Other hormones, including corticosteroids, somatotropin (growth hormone) and thyroid hormones antagonize insulin.
- Clinical symptoms of diabetes include the three “P’s”: *polyphagia*, *polydipsia*, and *polyuria*, or:
 - excessive hunger, thirst and urination
 - high blood and urine ketones
 - high blood and urine sugar (glucose)
 - metabolic acidosis

Long-term complications include:

- atherosclerosis
- blood vessel damage
- gangrene
- kidney damage
- loss of muscle protein (weight loss)
- nerve damage
- retinal damage

Insulin excess, usually caused by injection of amounts that are too high, can cause confusion, convulsion, disorientation, headache, low blood sugar, mental tremors, stupor, sweating, coma, or death.

HOW IS THE FIA™ GLUCOSE/INSULIN METABOLISM TEST PERFORMED?

1. The amount of glucose in SpectraCell’s patented, serum and protein-free FIA™ media is lowered to $\frac{1}{10}$ the usual amount. This amount provides barely enough glucose to support optimal cell growth (DNA synthesis) for most persons. Some persons will have a somewhat decreased growth response at this level of glucose. This is of no importance since the value is used to calculate the glucose/insulin metabolism

test. Of interest is the glucose concentration (72 mcg/ml) which is the same as the lower limit of blood glucose. Thus, the FIA™ glucose/insulin metabolism test starts with a nearly hypoglycemic amount of glucose.

2. Insulin is added (1.0 units/ml). There is no insulin in the patented media, or in other FIA™ tests. Lymphocytes in the media are then stimulated to grow with PHA (a mitogen). Glucose/insulin is then calculated by dividing the lymphocyte growth response (DNA synthesis) in the low glucose/insulin media, giving a percent control growth value.

Normally, the addition of insulin does not affect the growth of lymphocytes and the glucose/insulin metabolism test is ideally near 100% control growth. When values are significantly elevated and exhibit a growth response of 120% or greater, then glucose/insulin metabolism is considered deficient. This increased growth results from insulin function either enhancing or stimulating the cells’ ability to transport and utilize glucose for energy and growth.

CLINICAL APPLICATIONS

Approximately 1 in 5 persons tested by the FIA™ have shown a deficient glucose/insulin metabolism result. This is a relatively large proportion of the population who visit clinicians’ offices and underscores the essentiality of insulin function. Also, this test may not be affected by eating right and taking nutritional supplementation, which emphasizes the need to assess an individual’s intracellular glucose/insulin status.

There are four major clinical conditions which are associated with a deficient glucose/insulin metabolism result. Each relate to an imbalance of insulin function and thus, utilization of glucose.

1. Hypoglycemia

In a pilot study conducted at the University of Texas at Austin during the research and development of the FIA™ technology, a number of subjects exhibited a deficient glucose/insulin metabolism result. A glucose intolerance curve test was performed on these subjects, which involved feeding a known amount of glucose after an overnight fast, and drawing blood to measure blood glucose levels every four to six hours. No food was eaten during the test period, which is frequently uncomfortable. Ninety percent of the subjects exhibited hypoglycemia (low blood sugar) at one or more time points. The

remaining 10% were hyperglycemic and found to be diabetic upon further testing. Common clinical symptoms of hypoglycemia include blurring of vision, craving for sweets, depression, fatigue, headache, hunger, lethargy, mental confusion, and/or nausea.

2. Diabetes (Hyperglycemia)

Sometimes — but not always — persons diagnosed with diabetes exhibit a deficient glucose/insulin metabolism result. It must be stressed that this test is not a screen for diabetes and is not diagnostic for diabetes. It does, however, suggest further laboratory testing to rule out diabetes. Other diagnostic tests for diabetes are fasting blood sugar, two-hour post-prandial blood sugar, glucose tolerance curve, glycohemoglobin levels, and serum insulin levels (with or without stimulation).

3. Obesity

One theory of obesity suggests a resistance to insulin by peripheral tissues (or fat cells), leading to excess body fat formation and obesity. Since insulin function is decreased, cells are stimulated to store fat.

Another pilot study conducted by researchers at Rice University and Houston-area hospitals examined the glucose-insulin metabolism test results in 8 morbidly obese patients going into a hospital-based *very low calorie diet (vLCD)*. All 8 subjects exhibited a deficient glucose/insulin metabolism result at entry into the study. At the end of the *vLCD* period, most subjects showed a significant decrease in glucose/insulin metabolism test values. However, after two weeks of resuming regular eating patterns, the test was evaluated again to pre-diet status. Results indicated that the glucose/insulin metabolism test values may change within a several-week period (relatively quick compared to other FIA™ tests). This makes sense since insulin receptors and blood levels are constantly fluctuating.

4. Extreme Stress Or Corticosteroid Therapy

Severe stress such as third degree burns, blood infections, shock, major trauma or end-stage cancer have been associated with a deficient glucose/insulin metabolism result. In addition, high therapeutic doses of corticosteroids (for rheumatoid arthritis, inflammatory conditions or autoimmune disorders) have also been associated with deficient

glucose/insulin metabolism results. All of these conditions exhibit high levels of corticosteroids in the body which lead to insulin resistance and hyperglycemia. This is a well known fact of severe traumatic stress to the human body. According to SpectraCell's findings, and consistent with known physiological findings, the FIA™ glucose/insulin metabolism test is frequently elevated in this type of individual.

Because the glucose/insulin metabolism test measures the intracellular function of insulin, any of the above four factors could account for a deficient test result. It is up to the clinician to add clinical history to determine which of the four conditions most appropriately explain the test results.

REPLETION SUGGESTIONS

Since the FIA™ test for glucose/insulin metabolism measures the functional intracellular status of an entire system, no single micronutrient can replete a deficient status. Regardless of the suspected reason for deficient function, the same dietary advice is suggested. The primary goal is to reduce the glycemic index of the diet. The *glycemic index* is a measurement of how fast and how much a food can elevate blood glucose. To determine the glycemic index of a food, fasted volunteers are fed a standard of a food amount (100 grams) and blood glucose levels are determined much like a glucose tolerance test. The increase of blood sugar from resting levels is calculated to get an *area under the curve (AUC)*. The AUC for glucose has been set at 100% and all other foods are calculated based on the value for glucose.

In general, foods with a high glycemic index are loaded with glucose, sucrose or refined starches. Even whole grains and their food products have a high glycemic index. In general, legumes, fruits, vegetables, and foods with high fat or fiber content, including carbohydrates, tend to exhibit a lower glycemic index. The goal is to prevent a rapid rise in blood sugar which a deficient insulin function would not be able to control, thereby preventing clinical symptoms of hypoglycemia or hyperglycemia. This is accomplished by choosing foods with a low glycemic index. Tables listing the glycemic index of various foods can be found in dietetic or nutrition textbooks, or from the American Diabetes Association.

Another dietary suggestion is chromium supplementation, since chromium is an integral part of the insulin receptor (as part of the Glucose Tolerance Factor). A chromium

deficiency has been associated with hypoglycemia, pre-diabetic states, and diabetes.

Clinical outcomes of chromium supplementation have led to the normalization of blood lipids, blood glucose control and amelioration of hypoglycemic symptoms. However, the FIA™ glucose/insulin metabolism test is not a test for chromium function per se, although a chromium deficiency may be one underlying factor. Given the documented prevalence of deficient chromium intake in the U.S., this may be a significant reason for poor insulin function. Therefore, chromium supplementation is suggested.

A recent study also identified deficient intracellular magnesium status and exaggerated intracellular calcium status to be responsible for the impairment in insulin action and a worsening of insulin resistance in non-insulin-dependent diabetic and hypertensive persons. Daily magnesium repletion restored a more appropriate intracellular magnesium status, contributing to improved insulin-mediated glucose uptake.

SUMMARY

SpectraCell's FIA™ test for glucose/insulin metabolism is a unique scientific method to assess the intracellular function of insulin. Several important health conditions are associated with deficient test findings and additional medical testing may be appropriate to rule out diabetes or other health concerns. Repletion can be achieved by *low glycemic index* foods and specific micronutrient supplementation.

**To order this test,
call SpectraCell at 800/227-5227**

 **SpectraCell Laboratories, Inc.**
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