



Newsletter

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TRACE ELEMENTS AND GLUCOSE DISORDERS

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The incidence of diabetes worldwide is expected to double in the next 10 years affecting over 200 million people. It is known that dietary modifications can help considerably in improving blood-glucose control and therefore reduce the many complications caused by this condition. Mooradian and Morely published an excellent review article discussing the serum micronutrient status in patients diagnosed with diabetes. (Am. J. of Clin. Nutr. vol. 45, 1987) Their paper stated that "the relationship between nutrition and diabetes was suspected as early as 1674 and that "over the last 20 years, numerous studies have found alterations in micronutrient status of patients with diabetes mellitus. In some studies deficiency of certain minerals or vitamins has been correlated with presence of diabetic complications." They also state that there is much confusion concerning the nutritional requirements of patients with diabetes since many studies are contradictory in different population groups studied. This confusion would be expected since this condition is not usually viewed in accordance with metabolic individuality. I will review their excellent summary of serum micronutrients studied in relation to diabetes as well as studies from hair mineral analysis patterns.

SERUM NUTRIENT STUDIES

Zinc: Serum levels of zinc are usually found low in diabetic patients. Insulin is stored in a crystalline form and zinc is a constituent of crystalline insulin. Zinc affects the antigenic properties of insulin and the binding of insulin to hepatocyte membranes and a deficiency can lead to increased insulin resistance and hyperglycemia. Elevated glucose in turn produces hyperzincuria. Low zinc leads to poor or slowed wound-healing common in diabetic patients. Zinc has a biphasic effect, in that it is required for insulin storage and cellular binding, although high concentrations can lead to a reduction in insulin release.

Chromium: Chromium is a well-known component of the glucose tolerance factor (GTF). Other components include nicotinic acid, glycine, cystine, and glutamic acid. As a constituent of a metallo-enzyme, chromium is involved as a cellular receptor for insulin. A deficiency of chromium can result in elevated glucose, triglycerides, and cholesterol levels

Calcium: Calcium in a sufficient concentration is necessary for insulin release. In juvenile diabetic patients, serum calcium and magnesium are low with increased urinary excretion, along with decreased parathyroid hormone activity. These conditions are not present in adult onset diabetic (AOD) patients.

Copper: A deficiency of copper results in glucose intolerance, decreased insulin response, increased glucose response and is associated with hypercholesterolemia and atherosclerosis. Copper possesses an insulin-like activity and promotes lipogenesis. Serum copper is elevated in AOD patients.

Manganese: Manganese deficiency can impair glucose utilization. Intra-uterine deficiency produces islet cell atrophy. Hepatic manganese is elevated in some forms of diabetes, and may be related to increased arginase activity.

Iron: Excess iron accumulates in the pancreas and causes tissue injury. Excess iron relative to copper results in increased lipid peroxidation.

Selenium: Insulin reserves are diminished with deficiency of selenium and can contribute to glucose intolerance. Selenium deficiency results in decreased glutathione peroxidase activity.

Vitamin A: Vitamin A aids in the stimulation of insulin release from the pancreas. However, vitamin A is required in low concentrations and can inhibit insulin release at high concentrations.

Thiamin: Vitamin B₁ is low in the serum of diabetic patients, and is related to reduced transketolase activity. Deficiency of B₁ may be related to the development of diabetic neuropathy.

Pyridoxine, B12: Plasma vitamin B₆ and pyridoxal 5-phosphate (P5P) activity is reduced in AOD patients. B₁₂ deficiency is common in insulin dependent diabetics (IDD) and may result in pernicious anemia.

Ascorbic Acid: Plasma ascorbate is low in diabetic patients with increased dehydroascorbate levels. AOD patients have a higher turnover of ascorbic acid.

Vitamin D: Vitamin D is decreased in juvenile and elevated in AOD individuals. Vitamin D enhances insulin production, and is synergistic to, calcium, copper, PTH, insulin, and estrogen.

Vitamin E: Vitamin E requirements are increased in diabetic patients. High intake can reduce oxidative stress and improve the action of insulin.

HAIR TISSUE MINERAL ANALYSIS (HTMA) PATTERNS IN DIABETES

Zinc: A relative zinc deficiency is seen in Para-Sympathetic Types, (low Zn/Cu ratios), with an absolute deficiency found in Sympathetic Types. The biphasic effect of zinc may be due to its effect upon glucocorticoid stimulation. Antagonistic effects of zinc on insulin may occur in diabetic patients with low HTMA Na/K and Ca/K ratios. Zinc increases glucocorticoid activity, which raises potassium relative to sodium and antagonizes insulin release via calcium and vitamin D antagonism.

Chromium: Hair chromium is usually found low in both Para-Sympathetic and Sympathetic Types. Losses of chromium can be caused by elevated glucose that is common in Sympathetic Types. Hyperinsulinism frequently associated with Parasympathetic types also causes a loss of chromium.

Calcium, Magnesium: Calcium and magnesium are elevated in Para-Sympathetic Types. The Ca/Mg ratio is usually increased, indicating increased insulin production and release. Calcium and magnesium are low in Sympathetic Types, along with low Ca/K, and Na/K ratios, indicating decreased production and release of insulin. In juvenile diabetes, PTH, serum calcium and magnesium are low with increased urinary excretion of calcium and magnesium.

Copper: Copper possesses insulin-like activity and is often elevated in Para-Sympathetic Types. Both copper and insulin promote lipogenesis, which is why most people who develop AOD are overweight. Copper, calcium, vitamin D, PTH, insulin, and estrogen are synergistic and promote increased insulin production, which contributes to atherosclerosis. Copper is synergistic to calcium, which is why high tissue calcium is usually found with elevated tissue copper. Excess copper results in a low Zn/Cu, and high Ca/Mg ratio. Copper is usually low in Sympathetic Types. Copper deficiency results in glucose intolerance decreased insulin response and increased glucose response. Low tissue copper is associated with low Ca/K and Na/K ratios. You will therefore, notice that in individuals with copper deficiency corresponding low tissue calcium will be present. Copper deficiency is associated with hypercholesterolemia and atherosclerosis. A copper deficit has also been associated with enhanced glycation, the deleterious binding of sugars to protein. (Saari, Dahlen. Early and advanced glycation end products are increased in dietary copper deficiency. J. Nutr. Biochem. 10,4, 1999.)

Manganese: Manganese is usually low in Para-Sympathetic Types, but may be elevated in some. It is low in Sympathetic Types, but sometimes elevated in association with increased iron accumulation.

Iron: Tissue iron is usually found low in Para-Sympathetic Types, but may be elevated in Sympathetic Types. Excess iron accumulates in the pancreas and causes injury to the islets due to increased lipid peroxidation. Excess tissue iron is associated with an increased Fe/Cu ratio, and low Ca/K and Na/K ratios.

Selenium: Selenium may be low in Para-Sympathetic and Sympathetic Types. Insulin reserves are decreased with selenium deficiency causing glucose intolerance. Deficiency results in decreased glutathione peroxidase activity.

Vitamin A: Vitamin A requirements are increased in Para-Sympathetic Types, while its requirement is decreased in Sympathetic Types. Vitamin A is synergistic to zinc and can inhibit insulin release in high concentrations. This effect is due to vitamin A's antagonistic effect upon calcium and therefore can contribute to low Ca/K and Na/K ratios. The beneficial action of vitamin A may not actually be in stimulating insulin release but instead be in the improvement of tissue sensitivity to insulin.

Thiamin: Requirement for vitamin B₁ is increased in Para-Sympathetic Types. Sympathetic Types may have increased needs in certain circumstances, such as when a low Na/K ratio exists.

Niacin, Pyridoxine, B₁₂: Increased vitamin B₆ and B₃ requirements may be present in Para-Sympathetic and Sympathetic Types. Vitamin B₁₂ requirements are increased in Sympathetic Types, with low Na/K and Ca/K ratios.

Ascorbic Acid: Requirement for vitamin C is increased in Para-Sympathetic Types. AOD patients have a high turnover of ascorbic acid, which may be due to the elevated tissue copper, and/or low Zn/Cu ratio. Excess copper increases the oxidation of vitamin C. On the other hand, Sympathetic Types may have increased dehydroascorbate levels due to low tissue copper and/or elevated Zn/Cu. In this circumstance, vitamin C can act as a pro-oxidant instead of an anti-oxidant.



Vitamin D: Vitamin D requirements are decreased in Para-Sympathetic Types due to its' synergistic effects with insulin, estrogen, calcium, copper, and PTH. Elevated Ca/P, Ca/Mg, and low Zn/Cu ratios indicate this. Requirement for vitamin D is increased in Sympathetic Types particularly in the presence of low Ca/P, Ca/K, and Na/K ratios.

Vitamin E: Vitamin E may be required in both Para-Sympathetic and Sympathetic Types. However, due to its' stimulatory effect, vitamin E should be used cautiously in Sympathetic Types.

HAIR MINERAL PATTERNS AND DIABETES

Sympathetic Metabolic Types

The following illustration shows the HTMA results of a patient diagnosed with diabetes and anemia. This is a Sympathetic Type 1 HTMA pattern with an elevated iron of 10 mg% (ideal 2.2 mg%). As discussed earlier, high iron in itself could contribute to a diabetic condition. We can also see a low Ca/Mg ratio indicating a decrease in insulin production. This can be caused by elevated glucocorticoid (GC) secretion from the adrenal cortex. GC is antagonistic to insulin and antagonizes calcium retention. This is indicated by this patient's elevated sodium and potassium levels and low Na/K ratio. This pattern illustrates why zinc has a bi-phasic effect. As mentioned previously zinc is necessary for storage of insulin. However, in this case zinc can further exacerbate insulin antagonism due its' glucocorticoid enhancement. This is also indicated by the low Na/K ratio in that zinc increases potassium retention relative to sodium. Potassium antagonizes calcium thus reducing insulin release. This also explains the bi-phasic effects of vitamin A. Vitamin A is synergistic to zinc and therefore, enhances potassium retention thereby antagonizing calcium retention. Heavy metals can also affect glucose stability. But, the major factor in this patient is most likely the elevated iron, especially relative to copper. This metal pattern not only has an antagonistic effect upon insulin, but also is related to pancreatic tissue damage due to increased free radical generation caused by excess iron.

Parasympathetic Metabolic Type

The next set of lab results is from a patient also diagnosed with diabetes and anemia. This patient however is showing a Parasympathetic Type 1 pattern that is completely opposite from the previous patient's results. Even though both patients are diagnosed with diabetes, we can see that the cause and the approach to treatment will be completely different for each. This pattern is showing elevated calcium and magnesium levels and a high Ca/Mg ratio indicating hyperinsulinism. Hyperinsulinism could be caused by any number of factors, such as insulin resistance, autoantibody activity, or loss of insulin sensitivity at the cell due to a chromium deficiency. Excess calcium in the cytosol may be a contributing factor to insulin resistance (Am. J. of Kidney Dis. 21, 6, 1993). Copper is high in this case and we have already mentioned that copper has an insulin-like effect. Copper is an anabolic mineral and has a calcium raising effect, which in turn increases insulin release. This can cause an increase in parathyroid hormone (PTH) production that enhances vitamin D activity, which enhances insulin production and so on. This sets up a viscous cycle that requires some kind of intervention in the correct place in order to stop the cycle. This is why it becomes most necessary to provide specific therapy for the patient instead of the condition.

Women suffering from gestational diabetes typically show a parasympathetic HTMA pattern with markedly elevated copper, which normally rises during the course of pregnancy. Other research supports an association between gestational zinc deficiency and the development of diabetes. (Hales, CN, et al Fetal and infant growth and impaired glucose tolerance at age 64. *B.M.J.* 303, 1991) This emphasizes the importance of the mother's health and nutritional status on the unborn child.

Another common HTMA finding in patients with AOD is co-existing hypothyroidism. This should always be suspected in such patients, since insulin is a thyroid antagonist. This is further contributed to by the insulin-vitamin D-calcium-copper-estrogen-PTH-synergism, all of which are antagonistic to the thyroid. Disturbances in thyroid function can lead to hypercholesterolemia so closely associated with heart disease in the diabetic population. Studies have shown that indeed hypothyroidism exists in diabetic patients even though the hypothyroidism was clinically unrecognized. (Grey, RS, et al. Hypercholesterolemia in Diabetics with Clinically Unrecognized Primary Thyroid Failure. *Horm. Met. Res.* 13, 1981).

Glucose, Insulin Stability and Diet

Diet and weight control plays a major role in stabilizing glucose. Since insulin is an anabolic, lipogenic, hormone it can play a major role in weight control. Hyperinsulinism increases fat deposition and contributes to obesity. This is why most patients with adult onset diabetes are overweight. Obesity can be considered a result of poor insulin control rather than a cause. AOD is associated with hyperinsulinism and insulin has a suppressing effect upon the thyroid.

A study reported in JAMA concluded that dietary suggestions made by the American Diabetes Association of 55 to 75% carbohydrate and less than 30% fat intake contributes to hypertriglyceridemia, reduces serum HDL, worsens hyperglycemia and/or raised insulin levels in non-insulin-dependent diabetic patients. Groups following a diet made up of only 40% carbohydrates and 45% fats had better glucose control, without a rise in triglyceride and HDL and insulin levels. (*JAMA* 271, 18, 1994.) Studies have led the American Diabetes Association to issue a new set of nutrition recommendations for people with diabetes mellitus, replacing the 1986 recommendations. They state, "Overall, the 1994 recommendations make obsolete the concept of one diet for diabetes and physician orders for an "ADA diet"...Physicians and nurses can no longer depend upon preprinted diet sheets, formulated meal patterns, or even computer-individualized meal plans to provide nutrition care to patients with diabetes. The new recommendation state that diets high in fat may be preferable to high-carbohydrate diets for certain persons with diabetes. "A diet providing less than 30% of calories as total fat is no longer recommended for everyone. The guidelines may require adjustments in beliefs about food and diabetes, alteration in methods used to provide nutrition care, and modification in practice patterns of dietitians, physicians, and nurses. Changes in philosophy, scientific recommendations, and terminology shift the nutrition management of diabetes from a mathematical to a cognitive process..." (Nutrition Recommendations and Principles for People with Diabetes Mellitus. *J.Am.Diet.Assoc.* 94,5, 1994) This brings me to our dietary recommendations based upon individuals HTMA results. In the Slow Metabolic Type it is extremely important to have adequate protein relative to carbohydrates in order to increase the metabolic rate, stabilize glucose and insulin, and improve nutritional balance and function. On the other hand, the Fast Metabolic Type 1 is recommended to increase fats relative to protein in order to preserve glucose control and reduce excessive metabolic and endocrine activity. In certain types of Fast Metabolizers, those with an indication of protein catabolism, an increase in carbohydrate is warranted in order to spare protein.

Factors That May Contribute to the Development of Diabetes

This brings us to the question of what can cause diabetes, other than pancreatic tissue destruction? It is not uncommon for diabetes to develop following a severe stress such as trauma. Obviously these patients had the predisposition prior to their trauma. The traumatic event just triggered the manifestation of a condition waiting to happen. This is why our HTMA reports stress the existence of trends toward various disease processes. We cannot tell from the HTMA if the condition is clinical, but if the metabolic tendency exists, the possibility of its development is very likely. However, a person may have a subclinical susceptibility and never progress to a clinically recognizable diabetic condition if they do not experience a superimposed stressful event. A viral or bacterial infection can also precipitate a diabetic condition. From what we have learned we can see that a virus could precipitate diabetes in the slow metabolic type and a bacterial infection could contribute to diabetes in a fast metabolic type. Pak and colleagues have reported an association of CMV with diabetes. (Pak, CH., *Lancet* Jul. s, 1988. Harrison, et al also reported an inverse relation between cellular immunity in patients at risk of insulin-dependent diabetes. (*Lancet* 341, 1993.) This fits into our categorization of disease in sympathetic and parasympathetic, or humoral and cellular immune response groups. (TEI NEWSLETTER. 7,1, 1994. The Immune System and Hair Tissue Mineral Patterns. Nutritional, Neuro-Endocrine Immunology) Reports have shown that immunosuppressive drugs such as cyclosporin has improved glucose control in newly diagnosed diabetic patients. As result of immunosuppressive therapy, insulin treatment could be discontinued in many of the treated patients.

Emotions and Glucose Control

Emotions play a significant role in blood sugar regulation. Patients experiencing anxiety, depression or other emotional problems have greater difficulty in controlling blood glucose compared to those not suffering emotional problems. Poor glucose control can in turn contribute to emotional instability and interpersonal conflicts. (Swift, CR, et al Adjustment problems in juvenile diabetes. *Psychosom.Med.*29, 1967. Simonds, JF. Psychiatric status of diabetic youth matched with a control group. *Diab.*26, 1977. Lader, M. The psychopathology of anxious and depressed patients. CLINICAL APPLICATION OF PSYCHOPHYSIOLOGY. Fowles, D, ed. Col. Univ. Press, N.Y., 1975.) Stress can readily elevate blood glucose. Stress effects the autonomic nervous system, which in turn affects the secretory rate of insulin and glucagon. Emotions therefore affect glucose and insulin levels via sympathetic or parasympathetic stimulation and in turn, poor glucose and insulin control can affect neurological function. A vicious cycle can develop making it very difficult to maintain glucose and blood sugar control. A good example of this is seen in a condition called post-traumatic dysinsulinism. This condition commonly occurs following a stress, such as an automobile accident. I think most practitioners have seen such cases. In this type of patient, their symptoms are very difficult to bring under control. Symptoms may be neurological, musculoskeletal, and/or emotional and the patient seems to never stabilize. They may respond favorably to treatment for a day or two only to exacerbate the next day. Frequently they are described as hysterical due to their emotional instability. These problems can be due to significant swings in blood glucose and insulin levels. The nervous system also responds with wide fluctuations, making them very difficult patients to manage. When this cycle is broken, they will stabilize and begin responding to therapy. In such cases, the glucose control has to be attained before improvements of the somatic and emotional manifestations can occur.

Conclusion

Stabilization of blood glucose is important for many reasons. Patients with diabetes are susceptible to complications such as neuropathies, cardiomyopathy, vascular disease, poor wound healing and blindness. Even patients suffering with simple hypoglycemia would benefit from glucose control. Many common health conditions other than diabetes have an underlying disturbance in glucose control. Weight control for example is closely associated with glucose and insulin, as well as emotional problems such as; aberrant behavior, poor concentration and mental acuity. The emotional connection to poor glucose control is very strong and should not be overlooked, since the brain requires a constant supply of fuel (glucose).

Due to the adverse effects of elevated glucose or hypoglycemia, it is important to maintain glucose control in diabetic and non-diabetic patients alike. This involves control of insulin levels as well since glucose does not always correlate with insulin levels. A person can have a normal blood-glucose level and yet have an underlying hyperinsulinism condition. HTMA can help considerably in recognizing specific nutritional imbalances that may be present in patients with abnormal glucose and insulin levels as well as serve as an aid, in conjunction with other clinical tests, in recognizing the potential development of a glucose disorder.