Overview
What do depression, heart disease, and detoxification impairments all have in common? The answer lies in their association with amino acid imbalances. Low tyrosine or phenylalanine can result in abnormal levels of mood-regulating dopamine and catecholamines. Both low taurine and high homocysteine have been associated with cardiovascular problems. And low levels of methionine, glycine, and glutathione (among others) can result in compromised clearance of toxic substances from the body. Great Smokies’ Amino Acids Analysis is a quick and convenient means of getting to the root of some of these chronic disorders. Our report form provides levels of over 40 analytes.

Problem areas are targeted, such as dietary inadequacy (or malabsorption) of essential amino acids, insufficiencies of particular vitamins or mineral cofactors required in amino acid metabolism, and susceptibility toward particular diseases.

Precise results make possible specific nutritional intervention, resulting in improved clinical outcomes.

Amino acids are essential to life. In free form or linked as peptides they assume important roles in such activities as neurotransmitter function, pH regulation, cholesterol metabolism, pain control, detoxification, and control of inflammation. Amino acids comprise the building blocks of the proteins found in structural tissues of the body. In fact, the word “protein” derives from the Greek “protos,” meaning “first,” a designation underscoring its prominence.

The various functions supported by amino acids in the body depend upon proper amino acid metabolism. Metabolic impairments are hidden in many individuals. These impairments may be expressed as subtle symptoms or overt diseases. Amino acids analysis should be considered whenever a thorough nutritional and metabolic workup is desired for an individual. In addition to family history, a variety of conditions may alert the practitioner to the possibility of disordered amino acid metabolism, including chronic fatigue, frequent headaches, chronic gastrointestinal distress, intolerances to foods and chemicals, persistent inflammatory responses, depression, learning disabilities, malnutrition, neurological disorders, or symptoms of degenerative disease.

Proteins and Amino Acids
Molecules composed of several amino acids, up to several dozen, are generally classified as “peptides.” Many “short-chain” peptides of dietary origin are absorbed intact, and they may function in a manner not shared by individual amino acids. Most are broken down further, via digestive proteolysis, into their component amino acids. Distinctions between the many different amino acids can be made by examining their chemical structures.

Every amino acid molecule contains at least one amino group (-NH2) and carboxyl group (-COOH). Amino acids are in either an “L” or “D” configuration, the difference determined by which side of the molecule the amino group (-NH2) is attached. All, with the exception of glycine and taurine, have this asymmetry; taurine carries a sulfonic acid group instead of a carboxyl group. In natural protein, all amino acid residues are of the “L” configuration. “D” configurations may be formed by bacteria, tissue catabolism, or synthetically. Although a small portion of ingested “D” form amino acids can be “racemized,” or rearranged, to form “L” configurations, most “D” configured amino acids are unavailable for peptide and protein synthesis and may even inhibit enzymes. For this reason, D-configured amino acids are not desirable for nutritional supplementation. An exception in this case might be DL-phenylalanine (DLPA) which, owing to its ability to inhibit the normal enzymatic degradation of endorphins and enkephalins, has been used therapeutically for pain management.

What this test does:
Identifies nutritional deficits, metabolic impairments, and amino acid transport disorders.

Turn-around Time 10 days
Many amino acids are produced by the body. Others, the essential amino acids, cannot be endogenously synthesized in adequate amounts, so that they must be obtained from the diet. The eight essential amino acids in humans are: isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine.

Semi-essential amino acids are those for which there is some endogenous synthesis, but not enough for physiological needs. These include arginine, histidine, cysteine, and taurine (for infants).

Imbalances in any of these amino acids can indicate impairments in metabolism.

Some Important Amino Acids

Some amino acids deserve particular mention, owing to their pivotal role in the body. Examples include methionine, taurine, cysteine, lysine, arginine, tryptophan, and glutamine.

Methionine is a crucial essential amino acid which brings methyl groups and sulfur into the body. It is required for the formation of body tissues, metabolism of carbohydrates, lipids and amino acids, and antioxidant and detoxification processes. Methionine is the essential precursor of the important amino acids cysteine, glutathione, and taurine and, via cysteine, contributes to the formation of insulin and coenzyme A. Methylation (via S-adenosylmethionine) is essential to genetic expression, muscle metabolism, adrenal catecholamine balance, and formation of choline and acetylcholine. Methionine metabolism is subject to many impairments, resulting in a variety of disorders, including cardiovascular disease, neural tube defects, osteoporosis, and neuropsychiatric disorders.

Taurine, a non-protein metabolite of methionine, has several notable actions in the body. Acting as an anti-oxidant, taurine scavenges excess hypochlorite ions (OCl\(^{-}\)). In addition, it serves as a neurotransmitter, conjugates with cholesterol to form a component of bile, helps regulate the intra-cellular concentrations of magnesium, calcium, potassium, and sodium, and is magnesium-sparing. Taurine promotes potassium retention by the heart, and it appears to reverse cardiac abnormalities induced by cardiac glycosides or epinephrine. Full-term infants have minimal capacity to metabolize methionine. Mother’s milk is high in taurine, while cow’s milk contains only trace amounts. In response to “failure-to-thrive” problems, amino acids were finally added to baby formula in the 1980s.

Cysteine, a key player in methionine metabolism, forms disulfide linkages in and between protein chains. It reacts with a derivative of pantothenic acids to form coenzyme A, serves as a precursor of taurine, and is the rate-limiting component of the antioxidant and detoxifying tripeptide, glutathione (GSH). In the immune system, sulfhydryl compounds augment the activation of cytotoxic T cells, T-cell proliferation in response to mitogens, and the differentiation of T and B lymphocytes. Conjugation with GSH is a critical step in the detoxification and excretion of most xenobiotics and metabolically produced oxidizing agents. In acetaminophen toxicity, N-acetylcysteine protects against hepatotoxicity primarily by serving as a nutritional precursor for GSH synthesis. Total and reduced glutathione concentrations are commonly low in AIDS patients, and they appear to be a powerful yardstick for predicting survival in HIV infection.

GSH deficiencies have also been documented in a number of pulmonary diseases, including acute respiratory distress syndrome, asthma, chronic obstructive pulmonary disease, pulmonary fibrosis, and neonatal lung damage.

In amino acid metabolism, lysine assists the transfer of amino groups by forming the linkage between transaminase enzymes, such as SGPT and SGOT, and pyridoxal phosphate, the coenzyme needed for transamination. Lysine can fulfill this role because it carries two amino groups; one forms the attachment (peptide bond) to the transaminase protein and the other helps to anchor the pyridoxal phosphate. Lysine
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also appears to impact bone health by enhancing intestinal calcium absorption and improving renal conservation of the absorbed calcium.\textsuperscript{13} It is also essential for the formation of carnitine and the utilization of fatty acids for energy by cells\textsuperscript{8} and is needed for proper immune function. Supplementation with L-lysine has been shown to enhance thymus growth and improve immune system parameters.\textsuperscript{19}

Arginine requirements exceed the body’s capacity to synthesize it, thus qualifying it as a semi-essential amino acid. Among arginine’s varied properties is its ability to stimulate release of growth hormone and prolactin, as well as the pancreatic secretion of insulin and glucagon. Arginine functions as a precursor to nitric oxide, a key player in processes such as neurotransmission, control of platelet aggregation and adhesion, blood pressure regulation, immune system cytotoxicity, and relaxation of intestinal smooth muscle. Administration of arginine has been demonstrated to reduce intimal thickness and vascular reactivity in atherosclerosis,\textsuperscript{16} as well as to decrease platelet clumping and clot formation within arterial walls.\textsuperscript{17} Arginine also enhances collagen deposition, demonstrating its role in wound healing and disorders such as gastric ulcer.\textsuperscript{18}

Another of the essential amino acids, tryptophan, serves as the precursor of the hormone, serotonin, a vasoconstrictor and neurotransmitter influencing sleep, appetite, and mood. Studies of depressed patients have demonstrated reduced levels of tryptophan, suggesting in some cases of depression a reduced tryptophan availability to the brain.\textsuperscript{19,20} Serotonin, after methylation by S-adenosylmethionine, becomes melatonin, a key regulating hormone in the body. Melatonin modulates circadian rhythms in the body and immune and endocrine activity and possesses antioxidant and oncostatic properties. A dietary lack of tryptophan or insufficient S-adenosylmethionine may result in a significant deficiency of melatonin.

Glutamine is the most abundant amino acid in the bloodstream, serving as an important vehicle for nitrogen transport. In cells, glutamine can donate one of its nitrogen atoms as an amide to form nicotinamide from niacin (vitamin B3), a necessary step in the formation of the very important cofactor “NAD.” Although considered to be non-essential since it is synthesized by the body, it may be more aptly described as a “conditionally essential” amino acid—an amino acid which is non-essential in health, but required in greater amounts during certain physiological states where tissue utilization exceeds the rate of biosynthesis. Glutamine is important for the maintenance of GI mucosal integrity\textsuperscript{21}; its deficiency is associated with gut atrophy during stress\textsuperscript{22}; and large doses of glutamine have been shown to prevent mucosal atrophy and bacterial translocation resulting from various insults, including methotrexate and radiation injury.\textsuperscript{23,24,25}

Uses of Amino Acids Analysis

Owing to advancements in amino acid measurement, more than 40+ analytes can now be measured, providing information on a wide spectrum of metabolic and nutritional disorders, including: protein inadequacy, gastrointestinal insufficiencies, inflammatory responses, vitamin and mineral dysfunctions, detoxification impairments, cardiovascular disease, ammonia toxicity, neurological dysfunction, and inborn errors of metabolism. Because amino acid measurement was once limited to the detection of inborn errors of metabolism, such as phenylketonuria (PKU), many physicians are not aware of the vast amount of clinical information now available to them through amino acids analysis.

Dietary Protein Adequacy

Since essential amino acids cannot be formed in the body and must be obtained from the diet, low levels of essential and semi-essential amino acids can indicate dietary inadequacy. Catabolism of body protein may contribute relatively small amounts of essential amino acids to blood and urine.
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Gastrointestinal Dysfunction
Amino acids analysis can indicate various aspects of gastrointestinal dysfunction. Measured levels in the urine of the peptides anserine and carnosine can result from either excess amounts in the diet or deficient peptidase activity in the gut; subnormal levels of nutritionally essential amino acids, together with increased urine or plasma levels of these peptides, indicate incomplete digestive proteolysis.26 Altered intestinal permeability is commonly observed in such individuals. Since histidine is required to make histamine, the first digestive response in the stomach, low plasma or urine histidine may also suggest malabsorption. Finally, elevated urine hydroxyproline appears to be a hallmark for celiac disease and other malabsorption states, with the greatest hydroxyproline excretion occurring in those patients with the most pronounced steatorrhea.27 This is believed to reflect an increased turnover of collagen and may be related to the osteomalacia sometimes accompanying malabsorption.28

Renal Function
The kidney plays a major role in amino acid metabolism and nutrition; amino acid reabsorption by renal tubules salvages about 70 g of filtered amino acids per day in a 70 kg man. Comparison of blood and urine amino acid levels and measurement of the creatinine excretion in a 24-hour urine sample can provide an excellent assessment of kidney function. High blood levels with low urine levels and a low 24-hour creatinine suggest subnormal renal clearance, while the opposite is seen in abnormally high renal clearance.

Functional Adequacy of Vitamins and Minerals
Because various vitamins and minerals are needed as cofactors in amino acid metabolism, abnormal patterns in blood or urine can provide telltale signs of functional deficiency of these nutrients. For example, levels of those amino acids subject to transamination can point to pyridoxal phosphate (vitamin B6) dysfunction. These include alpha-aminoadipic acid, alanine, aspartic acid, tyrosine, leucine, isoleucine, and valine. Similarly, magnesium serves as an enzyme activator in a number of reactions, and certain elevations and deficits can suggest a deficiency. Ethanolamine, for example, might be elevated, while phosphoethanolamine, downstream from the former, would be depressed. Phosphoserine might be high, and serine, low. Other nutritional cofactors involved in amino acid metabolism include thiamine, riboflavin, niacin, B12 and folate, zinc, and manganese.

Inflammation
Three amino acids are critical to antioxidant, anti-inflammatory functions: cysteine, glutathione, and taurine. Cysteine is considered to be the rate-limiting factor in the synthesis of the antioxidant tripeptide, glutathione (GSH). Functioning as a reducing agent to maintain other molecules in the reduced form, GSH is thought to be important during inflammatory response, influencing the production of phagocytes. A study of healthy human subjects revealed that persons with healthy intracellular GSH levels had significantly higher numbers of CD4+ T cells than those with reduced GSH levels, and a reduction in GSH levels to the suboptimal range resulted, on the average, in a 30% decrease in these T cells. The decrease was prevented by treatment with N-acetylcysteine.29 Decreased concentrations of cysteine have been reported in patients following severe trauma,30 and lower GSH levels have been associated with malignancy.31 Taurine acts as a specific scavenger for the hypochlorite ion (OCl−), which is generated in vivo during phagocytosis and oxidant response. The concentration of taurine is very high in polymorpho-nucleocytes (PMNs) which distribute hydrogen peroxide during the inflammatory response. Adequate taurine naturally limits the degree of inflammation and allows formation of stable chloroamines from excess OCl−. When taurine is low, the inflammatory response is enhanced and aldehydes may form, commonly resulting in aldehyde sensitivities and oxidative stress reactions, such as the modification of LDL cholesterol by malondialdehyde.32

Detoxification Impairment
Many amino acids, free or in peptide form, are involved in the body’s detoxification of endogenous and exogenous compounds. Included in this group are methionine, cysteine, glutathione, glutamine, glycine, alanine, aspartic acid, and taurine. Deficiencies in any of these can result in impaired Phase II conjugation reactions, an accumulation
of potentially toxic intermediates, and subsequent tissue damage. Subnormal blood or urine levels of these amino acids can imply impaired detoxification functions which can provoke neurological diseases, chemical intolerances, and chronic fatigue.33

Cardiovascular Disease
Impaired methionine metabolism, particularly the condition known as homocystinuria, has been found associated with coronary artery disease,34 peripheral and cerebral occlusive disease,35 myocardial infarction,36,37 and stroke.38 Homocysteine is an intermediate in the catabolism of methionine, and it can either be remethylated into methionine or broken down into cysteine. When the enzymes involved do not function properly, homocysteine can accumulate, which then contributes to oxidative damage of LDL cholesterol and the vascular endothelium. Vitamins B6, B12, folic acid, betaine, and serine are all essential to methionine catabolism; consequently, deficiencies in any of these nutrients may aggravate the condition. An oral challenge of L-methionine (25 mg/kg body weight) during the day of the urine collection is often utilized to rule out homocystinuria.

Neurological Dysfunction
Amino acids, such as tryptophan, phenylalanine, and methionine, can influence pain threshold, mood, and sleep patterns. Tryptophan is the precursor of serotonin, which influences sleep patterns and mood. Phenylalanine converts to the neurotransmitter tyrosine and to the adrenal catecholamine, norepinephrine (NE), both of which influence mood and behavior. Numerous studies suggest that NE inhibits the release of adrenocorticotropic hormone (ACTH) by suppressing corticotropic releasing factor (CRF) secretion in the hypothalamus. Pre-treatment with supplemental tyrosine appears to prevent the behavioral depression and hypothalamic NE depletion observed following an acute stress and to suppress the rise in plasma cortisol.39 Tyrosine’s impact on mood may be partly related to its function as precursor to the thyroid hormones thyroxin and triiodothyronine. The analgesic peptides, endorphins and enkephalins, are composed of amino acids; methionine enkephalin has an analgesic potency 20 times that of morphine. Catecholamines must be methylated by S-adenosylmethionine (SAM) for proper function; low levels of SAM have been observed in some cases of depression.40

Ammonia Toxicity
Whenever an amino acid is broken down, nitrogen is released, either as an amino group (-NH2) or as an ammonium ion (NH3+). Although nitrogen is essential to the body, an excess can form ammonia which is toxic to brain tissue. Resulting symptoms can include behavioral dysfunction, headaches, diarrhea, and CNS disturbances. Studies have noted a correlation between excessive body burden of ammonia and Alzheimer’s disease.41 Because alpha-ketoglutaric acid, important in the Citric Acid Cycle, is also a major ammonia scavenger in the body, excess ammonia may deplete alpha ketoglutarate in the Citric Acid Cycle, stalling energy transfer inside body cells.42 Ammonia is either transported to the liver where it is fixed as the nontoxic form urea in the urea cycle, or it is attached to the amino acid glutamate, forming glutamine. Glutamine can act as a nitrogen shuttle, removing nitrogen from the CNS. Impaired ammonia detoxification may be indicated by elevated glutamine, asparagine, alanine, or glycine, as well as by elevated urea cycle intermediates (arginine, citrulline, argininosuccinate, ornithine). Hyperammonemia may be confirmed with a blood (venous) ammonia determination.

Inborn Errors of Metabolism
More than 70 inherited amino acidopathies are now known, all falling into two general classes: enzymatic defects in amino acid catabolism and disorders of transmembrane transport. The catabolic defects far outnumber the transport abnormalities. Most of these disorders are rare, their incidences ranging from 1 in 12,000 for phenylketonuria (PKU) to 1 in 200,000 for alkaptonuria.43 However, mild (hidden) homocystinuria is much more common, with an incidence estimated at 1 in 70 to 1 in 200.44,45 In general, the various disorders are named for the compound which accumulates to highest concentration in blood or urine. Symptoms range from none to severe neurological dysfunction, and they are usually prevented or mitigated by appropriate dietary amino acid restriction or vitamin supplementation.
Although the finding of a homozygous error in metabolism is uncommon, it is Dr. Jon Pangborn's clinical observation that the frequency of occurrence is increased over the general population in individuals who present with food and chemical intolerances, chronic illnesses, and degenerative disease conditions. Heterozygous conditions, usually mild errors or impairments in amino acid metabolism or transport, are far more frequent. Mild cystinuria, a renal transport disorder, has been observed in allergy and may occur in the general population with an incidence of 1 in 400. This condition is usually accompanied by renal excretion of lysine, ornithine and arginine.

**Amino Acids Analysis**

The Amino Acids Analysis employs state-of-the-art high performance liquid chromatography (HPLC) to perform the most comprehensive and sensitive assay available for urine or plasma analytes. The measured analytes are grouped on the report into functional categories, including the nutritionally essential and semi-essential amino acids, dietary peptide-related analytes, the non-essential protein amino acids, and the intermediary metabolites, providing information on nutrient cofactor status and disorders relating to their imbalances. Commentary is thorough and takes into account patterns of amino acids associated with specific organ systems or problem areas. Both urine and plasma analyses include control measurements to monitor and alert to problems with sample quality or representativeness.

**Urine versus Plasma**

The body fluids that are most commonly assessed for amino acid content are urine from a 24-hour collection and plasma following an overnight fast. 24-hr urine amino acid measurements show what is high and what is low over a 24-hr period, provided that renal function is reasonably normal. In contrast, blood plasma amino acid measurements show the levels of amino acids that are being transported at a point in time. There are several advantages to starting with a 24-hour urine analysis. Urine analysis reveals more distinctive patterns related to problems in enzymatic activity, nutrient cofactor adequacy, and transport. Urine is also not subject to the circadian rhythm variation in amino acids that is present in blood, and excesses or deficiencies over a period of time can be more easily assessed. Many conditions of amino acid wasting, e.g. cystinuria, are thus identifiable in urine samples. Due to renal conservation of amino acids, urine levels typically drop before plasma levels. For these reasons, a 24-hour urine is more likely to reveal marginal deficiencies. Only severe deficiencies will result in low values on both tests.

Plasma amino acids analysis may be preferred when age, toilet training, behavior, or patient cooperation present as complicating factors. Other possible reasons for selecting plasma analysis include severe malnutrition, anorexia, hematuria conditions.
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including menstruation), and rheumatoid arthritis, where the common pattern of low histidine only shows in a plasma sample. If poor renal clearance or renal failure is known beforehand, a blood plasma analysis is recommended. Also, in urinary wasting conditions or in nephrotic syndromes, the plasma levels are indicative of status while the urine levels serve to confirm the diagnosis.

For plasma sampling, an overnight, fasting measurement is conventional practice. Such sampling reduces dietary influences and accentuates metabolic status.

A comprehensive workup to assess the gross metabolic state would include both urine and plasma analyses, measured in the same time period, particularly for the patient with degenerative disease or with severe intolerances to foods or environmental substances. If a choice must be made because of cost or other factors, urine is preferred.

Amino Acids Therapies

The Amino Acids Analysis report includes a suggested schedule of amino acid supplements, based upon measured levels in blood plasma or urine. These levels are calculated based upon the measured level versus the reference range, the individual's age and sex, and a human needs tabulation derived from the National Research Council's table of amino acids requirements. Such supplements are to be prescribed by the practitioner, formulated and packaged by a qualified pharmacy, and taken orally by the patient.

Conclusion

Amino acids form the basic constituents of every living cell, and participate in myriad biochemical reactions in the body. Significant progress in amino acid research now provides practitioners with a wealth of information on amino acid imbalances and related symptomatology. With such advances in amino acid research, information can now be gleaned about protein and nutrient cofactor adequacy, enzyme functionality, predisposition to various degenerative disorders, wasting syndromes, gastrointestinal dysfunction, neurological disorders, impairments in detoxification, inborn errors of metabolism, and a wide array of clinical conditions. Results can be utilized in the design of specific replacement therapy, aimed at restoring balance where it is needed. Amino Acids Analysis should be considered whenever a thorough nutritional assessment is desired.

Related Tests to Consider

Comprehensive Digestive Stool Analysis (CDSA) and Intestinal Permeability:

Certain patterns of amino acids may suggest maldigestion, dysbiosis, or leaky gut. Subnormal levels of nutritionally essential amino acids, particularly the branched-chain amino acids leucine, isoleucine, and valine, and/or increased levels of the peptides, anserine and carnosine, can alert the health care practitioner to the possibility of maldigestion and/or malabsorption. “Leaky gut” is commonly associated with this picture. Irritation of the mucosal lining, apparent in inflammatory bowel disease, may be reflected in an elevated hydroxyproline, a marker for cell turnover. A CDSA in such cases may serve to confirm digestive or absorptive impairments, as well as reveal complications resulting from them, such as dysbiosis, infection, or reduced immune function. An Intestinal Permeability test may further reveal malabsorption or a “leaky gut” resulting from these imbalances.

Some amino acids that are intermediates in human metabolism are also intermediate or end products of microbial metabolism. Elevations of GABA, alpha-aminoadipic acid, beta-alanine, and others may be consistent with gut dysbiosis.

Detoxification Profile/Oxidative Stress:

Subnormal levels of amino acids involved in the body’s detoxification processes can indicate impairments in this area. Phase II conjugation reactions, as well as antioxidant activity, are extremely dependent on the availability of amino acid precursors, particularly the sulfur-bearing amino acids such as methionine, cysteine, glutathione, and taurine. Inadequate reserves can result in poor clearance of xenobiotics and endogenous compounds, as well as oxidative stress. Any system may be impacted, from the mitochondria and cell membranes to the neurological and immune systems. An Oxidative Stress or Comprehensive Detoxification Profile (including markers for oxidative stress) can help determine detoxification capacity, specific imbalances, and free radical damage, so that specific nutritional support may be selected.
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Elemental Analysis:
Several patterns in the Amino Acids Analysis are suggestive of mineral imbalances which may be further elucidated by Elemental Analysis, a profile of nutrient and toxic elements. Magnesium insufficiency, for example, may be suggested by high levels of ethanolamine, phosphoserine, and citrulline, and low levels of their downstream metabolites, phosphoethanolamine, serine, and argininosuccinic acid, respectively. Elevated ammonia may suggest insufficient manganese and/or aluminum toxicity. Patterns suggestive of maldigestion and malabsorption should alert the physician to the possibility of broad spectrum nutrient insufficiencies, along with the need for further investigation.

Comprehensive Cardiovascular Assessment
Proper methionine metabolism is imperative for proper cardiovascular function. Abnormal levels of related amino acids, particularly elevated homocysteine and subnormal taurine, have been noted in atherosclerosis and other cardiovascular disorders. When either of these imbalances are apparent in the Amino Acids Analysis, or when the pattern of amino acids suggests low magnesium, a thorough cardiovascular assessment is recommended in order to determine additional CV abnormalities and appropriate intervention. The Comprehensive Cardiovascular Assessment identifies ten markers associated with development of cardiovascular disease.

Bone Resorption Assessment
Osteoporosis is an insidious process which is usually not evident until a fracture has finally occurred, typically after significant bone calcium has already been lost. Several amino acid markers can help alert the physician to increased likelihood of the disorder, including elevated homocysteine, deficient cystathionine, and elevated hydroxyproline. Excess homocysteine can interfere with proper crosslinking of collagen, including that of bone; elevated levels of the amino acid have been noted in osteoporotic individuals. Elevated hydroxyproline may also imply increased resorption, especially if accompanied by other allusive markers. As proper mineral nutrition is essential to bone health, patterns of amino acids suggestive of maldigestion, malabsorption, or mineral insufficiencies may suggest inadequate reserves for the maintenance of healthy bones. The Bone Resorption Assessment can help determine the rate of current bone loss and monitor the efficacy of therapeutic intervention.

Therapeutic Uses of Amino Acids

| Alanine, Glycine, and Glutamic Acid: | Benign prostatic hypertrophy,47,48 |
| Arginine: | Wound healing,49 infertility,50 heart attack and stroke prevention,51 hypertension,52 chronic fatigue, especially muscular fatigue with myalgia.53 |
| Cysteine, N-Acetylcysteine (NAC), or Glutathione: | Intolerance to xenobiotics, detoxification impairments,54 free radical-associated disorders,55 pulmonary conditions,56 AIDS.57 |
| Glutamine: | GI repair,58 total parenteral nutrition (TPN),59 wasting disorders,60 immune support,61 chemotherapy side effects,62 surgery,63 burns,64 alcoholism.65 |
| Histidine: | Rheumatoid arthritis.66 |
| Leucine, isoleucine, and valine: | Alcoholism,67 surgery, starvation, or infection,68 muscle building,69 TPN.70 |
| Lysine: | Herpes simplex (HSV-1, HSV-2).71 |
| Phenylalanine, tyrosine: | Depression,72 Parkinson’s disease,73 pain,74 vitiligo.75 |
| S-Adenosylmethionine (SAM): | Depression,76 osteoarthritis,77 fibromyalgia,78 liver disorders,79 |
| Taurine: | Intolerance to chlorine, hypochlorite (bleach), phenols, nitrates, amines, or aldehydes,80-82 fat malabsorption in cystic fibrosis,83 seizures,84 eye disorders,85 gallbladder disease,86 heart disease,87 alcoholism.87 |
| Tryptophan: | Insomnia, depression,88 restless leg syndrome,89 alcoholism,90 weight control,91 Parkinson’s disease.92 |

How do I order this test?
For Amino Acids Analysis kits or information, please call a GSDL Accounts Receivable representative at 888-201-8333 or use our secure web contact center at www.gsdl.com/billing.
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