



Metabolic Analysis Profile

Why is this test important?

This profile measures 39 organic acids that play a role in four critical areas: gastrointestinal function and dysbiosis, cellular and mitochondrial energy metabolism, neurotransmitter metabolism, and nutritional assessment of vitamins and minerals that serve as critical enzyme cofactors. Test results allow practitioners to design comprehensive, customized therapies to restore optimal metabolic health.

What does this test involve?

All markers are measured in a single morning urine specimen and ratioed to creatinine. The test report includes an in-depth interpretation for abnormal results with a list of possible remedial nutrients. Reference ranges are available for children (ages 2-12) as well as adults.

What are the consequences of metabolic imbalances?

Chronic malabsorption can contribute to gastrointestinal distress, nutrient insufficiencies, and dysbiosis (disrupted flora balance). Chronic dysbiosis, in turn, may result in local inflammatory reactions, increased risk of colorectal cancer, or gut hyperpermeability with subsequent translocation of toxins and macromolecules into the body.

Imbalances in serotonergic or adrenergic function are frequently associated with neuropsychiatric disorders, insomnia, inability to manage stress, eating disorders, fatigue, or irritable bowel syndrome. Imbalances may also suggest nutrient insufficiencies or methylation impairments that impact multiple systems in the body.

The Citric Acid Cycle supplies the body with its primary energy needs. Glycolysis, glycogenolysis, and beta-oxidation of fats provide precursors for this cycle. Blocks in the citric acid cycle or impairments in any of these processes may lead to chronic fatigue, muscle pain and fatigue, accelerated cell breakdown, and unhealthy aging.

Because enzyme cofactors are involved in virtually every system in the body, insufficiencies in these vitamins or minerals can affect a wide range of functions, including immunologic, endocrine, musculoskeletal, and metabolic.

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Malabsorption & Dysbiosis Markers

Analyte	Result	Suspect	Consider
Arabinose <i>(Breakdown product of hyaluronic acid, also contained in certain foods)</i>	High	<ul style="list-style-type: none"> • Ingestion of arabinose-rich foods (apples, plums, cherries, grapes); OR possible joint inflammation (leading to release of hyaluronic acid) • Yeast overgrowth 	<ul style="list-style-type: none"> • Rule out arabinose-containing foods • Address any joint inflammation • Anti-yeast diet • Probiotics • Anti-fungals
Benzoic/Hippuric Acids Ratio <i>(Benzoate is metabolized in Phase II glycine conjugation to hippurate. Enzymes from gut bacteria may reverse this process, producing high benzoic acid)</i>	High	<ul style="list-style-type: none"> • Intestinal dysbiosis, ingestion of benzoic acid before testing 	<i>Consider</i> <ul style="list-style-type: none"> • Rule out high-benzoate foods (e.g., plums, prunes, rhubarb, cranberries, preservative in foods); probiotics, possible antimicrobials (check Bacterial Dysbiosis Marker)
Citramalic Acid <i>(Metabolite of yeast or anaerobic bacteria, including Clostridia)</i>	High	<ul style="list-style-type: none"> • Yeast or anaerobic bacterial overgrowth 	<ul style="list-style-type: none"> • Antifungals or antimicrobials (look at other markers), anti-yeast diet, probiotics
Dihydroxyphenylpropionic Acid (DHPPA) <i>(Produced when Clostridia acts upon unabsorbed tryptophan, tyrosine, or phenylalanine)</i>	High	<ul style="list-style-type: none"> • Clostridium overgrowth AND/OR malabsorption of tryptophan, tyrosine &/or phenylalanine 	<ul style="list-style-type: none"> • Antimicrobials, probiotics; investigate possible causes of malabsorption (Gluten sensitivity? Food allergy? Bacterial overgrowth in small bowel?, etc); mucosal support agents • S. boulardii
Indoleacetic Acid (IAA) <i>(Produced from bacterial degradation of unabsorbed tryptophan)</i>	High	<ul style="list-style-type: none"> • Malabsorption of tryptophan, possible gastric hypochlorhydria 	<i>Consider</i> <ul style="list-style-type: none"> • Investigate possible causes of malabsorption (Gluten sensitivity? Food allergy? Bacterial overgrowth in small bowel?, etc); consider mucosal support agents, betaine HCl
Phenylacetic Acid (PAA) <i>(Produced from bacterial degradation of unabsorbed phenylalanine)</i>	High	<ul style="list-style-type: none"> • Malabsorption of phenylalanine, possible gastric hypochlorhydria and/or Clostridia overgrowth 	<i>Consider</i> <ul style="list-style-type: none"> • Investigate possible causes of malabsorption (Gluten sensitivity? Food allergy? Bacterial overgrowth in small bowel?, etc); consider mucosal support agents, betaine HCl
Succinic Acid <i>(Produced from bacterial degradation of unabsorbed glutamine; also Citric Acid Cycle intermediate)</i>	High	<ul style="list-style-type: none"> • Bacterial degradation of glutamine (e.g., dysbiosis or UTI); OR insufficiencies of Fe or B2 (as FAD) (metabolism in Citric Acid Cycle) 	<i>Consider</i> <ul style="list-style-type: none"> • Correct malabsorption, dysbiosis, or UTI (Gluten sensitivity? Food allergy? Bacterial overgrowth in small bowel?, etc); mucosal support agents, iron and/or riboflavin
Tartaric Acid <i>(Breakdown product of hyaluronic acid, also contained in some foods)</i>	High	<ul style="list-style-type: none"> • Ingestion of tartaric acid-containing foods (fruits, especially grapes, raisins, or wine; also as "cream of tartar" in some soft drinks and baked goods; OR possible joint inflammation (leading to release of hyaluronic acid) • Yeast overgrowth 	<i>Consider</i> <ul style="list-style-type: none"> • Rule out tartaric acid-containing foods • Address any joint inflammation

Neurotransmitter Metabolites

Catecholamine Metabolites	Result	Suspect	Consider
Homovanillic Acid (HVA) (HVA = dopamine metabolite)	High	<ul style="list-style-type: none"> Increased catecholamine activity / stress pattern; OR pheochromocytoma; OR impaired production of norepinephrine from dopamine 	<ul style="list-style-type: none"> Stress management, adrenal support
	Low	<ul style="list-style-type: none"> Possible low precursors or neurotransmitters (phenylalanine, dopamine, DOPA, norepinephrine); possible low cofactors (B2, B3, B6, Mg, or Fe); possible impaired methylation 	<ul style="list-style-type: none"> L-tyrosine & B6, generally good response to NE reuptake inhibitors (e.g., imipramine); consider B2, B3 or Fe (if low); support methylation (methionine or SAME, B6, B12, folate, Mg)
Vanilmandelic Acid (VMA) (VMA = norepinephrine metabolite)	High	<ul style="list-style-type: none"> Increased catecholamine activity / stress pattern; OR pheochromocytoma; OR possible deficient CNS dopamine receptors; OR oxidant stress (if MHPG is normal or low) 	<ul style="list-style-type: none"> Stress management, adrenal support
	Low	<ul style="list-style-type: none"> Possible low precursors or neurotransmitters (phenylalanine, dopamine, DOPA, norepinephrine); possible low cofactors (B2, B6, Mo, Cu, or Fe); possible impaired methylation (if MHPG also low) 	<ul style="list-style-type: none"> L-tyrosine & B6; generally good response to norepinephrine reuptake inhibitors (e.g., imipramine); consider B2, Mo, Cu or Fe (if low); support methylation (methionine or SAME, B6, B12, folate, Mg)
3-methyl-4-OH-phenylglycol (MHPG) (MHPG = norepinephrine metabolite)	High	<ul style="list-style-type: none"> Increased catecholamine activity / stress pattern; OR pheochromocytoma; OR possible deficient CNS dopamine receptors 	<ul style="list-style-type: none"> Stress management, adrenal support
	Low	<ul style="list-style-type: none"> Possible low precursors or neurotransmitters (phenylalanine, dopamine, DOPA, norepinephrine); possibly low cofactors (B2, B3, B6, Cu, ascorbic acid); possible impaired methylation (if VMA also low) 	<ul style="list-style-type: none"> L-tyrosine & B6; generally good response to norepinephrine reuptake inhibitors (e.g., imipramine); support methylation (methionine or SAME, B6, B12, folate, Mg); consider B2, B3, Cu, ascorbic acid
Serotonin Metabolites 5-OH-indoleacetic acid (5-HIAA) (Serotonin metabolite)	High	<ul style="list-style-type: none"> Increased release of serotonin from gut (possible diarrhea-predominant IBS), platelets, or CNS (including use of SSRIs); OR carcinoid tumor (if extremely elevated) 	<ul style="list-style-type: none"> Rule out gut-associated food reactions (if IBS), consider tryptophan-rich foods or 5-HTP and B6 (tryptophan may become deficient over time)
	Low	<ul style="list-style-type: none"> Serotonin insufficiency 	<ul style="list-style-type: none"> Tryptophan-rich foods or 5-HTP and B6; generally positive response to SSRI antidepressants

Cellular Energy and Mitochondrial Metabolites

Glycolysis Metabolites	Result	Suspect	Consider
Lactic Acid <i>(Formed from pyruvate when hypoxia, recycled to pyruvate via zinc and O₂; serves as a “sink” for pyruvic acid when high)</i>	High	<ul style="list-style-type: none"> Hypoxia and/or zinc deficiency; OR metabolic stress (e.g. alcohol, toxic chemical exposure, or anemia); OR possibly insignificant when pyruvic acid is also high 	<ul style="list-style-type: none"> (If pyruvate NOT high) – Correct hypoxia; remove metabolic stress; correct anemia; zinc, possible CoQ10, vitamins B2, B3
	Low	<ul style="list-style-type: none"> Insignificant (see Pyruvic Acid) 	<ul style="list-style-type: none"> (If pyruvate also high) – (see “Pyruvic Acid”)
Glycolysis Metabolites	Result	Suspect	Consider
Pyruvic Acid <i>(Feeds into Citric Acid Cycle, converts to acetyl CoA; pyruvate is formed from carbohydrate via glucose or glycogen, and secondarily from fats (glycerol) and glycolytic amino acids)</i>	High	<ul style="list-style-type: none"> Impaired metabolism due to cofactor insufficiencies OR toxic metals (As, Hg, Sb, Cd); OR muscle injury; OR severe adrenal insufficiency (impaired conversion of pyruvate to alanine) 	<ul style="list-style-type: none"> Supplement cofactors (vitamins B1, B2, B3, B5, Mg, cysteine, or lipoic acid); remove toxic metals (As, Hg, Sb, Cd); rule out adrenal insufficiency
	Low	<ul style="list-style-type: none"> Deficient substrate for energy production / impaired production from glycogen (glycogenolysis), carbohydrates (glycolysis), or proteins (gluconeogenesis) 	<ul style="list-style-type: none"> Gluconeogenic amino acids (e.g., L-alanine, glycine, L-serine); vitamin B6, Mg; correct glucose/insulin imbalances; rule out adrenal insufficiency; consider Ca pyruvate supplementation
Citric Acid Cycle Metabolites	Result	Suspect	Consider
Citric Acid or Cis-aconitic Acid <i>(Metabolites of acetyl CoA, precursors of isocitric acid)</i>	High	<ul style="list-style-type: none"> Impaired metabolism due to toxic metals (Fl, Hg, As, Sb) OR low cofactors (Fe, GSH—depleted in oxidative stress); OR high amounts of dietary citric acid; OR metabolic acidosis (if mildly increased cis-aconitic acid but markedly increased citric acid) 	<ul style="list-style-type: none"> Rule out toxic metals; glutathione, N-acetylcysteine, Mg, or L-glutamine; consider anti-oxidants; rule out pancreatic insufficiency (can lead to metabolic acidosis from deficient bicarbonate)
	Low	<ul style="list-style-type: none"> Low or high pyruvic acid or low acetyl CoA (from fatty acid oxidation) 	<ul style="list-style-type: none"> (See notes for Pyruvic Acid)
Citric Acid Cycle Metabolites	Result	Suspect	Consider
Isocitric Acid <i>(Metabolite of cis-aconitic acid, precursor of alpha-ketoglutaric acid)</i>	High	<ul style="list-style-type: none"> Impaired metabolism due to low cofactors (B3, Mg, Mn) or inhibition by aluminum 	<ul style="list-style-type: none"> Rule out Al toxicity; consider vitamin B3, Mg, Mn supplementation
	Low	<ul style="list-style-type: none"> 2° to subnormal upstream metabolites; OR same causes of high cis-aconitic acid 	<ul style="list-style-type: none"> (See notes for high Cis-Aconitic acid)
Citric Acid Cycle Metabolites	Result	Suspect	Consider
Alpha-ketoglutaric Acid (AKA) <i>(Metabolite of isocitric acid, also glutamate; precursor of succinic acid)</i>	High	<ul style="list-style-type: none"> Impaired metabolism due to cofactor deficiencies OR toxic metals (As, Hg, Sb, Cd) (esp. if pyruvate is also high); OR possible inhibition by beta-ketoglutaric acid from yeast (see GI section) 	<ul style="list-style-type: none"> Supplement cofactors (vitamins B1, B2, B3, B5, Mg, lipoic acid); remove toxic metals (As, Hg, Sb, Cd); OR correct yeast overgrowth (see GI section)
	Low	<ul style="list-style-type: none"> Secondary to subnormal upstream metabolites; OR low amounts of other precursors 	<ul style="list-style-type: none"> Consider alpha-ketoglutarate supplementation

Citric Acid Cycle Metabolites	Result	Suspect	Consider
Succinic Acid (Metabolite of alpha-ketoglutarate, also methionine, valine, & leucine; precursor of fumaric acid; also formed from bacterial action on glutamine)	High	<ul style="list-style-type: none"> Impaired metabolism due to low cofactors (Fe or B2); OR bacterial degradation of glutamine (e.g., dysbiosis or UTI, malabsorption &/or glutamine excess) 	<ul style="list-style-type: none"> Supplement riboflavin and/or iron (if low); correct malabsorption, dysbiosis, or UTI; mucosal support agents No further action necessary

Citric Acid Cycle Metabolites	Result	Suspect	Consider
Fumaric Acid (Metabolite of succinic acid, precursor of malic acid); also produced during urea cycle and formed from phenylalanine and tyrosine)	High	<ul style="list-style-type: none"> Impaired metabolism due to low B3; OR may be secondary to high pyruvate or lactate; OR may result from yeast overgrowth 	<ul style="list-style-type: none"> Consider vitamin B3 supplementation, unless secondary to high pyruvate or lactate; rule out yeast overgrowth

Citric Acid Cycle Metabolites	Result	Suspect	Consider
Malic Acid (Metabolite of fumaric acid, precursor of oxaloacetic acid; also helps NADH enter mitochondria)	High	<ul style="list-style-type: none"> Impaired metabolism due to low B3; OR ingestion of L-malic acid or DL-malic acid (the latter interferes with its own metabolism); OR may be secondary to high pyruvate; OR may result from yeast overgrowth 	<ul style="list-style-type: none"> Consider vitamin B3 supplementation, unless secondary to high pyruvate; change from "DL" to "L" form of malic acid; rule out yeast overgrowth

Very low normal • May be secondary to low fumaric acid

Ketones & Fatty Acid Metabolites	Result	Suspect	Consider
Adipic Acid or Suberic Acid (Formed from "omega" oxidation of fats when beta oxidation is impaired)	High	<ul style="list-style-type: none"> Impaired mitochondrial beta oxidation of fats; may be secondary to insufficient carnitine, B2, or acetyl CoA, or to insulin excess; OR may be secondary to ketosis 	<ul style="list-style-type: none"> Consider L-carnitine or acetyl-L-carnitine, riboflavin, acetyl CoA precursors (cysteine, B5, Mg)

Ketones & Fatty Acid Metabolites	Result	Suspect	Consider
Beta-hydroxy-beta-methylglutaric Acid (HMG) (Formed from acetyl CoA, precursor of cholesterol and CoQ10)	High	<ul style="list-style-type: none"> Citric acid cycle impairment (anaerobic glycolysis); OR carbohydrate unavailability (e.g., high-protein diet, fasting, diabetes); OR inhibited utilization of HMG (e.g., from high cholesterol diet, yeast overgrowth, glucocorticoid excess, statins) 	<ul style="list-style-type: none"> Identify and correct specific underlying imbalance (e.g., remove yeast overgrowth, reduce dietary cholesterol, remove blocks in citric acid cycle)

Ketones & Fatty Acid Metabolites	Result	Suspect	Consider
Beta-hydroxybutyric Acid (BHBA) (Ketone formed from acetyl CoA)	High	<ul style="list-style-type: none"> Ketosis from carbohydrate unavailability (e.g., fasting, diabetes, strenuous exercise, ketogenic diet) 	<ul style="list-style-type: none"> (See comments above for HMG)

Markers for Cofactor Need

Analyte	Result	Suspect	Consider
Alpha-ketoisovaleric Acid or Alpha-ketoisocaproic Acid or Alpha-keto-beta-methylvaline Acid <i>(Metabolites of valine, leucine, & isoleucine, respectively)</i>	High	<ul style="list-style-type: none"> Impaired metabolism due to cofactor insufficiencies or toxic metals; OR "maple syrup urine disease" (if markedly elevated) 	Supplement cofactors (vitamins B1, B2, B3, B5, Mg, cysteine, or lipoic acid); remove toxic metals (As, Hg, Sb, Cd)
	Very low normal	<ul style="list-style-type: none"> Possible low B6; OR secondary to low branched-chain amino acids 	Supplement B6

Analyte	Result	Suspect	Consider
Kynurenic Acid <i>(Made from tryptophan when tryptophan's metabolism to nicotinic and picolinic acids is impaired)</i>	High	<ul style="list-style-type: none"> Low B6; may also indicate low vitamin B3 and/or picolinic acid 	Supplement vitamin B6, possibly also B3 and picolinic acid

Analyte	Result	Suspect	Consider
Formiminoglutamic Acid (FIGLU) <i>(Metabolite of histidine, precursor of glutamic acid via folate)</i>	High	<ul style="list-style-type: none"> Impaired metabolism due to low folate or disordered folate metabolism; may be consistent with impaired methylation and/or high homocysteine; OR may reflect "methyl trap" due to low B12 (compromised recycling of tetrahydrofolate); OR may result from excessive histidine supplementation 	Supplement folic acid; rule out low B12 (consider supplementing with B12, methylcobalamin, or folinic acid)

Analyte	Result	Suspect	Consider
3-hydroxypropionic Acid (3-HPA) <i>(Metabolite of propionic acid, precursor of methylmalonic acid via biotin and Mg)</i>	High	<ul style="list-style-type: none"> Low B12 (methylmalonic acid will also be high); OR low biotin &/or magnesium; inborn errors of metabolism (see report commentary) 	Supplement vitamin B12, biotin, and/or magnesium
	Very low normal	<ul style="list-style-type: none"> Amino acid insufficiencies (methionine, valine, isoleucine, or threonine); OR deficient gut bacteria (3-HPA also produced from gut fermentation); OR impaired beta oxidation of fat (will see high Adipic or Suberic Acid) 	Increase dietary amino acids; OR probiotics, prebiotics, fiber

Analyte	Result	Suspect	Consider
Methylmalonic Acid (MMA) <i>(Metabolite of 3-HPA, precursor of succinyl CoA via B12)</i>	High	<ul style="list-style-type: none"> Low vitamin B12; possibly low glutathione (GSH is required for B12 production) 	Supplement vitamin B12; check pyroglutamic acid level, follow guidelines if high

Analyte	Result	Suspect	Consider
2-hydroxyphenylacetic Acid (2-HPAA) <i>(Metabolite of phenylalanine via phenylpyruvate)</i>	High	<ul style="list-style-type: none"> Excessive phenylalanine (dietary or PKU) or tyrosine; OR reduced oxygenation (e.g., iron deficiency anemia, pulmonary disorder); OR low tetrahydrobiopterin (BH4), which may result in low neurotransmitters and/or nitric oxide 	Amino Acid Analysis is recommended to rule out excessive phenylalanine &/or tyrosine. Correct oxygenation if relevant. Supplement vitamin C (increases BH4 levels in body). 5-MTHF (from folic acid) may help nitric oxide production when BH4 is low

Analyte	Result	Suspect	Consider
4-hydroxyphenylpyruvic Acid (4-HPPA) (Metabolite of tyrosine, precursor of homogentisic acid)	High	<ul style="list-style-type: none"> Impaired metabolism to homogentisic acid due to cofactor insufficiencies (copper, vitamin C, O₂); OR possible low iron (if homogentisic acid is markedly elevated); 	<ul style="list-style-type: none"> Supplement vitamin C or Cu, improve oxygenation (e.g., correct anemia, pulmonary problems, cardiac insufficiency, etc.)
Homogentisic Acid (Metabolite of 4-HPPA)	High	<ul style="list-style-type: none"> Impaired metabolism due to cofactor insufficiency (iron, vitamin C, O₂); OR alkaptonuria (rare) 	<ul style="list-style-type: none"> Supplement iron (if low), vitamin C, improve oxygenation Consider NAC to protect enzyme
Alpha-ketoadipic Acid (AKAA) (Made from tryptophan and lysine via alpha-aminoadipic acid, also a byproduct of yeast; precursor of glutaric acid)	High	<ul style="list-style-type: none"> May be secondary to high glutaric acid (check glutaric level); OR impaired metabolism due to cofactor insufficiencies OR toxic metals (As, Hg, Sb, Cd); OR may be secondary to yeast or fungal infection (derives from alpha-aminoadipic acid)—see yeast markers 	<ul style="list-style-type: none"> Supplement cofactors (vitamins B1, B2, B3, B5, Mg, cysteine, or lipoic acid); remove toxic metals (As, Hg, Sb, Cd) Antifungals, anti-yeast diet, probiotics, if relevant
Glutaric Acid (Made from lysine and tryptophan via alpha-ketoadipic acid)	High	<ul style="list-style-type: none"> Possible low FAD (riboflavin) (cofactor for alternative metabolism of one of glutaric acid's precursors); OR inborn error of metabolism (see report commentary); may be associated with CETP genetic polymorphism 	<ul style="list-style-type: none"> Supplement vitamin B2, consider mitochondrial support nutrients (e.g. CoQ10)
Orotic Acid (Metabolite of aspartic acid, precursor of pyrimidines)	High	<ul style="list-style-type: none"> Possible liver damage (e.g., from alcohol), urea cycle dysfunction, ammonia excess OR; barbiturates; OR impaired metabolism due to cofactor insufficiencies (vitamins B3, B6, folate, Mg, glutamine, glycine, serine); OR use of allopurinol or chemotherapy 	<ul style="list-style-type: none"> Supplement vitamins B3, B6, folic acid, Mg, glutamine, glycine, serine Consider alpha-ketoglutarate and arginine for ammonia excess, support liver
Pyroglutamic Acid (Intermediate in the recycling of glutathione)	High	<ul style="list-style-type: none"> Impaired recycling to glutathione due to cofactor insufficiencies (Mg, cysteine, glycine, glutamic acid); consistent with deficient GSH 	<ul style="list-style-type: none"> Supplement Mg, N-acetylcysteine (NAC), possible glycine, L-glutamine, &/or GSH
	Low	<ul style="list-style-type: none"> Low glutathione (insufficient precursors, toxicity, or oxidant stress) 	<ul style="list-style-type: none"> Supplement NAC, possible Mg, glycine, L-glutamine, &/or GSH Identify and correct toxicity

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