

Nutritional Agents that Support Anabolic Metabolism and Build Cellular Energy (ATP)

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Discussion

The nutritional agents described in this paper provide nutritional support for recovery from the degenerative, catabolic effects of aging, intense physical exercise, surgery, or chronic disease. These vital nutrients enhance the body's ability to overcome the deleterious effects of many types of stress. When delivered in highly bioavailable forms, these nutrients enhance the Krebs cycle, facilitating cellular metabolism and the production of ATP (adenine tri-phosphate) – even under high work or stress loads. This also facilitates recovery from extreme stress or weakness in which the processes of absorption and assimilation are often diminished.

Performance athletes find that these nutrient compounds help them achieve top performance, maintain lean muscle mass and stay healthy while working at high capacity levels of energy output that require great endurance, stamina and quick recovery time. These natural compounds help the body clear lactic acid – recycling ATP and protecting cells from oxidative stress during periods of high-intensity workouts. Through enhancing ATP production, these nutrients support sustained energy and optimizes recovery time, while also supporting the body's natural ability to synthesize protein, which enhances lean muscle mass.

These same benefits apply to supporting elderly people or people of any age dealing with frailty syndromes, cachexia or sarcopenia. These are complex syndromes that can respond to herbal and nutritional anabolic support. The decline of muscle mass referred to as sarcopenia is one of the most relevant biomarkers of aging and is correlated with loss of skeletal density. Research suggests that even small losses of muscle mass over time can result in greater risk for later-stage chronic disease and premature aging.¹⁻³

CELLULAR ENERGY TRANSFER AND THE MITOCHONDRIA

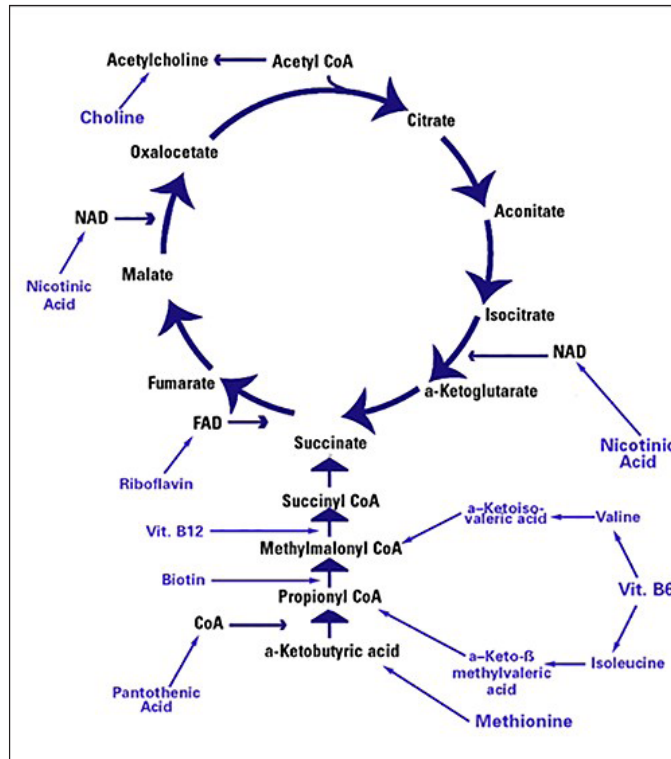
The efficiency of cellular energy transfer in our cellular mitochondria is vital for cellular function and maintenance. It governs physiological function and is critical for detoxification, growth of lean muscle and the maintenance of proper immune function. Many pathways support the proper functioning of cellular energy transfer and manufacture of ATP, including oxidative phosphorylation, the electron transport chain, and the Krebs cycle. The bioavailable nutrients outlined in this paper support the proper functioning of these three metabolic systems, protect the mitochondria from oxidative damage and enhance mitochondrial production of ATP.

There is a great deal of research showing a clear link between mitochondrial dysfunction and insulin resistance, sarcopenia, fatigue, obesity and other age-related conditions. Diminished mitochondrial capacity and the development of sarcopenia are hallmarks of biological aging.⁴⁻⁶

IMMUNONUTRITION

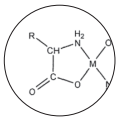
Since nutritional status is a determining factor in immune response, there is a large body of research on the role of nutrients in immune function. Specific branched chain amino acids (BCAAs), vitamins and minerals are recognized for their capacity to enhance healthy immune response. Adequate intake of high-quality absorbable protein is essential for optimum immune function. A stressed immune system generates a massive amount of free radicals to kill bacteria, fungus and other pathogens. Prolonged immune system activation generates free radical damage which contributes to hormonal and immune system weakness and promotes inflammation. Nutritional support with specific high-quality nutrients can aid cellular metabolism, modulate healthy anabolic/catabolic response, increase mitochondrial health and energy production and optimize immune function.⁷





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Nutritional Agents for Anabolic Support



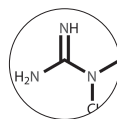
Magnesium Chelates

Magnesium, a vital mineral, is a cofactor in over 350 enzymatic reactions in human physiology, most of which are related to energy metabolism. As the second most abundant intracellular cation in the body (after potassium) it is vital to multiple cellular functions and metabolic pathways. About 99% of the body's magnesium is in the form of an intracellular cation. About 66% is in the bones, and about 33% is distributed in the cardiac and skeletal muscles and in the liver.⁸

Magnesium is a key major mineral necessary for bone and muscle strength, heart health, central nervous system function, correct assimilation of calcium and potassium and efficient enzymatic function. Magnesium is essential for neuromuscular activity, muscular relaxation and strength. A contributing factor to heart muscle strength, it supports a regular heartbeat.⁸⁻¹⁰

Magnesium influences protein, lipid and carbohydrate synthesis and influences bone strength. It facilitates

assimilation of calcium and potassium and enhances cellular energy production through carbohydrate and protein metabolism. Magnesium influences mitochondria, membrane receptors and enzymes. It plays a major role in ATP synthesis and exerts a regulatory role in energy (ATP) metabolism.⁸⁻¹⁰



Creatine Magnesium Chelate

Creatine magnesium chelate (CMC) benefits synthesis, exerts a positive anabolic influence and facilitates muscular hydration and endurance. It is recognized for its benefits in sports nutrition, healthy aging and cardiovascular health.

Creatine, an essential compound in physiological function, plays a key role in energy metabolism where it regenerates ATP and helps supply energy to muscles. Naturally synthesized in the body from the amino acids glycine, arginine and methionine, creatine increases muscle growth, strength and endurance. It is found to increase muscle creatine and phosphocreatine and to create a higher rate

of ATP resynthesis. This results in delayed onset of muscle fatigue and facilitates rapid recovery during repeated rounds of high intensity exercise.¹¹⁻¹⁶

Sports Nutrition: Enhances Endurance, Strength-Training and Anabolic Reserve

In a placebo controlled trial, CMC was compared to creatine monohydrate and placebo. CMC was found significantly superior to creatine monohydrate in enhancing performance and recovery.¹⁷ Magnesium creatine chelate supplementation was found to allow runners to exercise longer before reaching exhaustion, as compared to the control group.¹⁸

Researchers find creatine supports recovery and endurance in high-performance endurance and strength-training athletes. Studies report that those supplementing with creatine as compared to placebo showed greater strength gains during resistance training, with increases in endurance and muscle mass. Creatine supplementation is found to help reduce muscle fatigue.¹⁹⁻²⁴

Cardiac and Cardiovascular Health

Human studies report that creatine enhances cardiac and cardiovascular health. Creatine is found to improve cardiac function with an overall better force of heart contraction and a more complete output of blood from the heart. Studies report it enhances recovery and helps improve heart function after chronic heart failure.^{23,25,26}

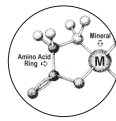
Healthy Aging and Chronic Conditions

In the field of sports nutrition, creatine is recognized for its benefits to enhance exercise tolerance, increase muscle strength and promote lean muscle mass. These benefits extend to the elderly and to those with chronic conditions where it is found to benefit people with myopathies, neurodegenerative disorders, rheumatic disorders and type 2 diabetes.²⁷⁻²⁹

Levels of energy-producing muscle phosphocreatine decline with aging. Studies show that supplemental creatine can increase available muscle stores of creatine and enhance phosphocreatine production in older people, even to levels similar to those of youthful adults. Creatine can also help reduce muscle fatigue and is found to help attenuate age-related muscle atrophy and strength loss.²⁷⁻³⁰ Creatine may also benefit those with chronic fatigue and fibromyalgia. Lower levels of creatine phosphate and ATP were found in people with fibromyalgia compared to control subjects.³¹

Research suggests creatine can raise growth hormone levels equal to that of intense exercise. Growth hormone plays a

vital role in regulating body fat levels, immune function, muscle mass, wound healing and bone mass along with other functions.³²



Magnesium Glycyl Glutamate Chelate

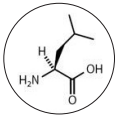
Magnesium glycyl glutamate (MGG) in a chelated form of glutamine, magnesium, and glycine provides bioavailable forms of these nutrients to enhance its anabolic effectiveness. Magnesium is an essential agent for energy production. Glycine is shown to increase muscle strength partially through enhancing growth hormone and facilitating creatine synthesis.^{33,34}

Glutamine is the most abundant amino acid in the blood and levels decline markedly during periods of injury, illness, trauma, radiation therapy and stress. This decline is contributing factor to muscle wasting. Glutamine supplementation is found to help prevent immunosuppression and muscle atrophy during periods of stress.³⁵

Although glutamine is not an essential amino acid, it is considered conditionally essential because it becomes essential during times of stress and during the healing process. Glutamine supplementation is found to reduce rate of infection, degree of inflammation, length of hospital stay and mortality. It improves gut barrier function and immune function especially cell-mediated immunity in critically ill patients.³⁶ Research shows numerous benefits of glutamine in experimental models of critical illness, including attenuated pro-inflammatory cytokine expression, improved gut barrier function, enhanced ability to mount a stress response and improved immune cell function.³⁷

Glutamine serves as a nitrogen donor and a carbon donor. It is an important muscle-building amino acid and helps replenish muscle glycogen after exercise. Glutamine is utilized as a source of energy and for nucleotide synthesis by rapidly dividing cells, such as those of the intestinal lining and certain immune cells (thymocytes, lymphocytes and macrophages). Glutamine supports intestinal function and is found to enhance healing from gastric and peptic ulcers. It is a vital nutrient used by both the intestinal immune cells (the lymphocyte-rich Peyer's patches) and mucosal cells.³⁵

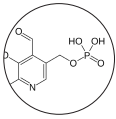
Glutamine is found to exert profound physiological influence including immune-modulatory, anti-catabolic/anabolic and gastrointestinal mucosal-protective actions. In the brain, glutamine is a substrate for the production of both excitatory and inhibitory neurotransmitters (glutamate and gamma-aminobutyric acid, known as GABA). It also demonstrates antioxidant activity as a precursor amino acid for the production of glutathione.³⁸⁻⁴²



Branched Chain Amino Acids

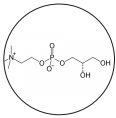
The BCAAs isoleucine, leucine and valine are vital factors involved with muscle growth and repair. BCAAs provide efficient substrate for the synthesis of new proteins and enhance anabolic reserves in the muscles.⁴³⁻⁴⁵ They are metabolized directly into muscle and other vital tissues and human muscle protein includes around 30% BCAAs.

BCAAs are valued by athletes to enhance recovery time and are involved with numerous metabolic processes. The BCAA leucine is particularly researched for its benefits to protein synthesis and energy production. BCAAs are found to minimize protein degradation and to enhance growth hormone. An increased supply of BCAAs is shown to exert a sparing effect on muscle glycogen breakdown during exercise. They are valuable to enhance anabolic reserves and restoration.^{46,47}



Vitamin B6: PAK

Vitamin B6 in the form of pyridoxine (vitamin B6) bound to alpha-ketoglutarate (PAK), is a metabolite in the Krebs (or TCA - Tricarboxylic-acid-cycle) cycle. This unique combination facilitates transport of pyridoxine and alpha-ketoglutarate into the mitochondria, facilitating an increase in muscle ATP levels especially during heavy exercise. PAK is found to enhance cellular energy, increase cellular oxygen intake and to reduce lactic acid buildup.⁴⁸⁻⁵¹



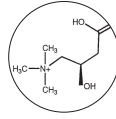
Alpha Glycerol Phosphoryl Choline

Alpha Glycerol Phosphoryl Choline (A-GPC) is a phospholipid metabolite found in high concentrations in neuronal membranes. A-GPC is a potent choline donor. A precursor of the neurotransmitter acetylcholine, choline is an essential component of phospholipids that form cellular membranes. Phosphoryl choline is known for its role in neuron health, cell membrane composition and cognitive function.

Choline is derived from dietary foods and through biosynthesis in the liver. Because of its many roles in human metabolism, from cell structure to neurotransmitter synthesis, choline deficiency is found to impact conditions such as liver disease, atherosclerosis and neurological disorders.^{52,53} Choline is needed for neurotransmitter synthesis (acetylcholine), cell-membrane signaling (phospholipids), lipid transport (lipoproteins) and methyl-group metabolism (homocysteine reduction).^{54,55}

A-GPC is considered particularly beneficial for sports nutrition and supportive for healthy aging. It helps maintain healthy function of cellular membranes, enhances release of

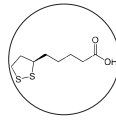
hGH (human growth hormone) and enhances mental focus and cognitive function.^{52,56}



L-Carnitine

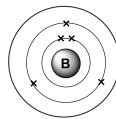
L-carnitine plays a key role in energy production and specifically influences lipid metabolism. In the human body it is synthesized from the amino acids lysine and methionine.^{57,58} Carnitine transports long-chain acyl groups from fatty acids into the mitochondrial matrix so they can be broken down to acetyl-CoA to enter the citric acid cycle for production of cellular energy.⁵⁹⁻⁶¹ Studies find carnitine beneficial for cardiac health, enhancing health and function of the heart muscle and exerting a positive influence to help lower triglyceride and cholesterol levels while benefiting healthy HDL levels.⁶²

Carnitine benefits mitochondrial health, cellular respiration and improves cell membrane potential. It is shown to improve energy production in brain cells and is considered neuro-protective because of its antioxidant activity and ability to stabilize cell membrane activity. Carnitine is found to possess restorative (trophic) benefits and demonstrates the ability to activate DNA repair enzymes and to enhance antioxidant status. The combination of carnitine and lipoic acid is shown to help prevent free radical damage to heart mitochondria during the aging process.^{58,63}



Alpha Lipoic Acid

Alpha lipoic acid (ALA), also called thiotic acid, is well-known for its wide spectrum of antioxidant activity, able to quench free radicals in both aqueous and lipid domains. It demonstrates the remarkable ability to recycle other antioxidants including glutathione, coenzyme Q10, vitamins C and E and even itself. ALA is well-known as a redox-coupling agent that works with glutathione in a cyto-protective role. It has the ability to raise levels of intracellular glutathione. It functions as a coenzyme essential for ATP production and contributes to cellular health. For these and other reasons, ALA is often called a universal antioxidant. ALA is the primary water-soluble antioxidant and acts as a major detoxification agent.^{64,65}



Mineral Cofactors:

Potassium, Boron, Chromium, Vanadium, Zinc

Mineral cofactors enhance healthy cellular and metabolic functions. Potassium, a mineral essential for life, is the most abundant intracellular cation.¹⁰ It is widely available in natural foods including avocados, nuts, and green leafy vegetables. Integral to cellular function it also is an electrolyte and plays a key role in the health and function of the heart, bones and muscles.

Boron is a valuable trace mineral in human health where it is essential for bone metabolism and joint health. It influences bone metabolism through its interactions with other minerals and vitamins including calcium, magnesium and Vitamin D. It improves bone absorption of calcium and enhances collagen synthesis.^{66,67}

Chromium is an essential micronutrient for humans that potentiates insulin sensitivity and functions as a cofactor in all insulin-related activities. This trace element is vital to help regulate carbohydrate and lipid metabolism. Current studies indicate that prolonged, intense exertion can lead to chromium depletion because exercise effects chromium turnover and body stores.^{68,69}

Vanadium is a trace element that has multiple functions in human physiology. It is shown to exert a beneficial influence in insulin response and glucose metabolism in diabetics. Vanadium contributes to balanced tissue levels of reactive oxygen species and enhances healthy glucose and lipid metabolism.⁷⁰⁻⁷²

Zinc is an essential mineral that plays a role in cellular metabolism, immune function, protein synthesis and wound healing. It is essential for the activity of over 100 enzymes.⁷³

For more information on any of the ingredients listed here, including extensive research or individual monographs compiled by Donnie Yance, please contact Natura at 888.628.8720.

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