Life Extension Magazine March 2013

Report

Carnitine Restores Cellular Function

By Logan Bronwell

A wealth of emerging technology demonstrates that as we gain control over individual mechanisms involved in cellular aging, systemic symptoms of **degeneration** can be slowed *or even reversed*.[1]

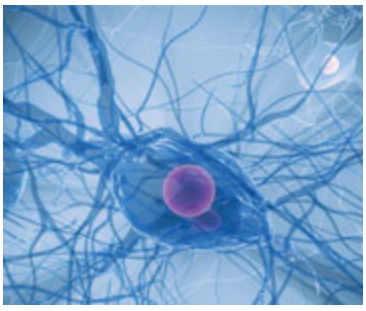
One of the most promising mechanisms addresses our ***mitochondria,***[2,3] the powerhouses found in all human cells that control the energy we need to stay alive.[4]

Over time, our mitochondria decrease in both number and function. The result is essentially a short-circuiting of power to every area of your body. Keeping these cellular powerhouses functioning properly can postpone many of the so-called "inevitable" signs of aging. Research now shows that the amino acid **carnitine** can forestall and even reverse many well-known factors of aging.

With advancing age, carnitine levels decline in all of our tissues.[2,3] That spells trouble for **mitochondria**, which become starved of energy and filled with cellular waste.[3,4]

Simply put, a ***carnitine deficiency*** leads to the wholesale destruction of our mitochondria. And, ultimately, this loss of mitochondrial function is likely to hasten death. Fortunately, **carnitine** is sold as a dietary supplement in the United States, available without the need of a doctor's prescription as it is in some other countries.

Why Mitochondria Decline with Aging



Mitochondria reside in ***every*** cell in our bodies; they power cells by converting food into the energy our body needs to operate.[4] Think of the mitochondria like the power company that supplies energy to your home. If the power goes out, your food spoils, your heating and air condition won't work, you have no light. The same effect occurs within your body. If the mitochondria—your power supply—isn't functioning properly, or if they decrease in numbers, then your cells won't have the energy they need to power your body's many functions.

As the amount of functioning mitochondria decreases, many of the "symptoms" of aging manifests. In part, this occurs because of the mitochondria's continual burning of fatty acids to produce energy. In the process of releasing energy, huge bursts of ***oxidant*** compounds damage **mitochondria** and the cells that contain them.[4] This steady assault leads to the gradual loss of ***mitochondrial function*** in all of our tissues.[5]

The age-related decline in ***mitochondrial activity*** is largely responsible for cardiovascular and neurological disorders as well as obesity and type II diabetes.[6-9] Loss of mitochondrial function in muscle tissue also leads to the familiar "flabby" body composition we associate with older people because it causes muscle atrophy and increased body fat mass.[10] From this list, you can see how essential carnitine is to your daily health.

Total carnitine levels in aging individuals are roughly 20% lower than in youth,[11] which leaves mitochondria increasingly vulnerable to damage.

Fortunately, studies have proven that supplementing with carnitine can restore mitochondrial function to near-youthful levels.[12]

Carnitine Reduces Death Rates

The heart muscle uses fat as its primary energy source. Carnitine is a fat-transporting compound that is absolutely essential for normal heart function.[13] Over time, the decline of carnitine plays a role in the weakening of the heart's muscles. [14]

People with heart muscle damage from heart attacks or heart failure have especially low carnitine levels.[15-17] Fortunately, carnitine supplementation has proven to be remarkably effective in fighting and even reversing the heart-weakening effects from that drop in carnitine levels.[14]

In one study, 160 male and female heart attack survivors between 39 and 86 years old received either 4 grams/day of L-carnitine or a placebo for 12 months.[18] The patients taking L-carnitine experienced significantly favorable decreases in heart rate and blood pressure; they also had improved blood lipid profiles. Most importantly, those supplementing with carnitine had a dramatically reduced death rate compared to those not taking carnitine. Patients taking carnitine had a death rate of just 1.2% in the entire year, while 12.5% of control patients died, with the majority of deaths attributed to repeat heart attacks.[18]

L-carnitine supplementation also prevents the progression of heart muscle damage in people with congestive heart failure and improves exercise tolerance in people who develop chest pain (angina) with exertion.[15] In one study, 55% of patients experienced improvement in their standard heart failure classification.[15]

People with angina, an early sign of heart muscle threatened by ischemia (low blood flow), benefited from carnitine supplements. A natural derivative of L-carnitine, propionyl-L-carnitine, at a dose of 500 mg 3 times daily, increased the mean time that patients could exercise without EKG signs of ischemia by an impressive 450%.[16] That result indicated improved blood flow to heart muscle cells following ischemia, an effect amply demonstrated in animal studies.[19,20]

Carnitine also increases concentrations of nitric oxide that help endothelial cells relax and increase blood flow, which can help lower blood pressure.[21-23] Three weeks of supplementation with **2 grams** of L-carnitine improved blood flow by 17% during the critical after-meal period in a group of people fed a high-fat meal; placebo patients had a 12% decrease in blood flow.[24] And a daily 6-gram intravenous dose of propionyl-L-carnitine for one week improved walking distance in people with peripheral arterial disease by 28%.[25]

Two Groups Gain Exceptional Benefits

Two groups stand to gain exceptional benefits from carnitine supplementation: diabetics and those on dialysis. Both groups are at especially high risk for cardiovascular complications and early death, and both groups have an even greater depletion of carnitine than others of the same age.[17,26]

Dialysis exerts huge stresses on the human body, all of which accelerate atherosclerosis and heart disease. The addition of a 1-gram, IV dose of L-carnitine at the end of each dialysis session markedly reduced chemical markers of stress and increased levels of the protective cytokine *adiponectin*.[26]

The same 1-gram dose, given orally, produced a marked reduction in serum inflammatory markers and factors that promote

excessive blood clots.[27] Finally, a dose of **10 mg/kg** of carnitine (about **750 mg/day** in an average-sized person) produced a significant **12%** decrease in the size of the heart's left ventricle in dialysis patients. [28] That "left ventricular hypertrophy" is a known complication of hemodialysis and contributes to early heart failure.

Diabetics suffer from both *ischemic* (low blood flow) and non-ischemic heart muscle dysfunction, much of which can be reduced by long-term oral L-carnitine supplements.[29] Animal studies show that whether you're a diabetic or not, oral supplementation with L-carnitine helps your heart muscle pump harder and more efficiently.[29] Even more impressive, carnitine's mitochondria-friendly actions help reduce body fat mass, which in turn improves insulin sensitivity and may help control blood sugar levels.[30,31]

WHAT YOU NEED TO KNOW

Anti-Aging Benefits of Carnitine

- A major cause of aging is the decline in function of mitochondria, the tiny powerhouses that energize our cells.
- Most chronic diseases of aging reflect loss of mitochondrial function and numbers, limiting the energy available to cells as we age.
- Poorly-functioning mitochondria also impose huge oxidant stress on their parent cells, further accelerating aging and shortening life.
- L-carnitine, a natural molecule with several related forms, provides mitochondria with both the energy they need and the antioxidant protection that they must have to retain their youthful function.
- Carnitine supplements extend life by increasing energy to tissues throughout the body.
- Carnitine supplementation has proven effective in reducing fatigue, enhancing cardiovascular function, improving body composition and promoting weight loss, lowering blood sugar levels, and delaying or reversing brain degeneration.
- Its energy-releasing properties make carnitine a useful supplement for reducing the deadly cachexia experienced by many cancer patients.

Carnitine Fights Diabesity

As ***obesity*** rates skyrocket, more and more Americans are developing **type II diabetes** as a result, producing a syndrome called "diabesity."[32,33]

Since carnitine helps the mitochondria utilize energy, it plays a critical role in reducing the occurrence and impact of diabesity.[34] Recent studies show that in addition to helping the mitochondria burn fat as energy, carnitine is also vital for removing waste products from mitochondria.[2,35] This is important, because we now recognize that the buildup of mitochondrial waste products is one of the most important contributors to insulin resistance, which further promotes high blood sugar and obesity.[4]

Obesity and aging contribute to low carnitine levels, which compromises mitochondrial performance and increases insulin resistance, promoting further obesity and carnitine reduction.[2] Restoring carnitine levels to their youthful values is an effective way to break this deadly cycle.[2]

Human volunteers who took L-carnitine **3 grams/day** for 10 days had favorable changes in body composition.[36] Supplemented patients used their fat for energy, burning it **22%** faster than control patients, without any increase in muscle protein breakdown. Another study, using **2 grams/day** for 6 months, demonstrated a loss of total fat mass of **4 pounds**, with a gain in lean muscle mass of **8.4 pounds**.[37]

Animal studies confirm and extend these findings, showing that propionyl-L-carnitine decreases body weight gain, food intake, and fat composition, while improving insulin resistance.[34]

Carnitine also has multiple favorable effects on blood sugar and insulin resistance, the hallmarks of type II diabetes.[35] Animals fed a high fat diet develop the same symptoms and signs that humans do: obesity, insulin resistance, abnormal lipid profiles, and liver damage which are known as ***metabolic syndrome***. Just 4 weeks of treatment with L-carnitine reversed all of those abnormal parameters.[30,32,38,39]

Similar effects have been found in diabetic humans. Two grams of L-carnitine twice daily for 10 days improved insulin sensitivity and reduced insulin levels.[40] L-carnitine supplementation of **2 grams/day** caused a significant reduction in plasma free fatty acids, which contribute to insulin resistance.[41] Three grams/day were shown to reduce simulated ***after-meal*** blood sugar spikes from **157 mg/dL** to **132 mg/dL** (oral glucose tolerance test).[42] A significant number of studies document the deadly impact of elevated ***after-meal*** glucose levels.

IMPORTANT FORMS OF CARNITINE

The basic L-carnitine molecule that supports mitochondrial function is available in several forms, each of which offers specific functions:

L-carnitine tartrate is a stable salt form of L-carnitine and has been shown to be absorbed faster than other L-carnitine compounds.[81] It favorably affects biochemical markers of recovery from physical exertion, optimizing the processes of muscle tissue repair and remodeling.[82]

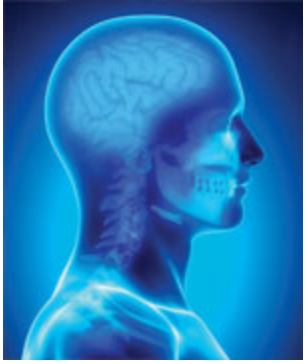
Acetyl-L-carnitine is a molecule chiefly active in moving fat molecules across the mitochondrial membrane.[69] It readily crosses into the brain from the bloodstream, and its extra acetyl molecule provides additional energy directly to brain cells.

ArginoCarn®* is a patented form of acetyl-Lcarnitine arginate dihydrochloride that is molecularly bonded to the amino acid arginine and known as the AminoCarnitine® generation. In a way that closely resembles natural nerve growth factor, this compound induces outgrowth of the tiny but essential nerve cell protrusions called neurites that underpin memory formation and learning.[70]

Glycine propionyl-L-carnitine hydrochloride (GlycoCarn®)* is a patented form of AminoCarnitine® that is molecularly bonded to the amino acid glycine and known as the AminoCarnitine® generation. Propionyl-L-carnitine is essential in carbohydrate and lipid metabolism and is a potent antioxidant.[31] It is especially useful in cardiovascular diseases.[31] The related glycine form has also been shown to extend those benefits to skeletal muscle, enhancing exercise performance.[71]

* ArginoCarn® and GlycoCarn® are registered trademarks of Sigma-tau HealthSciences, Inc. and are protected by US patent US 6703042 and worldwide production patent EP1202956

Carnitine Defends Memory



Most forms of age-related memory and cognitive decline are closely related to ***mitochondrial dysfunction*** in brain tissue. That provides an obvious opportunity for intervention with a mitochondrial enhancer such as carnitine. Most studies of neurodegeneration used the acetyl-L-carnitine form of carnitine.

The impact of acetyl-L-carnitine is especially important in Alzheimer's disease, the leading cause of dementia and mild cognitive impairment in the United States. One early study showed that supplementing with acetyl-L-carnitine every day for a year led to improvements on the cognitive portion of a standard Alzheimer's disease rating scale in patients younger than 61. [43]

More recent studies have shown good effects even in older patients, but, as with all forms of prevention, the earlier you start taking carnitine, the more powerful the effects on memory. Doses ranging from **1.5** to **3 grams/day** of acetyl-L-carnitine have consistently been shown to produce treatment effects several-fold greater than placebo alone, with the greatest impact in patients in the earlier stages of the disease.[44-46] Improvements from acetyl-L-carnitine supplementation can be seen as early as 3 months, and continue to increase over time.[45] (Carnitine has not been found effective in patients with advanced Alzheimer's.)

Laboratory studies explain some of the reasons for acetyl-L-carnitine's impact on Alzheimer's disease, and most of them focus on carnitine's mitochondrial protective properties.

Scientists can induce Alzheimer's-like changes in brain cells using a variety of chemical techniques, and they consistently find that treatment with acetyl-l-carnitine enhances mitochondrial function and slows development of those changes, which include accumulation of the "Alzheimer's protein" ***amyloid beta*** (*Abeta*).[47] Even after dangerous quantities of ***amyloid beta*** form in brain tissue, acetyl-L-carnitine treatment reduces its impact.[3]

Lab animals with conditions similar to Alzheimer's disease demonstrate improved memory and learning when treated with acetyl-L-carnitine.[47,48] In fact, treated animals show increased expression of important memory-associated proteins that had become impaired by Alzheimer's disease. [49]

Acetyl-L-carnitine is useful in other forms of cognitive decline as well, even in poorly-defined conditions such as mild cognitive (or mental) impairment. People supplemented with **1.5** to **2 grams** of acetyl-L-carnitine daily show marked improvement on standard mental status and memory scores.[50,51] These effects are especially impressive among the very old, including at least one study of people over 100 years old.[37]

Carnitine Benefits Body Composition

Carnitine's influence on mitochondrial function can improve age-induced changes in body composition. When lab animals were given carnitine, they experienced reductions in their abdominal fat mass, increases in their muscle strength, and lower concentrations of *leptin*, a cytokine that triggers fat-induced inflammation.[10,52]

Human volunteers who took **3 grams/day** of L-carnitine for 10 days had favorable changes in body composition.[36] Patients taking L-carnitine used their fat for energy, burning it **22%** faster than control patients, and without any increase in muscle protein breakdown. Another study using 2 grams/day demonstrated a loss of total fat mass of **4 pounds**, with a gain in lean muscle mass of **8.4 pounds**.[37]

Additional studies on animals confirm and extend these findings, showing that propionyl-L-carnitine decreases body weight gain, food intake, and fat composition, while improving insulin resistance.[34]

Benefits of supplementation go well beyond memory, however. Not surprisingly for a ***mitochondrial function-boosting*** compound, improvements in energy level, and reduction in physical and mental fatigue are commonly reported in studies of carnitine supplementation (both with L-carnitine and acetyl-L-carnitine).[37,53] And a few studies have found improvements in depression while patients supplement with L-carnitine.[54,55]

Finally, as a result of the obesity epidemic (and with liver disease and cirrhosis on the rise),[56] researchers are showing a growing interest in using carnitine to optimize liver mitochondrial function and prevent or mitigate the effects of liver failure. Several studies have demonstrated clinical and biochemical improvements in patients with hepatic encephalopathy, a condition in which rising blood ammonia levels impair cognitive and motor function.[57-59]

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Carnitine Combats Cancer Wasting

One of the most painful and tragic consequences of many cancers is their induction of *cachexia*, the progressive loss of appetite, energy, and body fat, with increased muscle wasting.[60,61] Cancer cachexia is induced by many factors, the most prominent of which is decreased tissue carnitine levels.[60-62] Diminished appetite contributes to poor nutrition and further declines in carnitine levels.[63,64]

Many strong studies now demonstrate that the carnitine supplements can reduce the rate and severity of cancer cachexia.[65,66] Many also show improvements in appetite, fatigue, and quality of life—especially in the form of L-propionyl carnitine.[61,67,68]

EXERCISE-RELATED BENEFITS OF CARNITINE

- Carnitine reduces exercise-induced oxidative stress. Studies show that carnitine sharply reduces harmful fat oxidation byproducts in muscle tissue.[72-77]
- Carnitine reduces fatigue following moderate exercise. A study of middle-aged men and women showed that **2 grams/day** of L-carnitine improved recovery time after physical exertion.[78] A human study done with kidney patients on hemodialysis (a group chronically plagued by fatigue) showed that a large IV dose of carnitine could increase the amount of time they were able to exercise before becoming fatigued by **22%** —while also beneficially lowering heart rates.[76]
- Carnitine enhances muscle performance and endurance.[10,72,79] One study in animals demonstrated a **39%** increase in the distance the animals were able to run before they experienced exhaustion in normal air, and an astonishing **50%** increase when the animals ran under low-oxygen conditions.[79]
- Carnitine increases exercise tolerance for people who experience angina with exertion.[30] Patients taking **500 mg** 3 times daily of propionyl-L-carnitine (a natural derivative of L-carnitine) experienced a **450%** increase in the mean time they could exercise without EKG signs of ischemia.[31] That result indicated improved blood flow to heart muscle cells following ischemia, an effect proven time and again in animal studies.[34,35]
- Carnitine enhances the performance of trained endurance athletes. One study showed that **2 grams/day** of

L-carnitine reduced heart rates and lowered blood sugar levels during exercise.[80] Another study demonstrated that athletes using **4.5 grams/day** of glycine propionyl-L-carnitine experienced increased muscle power with decreased fatigue-inducing lactic acid accumulation.[71]

Summary

Loss of mitochondrial function is a major contributor to the process of aging. It deprives vital tissues in our body of the energy they need to perform normal tasks and to keep us vibrant, healthy, and young. Carnitine, a natural facilitator of energy transport in mitochondria, is essential for keeping mitochondria healthy and preventing their age-related loss.

Supplementing with carnitine can help preserve cell energy levels, reduce fatigue, enhance heart muscle strength, reduce the impact of obesity and diabetes, slow signs of brain aging, and protect heart attack victims from dying.

If you have any questions on the scientific content of this article, please call a Life Extension® Health Advisor at 1-866-864-3027.

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