

# What Do L-Carnitine Supplements Really Do?

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## STORY AT-A-GLANCE

- › Your body needs carnitine for energy production; it helps transport long-chain fatty acids into your mitochondria where they're oxidized and turned into energy in the form of adenosine triphosphate (ATP)
- › Acetyl-L-carnitine has many beneficial effects on brain metabolism, protects against neurotoxic insults and has been shown to benefit certain forms of depression
- › Carnitine has been widely studied for autism as a treatment that targets mitochondria; one meta-analysis found low carnitine in 80% of children with autism
- › Carnitine may help moderate oxidative stress and decrease inflammation, benefiting heart health; it may also help prevent potentially fatal arrhythmias
- › Carnitine supplementation significantly improved ovulation and pregnancy rates, while reducing BMI and insulin resistance, in women with polycystic ovary syndrome (PCOS)

Carnitine is another important nutrient that's abundant in animal foods. Your body produces L-carnitine from the amino acid lysine, and while healthy people are typically able to synthesize enough, certain conditions — like pregnancy — may cause your body's need for carnitine to exceed its ability to produce it. For this reason, carnitine is considered a conditionally essential nutrient.<sup>1</sup>

L-carnitine and acetyl-L-carnitine are forms of carnitine found in dietary supplements. While your body absorbs carnitine from animal foods such as grass fed beef better than

carnitine in dietary supplements,<sup>2</sup> some research suggests L-carnitine supplements may benefit certain conditions.

## **Carnitine for Brain Health**

Your body needs carnitine for energy production. It helps transport long-chain fatty acids into your mitochondria where they're oxidized and turned into energy in the form of adenosine triphosphate (ATP),<sup>3</sup> which is needed by your cells for life, repair and regeneration. Carnitine may also help remove toxins from the mitochondria.<sup>4</sup>

Acetyl-L-carnitine (ALCAR) is more easily absorbed in your gut than L-carnitine, and also crosses the blood-brain barrier.<sup>5</sup> ALCAR has many beneficial effects on brain metabolism, protects against neurotoxic insults and has been shown to benefit certain forms of depression. In one study,<sup>6</sup> healthy mice given ALCAR for 25 days at a dose of about half a gram per kilo were found to have increased levels of the neurotransmitters noradrenaline and serotonin.

According to the authors, this is "consistent with ALCAR's potential efficacy for depressive symptoms." In another study, ALCAR was found to improve the clinical condition of patients with degenerative cerebellar ataxia, a condition resulting in the loss of control of bodily movements.<sup>7</sup> According to the authors, "statistically significant improvement of some symptoms and a slow progression of the disease in both groups of patients" were observed.

## **Carnitine for Alzheimer's Disease and Autism**

Carnitine is also being studied for use in Alzheimer's disease. According to the National Institutes of Health:<sup>8</sup>

*"Cholinergic neurons use the neurotransmitter acetylcholine, and Alzheimer's disease is often treated by increasing acetylcholine levels or preventing its breakdown. Carnitine might be conditionally essential in individuals with Alzheimer's disease because it may support acetylcholine synthesis and help*

*remove toxic compounds to alleviate mitochondrial dysfunction associated with extensive degeneration of brain structures.*

*Therefore, researchers have examined whether acetyl-L-carnitine supplements benefit individuals with Alzheimer's disease or other forms of dementia, but studies have had mixed results."*

In a meta-analysis of 21 studies, adults with mild cognitive impairment or Alzheimer's disease took 1.5 grams to 3 grams of acetyl-L-carnitine or placebo daily for three to 12 months. Those taking acetyl-L-carnitine had greater improvements than those taking placebo.<sup>9,10</sup>

It's also been widely studied for autism as a treatment that targets mitochondria. One meta-analysis found low carnitine in 80% of children with autism.<sup>11</sup> As explained in Seminars in Pediatric Neurology:<sup>12</sup>

*"Two medium sized (n = 30, 30) double-blind placebo-controlled studies using L-carnitine treatment (50 mg/kg/d for 3 months and 100 mg/kg/d for 6 months) found that scores on the Childhood Autism Rating Scale (CARS) improved with L-carnitine as compared to placebo with one study finding that greater symptomatic improvement was correlated with a greater increase in blood carnitine levels.*

*A small (n = 10) 8-week open-label trial of L-carnitine used particularly high doses (up to 400 mg/kg/d in 3 divided doses, maximum of 6000 mg/d) ...*

*Several parental rated measures showed improvements in behavior and hyperactivity before correction for multiple comparisons and improvements in language correlated with post-treatment blood carnitine levels. Children with ASD and genetic mutations in the carnitine pathway also appear to respond to L-carnitine.*

*... Thus, L-Carnitine is a promising treatment for children with ASD. For child neurologists, it is always important to remember that children with ASD could*

*have an underlying defect in carnitine metabolism."*

## **Carnitine for Heart Health**

There's some evidence that carnitine may help moderate oxidative stress and decrease inflammation, benefitting heart health. It may also help prevent potentially fatal arrhythmias, or irregular heart rhythms.<sup>13</sup>

One meta-analysis involving 3,629 adults found, "Compared with placebo or control, L-carnitine is associated with a 27% reduction in all-cause mortality, a 65% reduction in Vas [ventricular arrhythmias], and a 40% reduction in anginal symptoms in patients experiencing an acute myocardial infarction."<sup>14</sup>

There's some controversy over carnitine for cardiovascular disease, however, because it's metabolized by gut microbiota into trimethylamine-N-oxide (TMAO), a substance associated with an increased risk of cardiovascular disease,<sup>15</sup> although the evidence on that is mixed.

According to James DiNicolantonio, Pharm.D., who is also the coauthor of my book, "Superfuel: Ketogenic Keys to Unlock the Secrets of Good Fats, Bad Fats, and Great Health," the likely true cause of elevated TMAO levels is hepatic insulin resistance.<sup>16</sup> Because carnitine (and choline) raises TMAO, some recommend limiting dietary and supplementary intake of these nutrients.

However, DiNicolantonio and his coauthors point out there's a significant flaw in this theory, stating, "... supplemental carnitine is known to be highly protective in patients with vascular disease; and fish, the richest dietary source of preformed TMAO, is also protective."<sup>17</sup> There's little evidence to suggest that dietary intake of TMAO or its precursors actually promote CVD, provided your renal function is normal. DiNicolantonio explains:<sup>18</sup>

*"With respect to carnitine and CV risk, a meta-analysis<sup>19</sup> of prospective clinical trials in patients who had recently experienced a myocardial infarction*

*concluded that carnitine supplementation is markedly protective with respect to total mortality, ventricular arrhythmias and new-onset angina ...*

*Clinical trials<sup>20,21</sup> have also reported favorable effects of supplemental carnitine or carnitine esters on angina, intermittent claudication and heart failure.*

*Moreover, rodent atherogenesis studies, in which carnitine has been administered in doses reasonably proportional to the supplementation doses used clinically, have found that carnitine is anti-atherogenic, despite its propensity to raise TMAO ...*

*It is therefore reasonable to suspect that moderately elevated TMAO, rather than being a mediator of the associated CV risk, is a marker for factors which both promote CV events and increase plasma TMAO."*

## **Carnitine for Weight Loss**

Research suggests L-carnitine supplements, which are the least expensive form on the market with an absorption rate of 14% to 18%,<sup>22</sup> may be useful for weight loss. In a systematic review and meta-analysis of 37 trials, L-carnitine supplementation significantly decreased body weight, body mass index and fat mass, particularly in adults who are overweight or obese.<sup>23</sup>

"A nonlinear dose-response association was seen between L-carnitine supplementation and body weight reduction ... suggesting that ingestion of 2000 mg L-carnitine per day provides the maximum effect in adults," the team, from Shahid Sadoughi University of Medical Sciences in Iran, noted.<sup>24</sup>

## **Carnitine May Improve Fertility**

L-carnitine concentrates in the epididymis, a duct behind the testis where sperm mature. Concentrations of L-carnitine in semen have been linked to the number of sperm, suggesting it may play an important role in fertility in men. Some research also shows

that L-carnitine supplementation for two months may improve sperm quality and motility.<sup>25</sup> According to the NIH:<sup>26</sup>

*"Carnitine might play a role in sperm maturation, sperm motility, and spermatogenesis. It might also reduce oxidative stress, which could improve oocyte growth and maturation. Therefore, researchers are examining whether supplemental carnitine improves sperm count, concentration, and motility as well as pregnancy rates."*

Women with polycystic ovary syndrome (PCOS), which can affect fertility, may also benefit from carnitine. A systematic review and meta-analysis involving women with PCOS revealed that carnitine supplementation ranging from 250 mg to 3,000 mg daily for 84 to 90 days significantly improved ovulation and pregnancy rates, while reducing BMI and insulin resistance.<sup>27</sup>

## **Carnitine to Boost Athletic Performance**

There's interest in the use of carnitine to enhance athletic performance, in part because carnitine preserves muscle glycogen while boosting fat oxidation. "It also spares the use of amino acids as energy sources during exercise, making them potentially available for new protein synthesis, and decreases the accumulation of lactate," NIH notes,<sup>28</sup> but research is mixed on its benefits.

In one study published in the *Journal of Physiology*, the data showed L-carnitine supplementation for six months raised levels of muscle carnitine by 21%.<sup>29</sup> Further, participants taking carnitine supplements raised their athletic performance and work output by 11% in a 30-minute performance trial.

The researchers explained this improvement "by the dual role of carnitine – glycogen sparing at low intensities and reduced muscle lactate accumulation at high intensities."<sup>30</sup>

Where carnitine further shines is for those with frailty. It's been suggested that carnitine deficiency could cause frailty via mitochondrial dysfunction, with research showing pre-

frail older adults had decreases in frailty and improvement in hand grip strength when they took 1.5 grams of carnitine daily for 10 weeks.<sup>31</sup>

## **Carnitine for Liver Health and More**

Additional research is looking into the effects of carnitine supplementation on nonalcoholic fatty liver disease (NAFLD). A systematic review and meta-analysis revealed that L-carnitine supplementation may improve liver function and regulate triglyceride metabolism in those with NAFLD. Writing in *Systematic Reviews*, researchers explained:<sup>32</sup>

*"The main drivers in NAFLD are inflammation and accumulation of lipids, and L-carnitine has been shown to have anti-inflammatory effects by upregulating the peroxisome proliferator activator receptor- $\gamma$  (PPAR- $\gamma$ ) in the liver. L-carnitine is also closely related to fat metabolism."*

Beyond the liver, carnitine also shows promise for a range of other health conditions, including:<sup>33,34</sup>

- Insulin resistance
- Diabetes
- Osteoarthritis
- Muscle cramps

In another example, a systematic review and meta-analysis found men and women experienced improvements in waist circumference and blood pressure, two biomarkers of metabolic syndrome, when taking carnitine supplements.<sup>35</sup>

The studies used carnitine doses between 0.75 grams (gm) and 3 gm per day for eight to 24 weeks, with researchers suggesting biomarkers of metabolic syndrome could improve with a carnitine dose of 1 gm to 3 gm per day, by reducing fasting blood sugar and triglycerides, while increasing high-density lipoprotein (HDL) cholesterol.

# Are You Getting Enough Carnitine?

Most people can effectively synthesize between 11 mg and 34 mg of carnitine per day, which is typically enough to prevent deficiency.<sup>36</sup> Animal foods, including meat, seafood and dairy, are the richest sources of L-carnitine, so if you eat animal protein it will virtually assure you receive enough carnitine without having to take supplements.

However, if you eat a primarily plant-based diet or are targeting certain conditions, you may need to consider supplementation. Acetyl-L-carnitine (not regular L-carnitine), for instance, appears to be particularly **beneficial for improving memory**, but you need about 2,000 mg to 2,500 mg a day. Most notice a difference after a few weeks.

If you do choose to supplement, be sure to choose a reputable source. When NOW Foods tested seven largely unknown brands of acetyl-L-carnitine, none met label claims and most were labeled incorrectly.<sup>37</sup>

## Sources and References

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