

# Top Supplements for Mitochondria Function

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## STORY AT-A-GLANCE

- › Mitochondria are the structures inside your cells that produce about 90% of the energy generated in your body
- › Mitochondria are key to health and disease prevention; without mitochondrial health, your well-being and longevity may suffer
- › Supplements you can use strategically to support your mitochondria include vitamin K2, glycine, coQ10, B vitamins and niacinamide, and PQQ
- › Eating right, timing your meals and exercising are additional strategies to support mitochondrial health

Mitochondria, are the structures inside of your cells that produce about 90% of the energy generated in your body.<sup>1</sup> This energy is necessary for cellular regeneration and detoxification, as well as muscle contraction and each biochemical cascade that occurs. In short, your cells require energy to function, and healthy mitochondria are critical to that energy supply.

Mitochondria also play an important role in apoptosis, or programmed cell death, ensuring that malfunctioning cells die and are cleared from your system. In short, mitochondria are key to health and disease prevention. Without mitochondrial health, your well-being and longevity may suffer.

## 6 Supplements to Support Your Mitochondrial Health

There are many strategies to optimize mitochondrial function. Eating right, timing your meals and exercising are among them. However, there are also supplements you can use strategically to support your mitochondria. Top options include the following.

## 1. Vitamin K2

There are two types of vitamin K: phyloquinone, or vitamin K1; and menaquinones, or vitamin K2. Vitamin K1 is derived from green, leafy vegetables such as spinach, kale, broccoli and cabbage, and is best known for the role it plays in blood clotting.

Vitamin K2 is better known for its role in bone and heart health, and is found in grass fed animal products such as meat, eggs, liver and dairy, as well as in fermented foods, including sauerkraut, certain cheeses and the fermented soy food natto.

Vitamin K2, a fat-soluble vitamin, also has antioxidant effects and is neuroprotective. In one study, researchers even revealed vitamin K2 modulates mitochondrial dysfunction caused by neurotoxins.<sup>2</sup> They exposed SH-SY5Y cells, which serve as a model for neurodegenerative disorders, to 6-hydroxydopamine (6-OHDA), a neurotoxic compound used to destroy neurons in the brain.

They then treated the cells with vitamin K2, which led to multiple improvements. While 6-OHDA induced abnormal mitochondrial changes, vitamin K2 significantly suppressed the negative changes.

Vitamin K2 also inhibited the accumulation of reactive oxygen species (ROS) and promoted mitophagy, which is the removal of damaged mitochondria via autophagy – an essential function to maintain cellular health. Writing in the journal *Nutrients*, the scientists explained:<sup>3</sup>

*“... [V]itamin K2 can release mitochondrial damage, and ... this effect is related to the participation of vitamin K2 in the regulation of the mitochondrial quality-control loop, through the maintenance of the mitochondrial quality-control system, and repair mitochondrial dysfunction, thereby alleviating neuronal cell death mediated by mitochondrial damage.”*

## 2. Glycine

Glycine is a nonessential amino acid, as your body can manufacture some on its own. However, most of us do not make enough glycine to maximize its health benefits, which include increased longevity and protection against age-related disease.<sup>4</sup>

While it's long been suggested that age-related mutations in mitochondrial DNA are responsible for making mitochondria less efficient as you get older, Japanese researchers suggested epigenetic changes may, instead, be the key players.<sup>5</sup>

Further, they were able to restore gene regulation in aging mitochondria to a more youthful state using glycine.<sup>6</sup> According to the study, "Treatment of elderly fibroblasts with glycine effectively prevented the expression of these aging phenotypes."<sup>7</sup>

Collagen – the most abundant protein in your body<sup>8</sup> – is made mostly of glycine. It's also a precursor to glutathione, a powerful antioxidant that declines with age. However, inducing autophagy and mimicking methionine restriction<sup>9</sup> may be behind glycine's antiaging effects. Even intermittently restricting methionine leads to benefits like improved glucose homeostasis, reduced obesity and protection against fatty liver.<sup>10</sup>

Researchers at Baylor College of Medicine also looked into supplementation with a combination of glycine and N-acetylcysteine (NAC), two glutathione precursors known as GlyNAC when taken together.

They had previously shown that young mice deficient in glutathione had mitochondrial dysfunction, and supplementing with GlyNAC in older mice not only improved glutathione deficiency but also mitochondrial impairment, oxidative stress and insulin resistance.<sup>11</sup>

Additional research they conducted in HIV patients,<sup>12</sup> and found GlyNAC supplementation improved "deficits associated with premature aging" in this population.<sup>13</sup> This included improvements to oxidative stress, mitochondrial dysfunction, inflammation, endothelial dysfunction, insulin resistance, genotoxicity, strength and cognition.<sup>14</sup>

A subsequent pilot trial in older humans found similar results, with GlyNAC supplementation for 24 weeks correcting glutathione deficiency and improving multiple measures of health, including mitochondrial dysfunction, endothelial dysfunction, inflammation, cognition, strength and more.<sup>15</sup>

### **3. Coenzyme Q10 (CoQ10)**

CoQ10, a fat-soluble antioxidant, is found in nearly every cell in your body but concentrates in the mitochondria, where it's involved in energy production.<sup>16</sup> As a cofactor in the electron-transport chain, CoQ10's primary action involves the synthesis of adenosine triphosphate (ATP), which your cells need for life, repair and regeneration.

Many conditions, including heart disease, appear to be rooted in mitochondrial dysfunction.<sup>17</sup> Cardiac muscle cells have about 5,000 mitochondria per cell,<sup>18</sup> where CoQ10 concentrates. For further comparison, mitochondria make up about 35% of the volume of cardiac tissue and only 3% to 8% of the volume of skeletal muscle tissue.<sup>19</sup>

While CoQ10 doesn't stimulate the growth of new mitochondria, it's essential to its metabolic function.<sup>20</sup> Further, according to researchers with Liverpool John Moores University in the U.K.:<sup>21</sup>

*“Secondary deficiencies of CoQ10 typically occur in the mitochondrial myopathies, cardiovascular disease, type II diabetes, chronic kidney disease, liver disease and critical illness. Depletion of CoQ10 in these disorders may compromise cellular antioxidant status and result in impaired mitochondrial function and cellular energy supply, resulting in, for example, heart failure.”*

Ubiquinol is the reduced version of CoQ10. Young people are able to use CoQ10 supplements quite well, but older people do better with ubiquinol, as it's more readily absorbed. You can get some CoQ10 from food as well. Food sources include wild-caught salmon, mackerel, sardines, eggs and organ meats.<sup>22</sup>

You may also be able to improve your body's conversion of CoQ10 to ubiquinol by eating lots of green leafy vegetables, which are loaded with chlorophyll, in combination with

sun exposure.<sup>23,24</sup>

If you're taking a statin drug you must also take at least 100 to 200 mg of ubiquinol or CoQ10 per day, or more. Supplementation is also appropriate for those with chronic diseases such as heart disease, diabetes, amyotrophic lateral sclerosis (ALS), chronic fatigue and autism. Ideally, split the dose up so you're taking it two or three times a day, rather than taking it all at once, as this will result in higher blood levels.

## 4. Pyrroloquinoline Quinone (PQQ)

PQQ is a vitamin-like substance and cousin to CoQ10, which helps with mitochondrial biogenesis. The greater number of mitochondria you have, the more energy your cells are able to produce, and the better they function overall. So, having sufficient amounts of PQQ encourages the proliferation of mitochondria.

In a study on mice, supplementing with PQQ modulated both the quantity and function of mitochondria.<sup>25</sup> Animal and human studies using doses between 10 and 20 milligrams (mg) of PQQ show significant improvement in mental processing and memory.<sup>26</sup> The best results are obtained when you take PQQ in combination with CoQ10.

PQQ has also been shown to protect against the development of alpha-synuclein, a protein associated with Parkinson's disease, and beta-amyloid, associated with Alzheimer's. Other research suggests "daily supplementation with 20 mg PQQ optimizes mitochondrial biogenesis in human subjects."<sup>27</sup>

## 5. B Vitamins

B vitamins are also needed for optimal mitochondrial functioning. According to natural medicine physician Dr. Frank Shallenberger:<sup>28</sup>

*"B vitamins are absolutely critical for mitochondrial function – especially niacin, riboflavin and folate. Orally speaking, with niacin, I typically start them at 100 to 200 milligrams a day [but] you can go up to 2,000 mg easy on some patients. I*

*use a B complex because I like to balance it out, but I'm focusing primarily on niacin, folate and riboflavin."*

Riboflavin deficiency may also be involved in mitochondrial dysfunction that could trigger central nervous system disorders, including potentially migraines. According to research published in *Frontiers in Neurology*, "Riboflavin ameliorates oxidative stress, mitochondrial dysfunction, neuroinflammation and glutamate excitotoxicity, all of which take part in the pathogenesis of PD [Parkinson's disease], migraine headache and other neurological disorders."<sup>29</sup>

People with migraines have been shown to have higher levels of mitochondrial dysfunction, and at least two polymorphisms in mitochondrial DNA have been shown to heighten migraine susceptibility.<sup>30</sup> Riboflavin may help relieve this mitochondrial dysfunction. Foods rich in riboflavin include spinach, beet greens, crimini and portabella mushrooms, pastured eggs, asparagus, grass fed beef liver and beef tenderloin.

## 6. Niacinamide

**Niacinamide**, also known as nicotinamide, is a form of niacin (vitamin B3) that plays a vital role in energy metabolism. It's essential for the mitochondrial electron transport chain to function. Without it, your mitochondria cannot make energy.

Niacinamide is so important because it is a precursor for **NAD+**, which is involved in the conversion of food to energy, maintaining DNA integrity and ensuring proper cell function. NAD+ is also a primary fuel for sirtuins, longevity proteins that become depleted with age.

Niacinamide at a dose of 50 milligrams three times per day will provide the fuel for the rate limiting enzyme for NAD+, NAMPT. Niacinamide also has potent antiobesity effects, can help prevent neurodegeneration and heart failure, and reverse leaky gut.

Niacinamide may also help prevent neurodegeneration by allowing for higher energy levels through energy metabolism in the mitochondria. "There are many studies, going back decades, demonstrating that a drop in NAD+ levels, and thus of NAD/NADH, is a

common feature of virtually all neurodegenerative diseases,” writes bioenergetic researcher Georgi Dinkov.<sup>31</sup>

I recommend getting niacinamide in powder form because the lowest available dose in most supplements is 500 mg, and that will decrease NAD+ due to negative feedback on NAMPT, which is the opposite of what you’re looking for. Niacinamide will only cost you about 25 cents a month if you get it as a powder. Typically, one-sixty-fourth of a teaspoon of niacinamide powder is about 50 mg.

I also recommend taking one aspirin tablet daily. Aspirin plays a role in mitochondria function<sup>32</sup> and also has other health benefits. Importantly, it helps increase the oxidation of glucose as fuel for your body while inhibiting the oxidation of fatty acids, specifically [linoleic acid](#). Dinkov adds:<sup>33</sup>

*“Since aspirin is known to modulate autophagy (raise it when it is abnormally low and lower it when it is abnormally high) and niacinamide is a very effective NAD precursor, it is reasonable to try them in combination that should be synergistic when it comes to protecting the brain (and the entire organism) from diseases and even aging.”*

## **What Else Works to Boost Mitochondrial Function?**

There are a number of strategies you can use to optimize your mitochondrial health and function. A foundational dietary strategy is to eat the right fuel, focusing on an ancestral diet and avoiding highly processed foods. Processed food diets prevent your body from efficiently burning fat as its primary fuel. Once you focus on whole foods and become an efficient fat burner, you automatically minimize the oxidative stress placed on your mitochondria.

Meal timing is another important factor. One of the worst things you can do to your mitochondria on a regular basis is eating shortly before going to bed. Ideally, eat your last meal of the day at least three hours before bedtime.

By supplying your body with food at a time when your body needs it the least (since you're sleeping), excessive amounts of free radicals end up being formed, which then spill out and damage mitochondrial DNA. Excess carbohydrates, in particular, result in a backup of electrons that causes the production of superoxide.

Exercise is also useful, as it upregulates genes like PGC-1 alpha and nuclear gene factors like Nrf2. These genes help your mitochondria become more efficient. Mitochondria are also vulnerable to emotional stress and environmental toxins, like heavy metals. Regular use of a near-infrared sauna may offer help for both detoxification and stress relief.

As an added benefit, 95% of melatonin is produced in your mitochondria in response to near-infrared light. Melatonin is an antioxidant that helps mop up ROS that damage your mitochondria. So, by getting plenty of near-infrared exposure, either from a near-infrared sauna or sun exposure during the day, your mitochondria will be bathed in melatonin, thereby reducing oxidative stress.<sup>34,35</sup>

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