THE NASM GUIDE TO

POPULAR FITNESS SUPPLEMENTS

ARE THEY WORTH THE MONEY AND WHAT DOES THE RESEARCH SAY?

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Welcome!

We are excited that you made the decision to dive into this topic with us and learn more about the evidence regarding the most popular fitness supplements. This guide will help you understand what the most popular fitness supplements are, what they claim to do, and if there is any evidence to support those claims. You will also learn about any potential side effects or reasons why you should consider not taking those supplements.

Supplements can be a difficult area to navigate as there is not a lot of pre-market regulation, meaning that supplements can be sold, especially in the United States, without a lot of regulation before they reach the consumer. This often means that the claims around supplements are not always fully tested, which can equate to a lot of supplements that overstate their efficacy and benefits.

This guide is focused on giving you evidence-based insights into the most popular supplements and will provide you with a framework on how to make decisions about which supplements you decide to take. We hope that after reviewing this guide, you take away some useful concepts and powerful tools, and will feel empowered to make decisions around supplements that are best for your body and your health. We are thankful you are here and excited to go on this journey with you.

About NASM

The National Academy of Sports Medicine is the leader in educating and credentialing fitness, wellness, and performance professionals across the globe. NASM provides valid, up-to-date learning content on topics that improve the health and well-being of those they serve. We pride ourselves in creating practical content you can apply right away. Learn more at www.nasm.org, your favorite social media platform, or wherever you listen to podcasts.

Getting the Most from This Guide

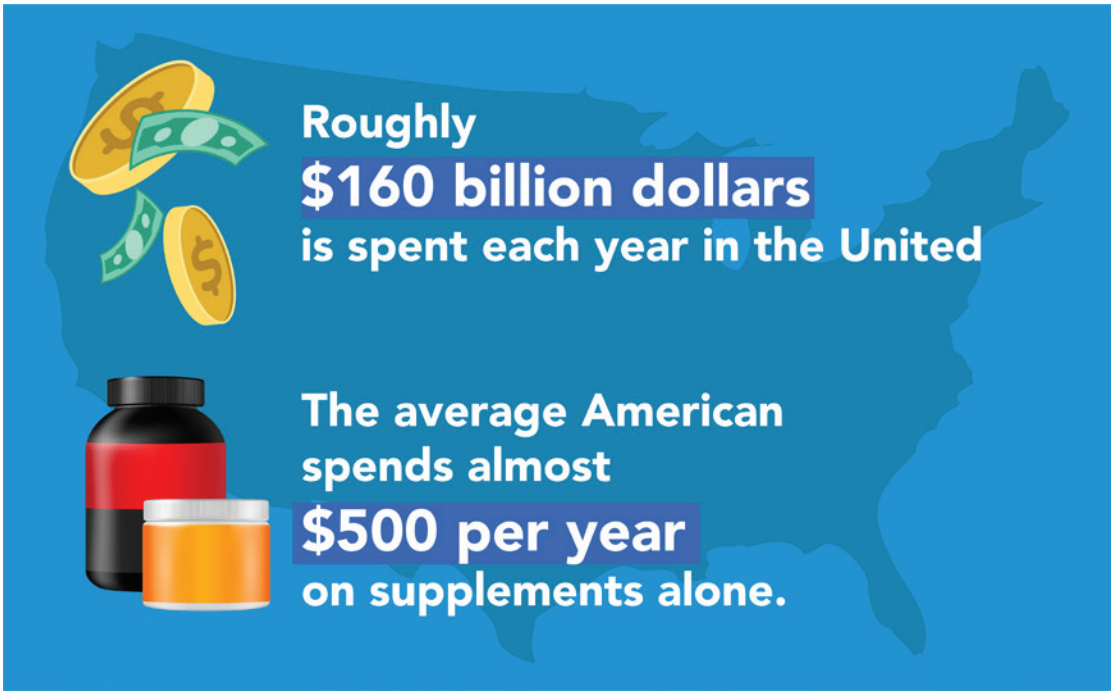
This Guide to Popular Fitness Supplements will walk you through information explaining a little bit of the "why" behind the "how". We have gone through all the information out there and distilled it down into actionable information for you. Then we'll give you key takeaways and actionable steps to apply whenever you like. Our goal is to make sure you have enough of the right information to make the best decisions for yourself!

Come back and use the information as a reference any time. Be sure to use the key takeaways and application strategies in whatever way makes sense for you. Don't feel obligated to put everything into action right away. When you're ready for a deeper dive on the topic, check out our recommended resources.

Introduction

Supplements have been a major part of the health, wellness, fitness, and dieting industries for the last several decades. The growth of the consumer product goods category and the rise of social media have helped propel the supplement industry into a massive market. Roughly $160 billion dollars is spent each year in the United States, which means the average American spends almost $500 per year on supplements alone.

Despite this being a massive market, the regulation on the supplement industry is much looser than you might think. In fact, there is essentially zero requirement for a company to have their supplements approved by the FDA or any other regulatory body for orally consumed dietary supplements. In contrast, drugs or medical devices have to go through rigorous testing by the FDA before they can be solved, even over-the-counter medications. This means that you can create a supplement, market it, and sell it without any meaningful oversight from the FDA. This has led to a lot of supplements being sold that make claims that have very little evidence behind them.



DIGGING DEEPER

In 1973, the FDA issued regulations that defined supplements that delivered more than 150% of the Recommended Daily Allowance (RDA) as a drug, which required the supplement industry to have FDA approval prior to selling any product that met this criteria.

In 1976, these regulations were amended based on the Health Research and Health Services Amendments from Congress. These amendments, known as the Proxmire Amendments, were based on the argument that the FDA should not be able to limit the potency of foods or vitamins and minerals in food supplements due strictly to potency. After an appeal to the court, the 1973 regulations were repealed entirely.

This led to an expansion of the supplement market and led to the creation of new and stronger supplements. This eventually led to the Nutrition Labeling and Education Act of 1990, which allowed for health claims to be included on supplements that describe the relationship between a nutrient and a disease or health condition.

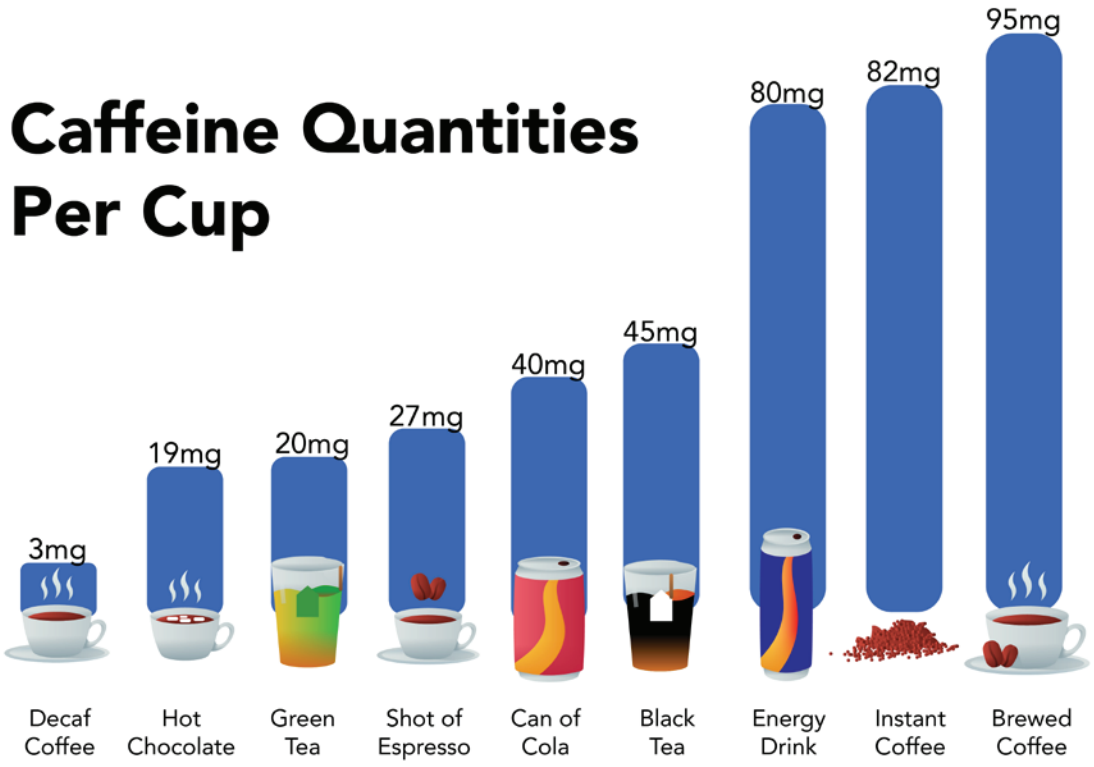
Eventually, the Dietary Supplement and Health Education Act of 1994 was passed, which exempted dietary supplements from being regulated by the FDA prior to going to market and places the burden on the FDA to conduct any regulatory investigations on products after they are sold to the public (Institute of Medicine [US] & National Research Council [US] Committee on the Framework for Evaluating the Safety of Dietary Supplements, 2005).

This guide is designed to introduce you to 10 of the most commonly consumed supplements and provide you with the information you need to make your own decisions on what supplements you choose to consume or not. This guide will provide the most up-to-date review of the research behind each supplement, what dose is effective, and what side effects might result from consuming each supplement.

Caffeine

Caffeine is a molecule typically found in plants but can also be manufactured or extracted from plants and consumed in supplement forms such as pills, in beverages, or in food. Because it is such an integral part of most of our lives and our societies, we often do not think about it as a supplement, but it is probably the most consumed supplement on the planet.

Caffeine primarily functions as a stimulant to your central nervous system (your brain) but also can affect the rest of your body. It is also technically the most commonly consumed psychoactive compound in the world, with the average person consuming around 100 mg of caffeine a day.

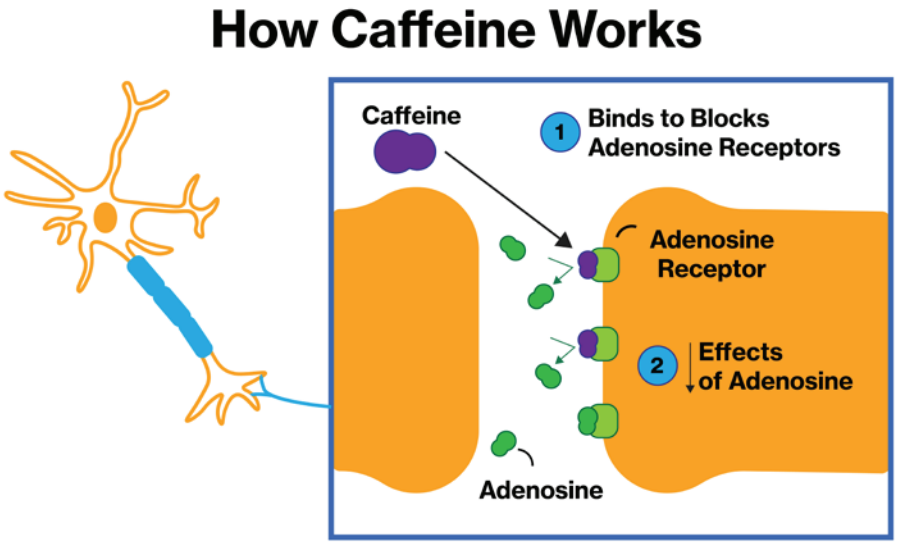


What Is It Claimed to Do?

Caffeine is a supplement that actually is claimed to have several effects. The first is that caffeine is claimed to be a stimulant and gives you more energy. The second is that it is claimed to help increase exercise capacity; specifically, it increases your ability to perform strength-based exercises and it increases your capacity for endurance exercise. Lastly, caffeine is often claimed to be a fat-loss supplement due to its stimulatory effects.

How Does It Work?

Caffeine works primarily in the brain but also works elsewhere in the body. Caffeine works by blocking a molecule called adenosine from binding to its receptors on nerve cells. In the brain, adenosine helps regulate sleep and primarily acts to create a tired or drowsy effect. This means that caffeine actually works by blocking tired signals in the brain.



Outside the brain, caffeine has a lot of other effects. Caffeine can affect blood pressure, heart rate, breathing rate, and increase urination and gastric motility. Additionally, caffeine also has been shown to affect muscle contraction, increasing the contractility and delaying fatigue in skeletal muscle (Domaszewski et al., 2021; Tarnopolsky & Cupido, 2000). Lastly, caffeine has shown to increase fatty acid oxidation and shift metabolism to favor fat metabolism, especially during exercise (Glaister et al., 2016; Leelarungrayub et al., 2011).

What Is the Evidence?

Caffeine is one of the most well-studied and well-researched supplements on the market and there is very clear evidence for the major claims. From an energy perspective, caffeine reduces fatigue, decreases drowsiness, and increases wakefulness (Childs & de Wit, 2006).

The effects of caffeine on strength and muscular performance have also been well-studied. In fact, a meta-analysis found that caffeine showed measurable improvements in strength and power (Grgic et al., 2018). Similarly, caffeine has been shown to improve performance in endurance exercise as well, increasing power output and decreasing completion time during time-trials (Southward et al., 2018).

The evidence around caffeine as a fat burner is a little less clear. Caffeine increases the mobilization of fatty acids from your fat tissue into your bloodstream. However, it looks like a lot of that ends up going back into your fat tissue after a few

hours and only a small portion of that fat is burned by your body (Acheson et al., 2004). However, that does not mean that caffeine has no effect on fat loss as there is evidence to suggest it does increase energy expenditure and fat oxidation; it is just a very small effect that does not appear to meaningfully move the needle for weight loss for most people (Astrup et al., 1990; Conger & Tuthill, 2022; Norager et al., 2006)

Dosing Recommendation

Caffeine dosing has been well-defined over the last several decades of research. Virtually all the potential benefits of caffeine exist in a dosing range of ~3 to 6 mg/kg, with doses above that showing no additional benefits. This means the average adult will get the majority of the benefits of caffeine with ~200 to 300 mg of caffeine a day, which is the equivalent of around 1.5 to 2 cups of strong black coffee a day. Doses above this are where many of the side effects begin to appear. As such, the dosing recommendation for most people is ~200 to 300 mg per day.

Side Effects

Caffeine might acutely increase blood pressure and heart rate, and some evidence has suggested that higher doses of caffeine (greater than 400 mg) might increase anxiety among people with established anxiety disorders (Klevebrant & Frick, 2022).

HMB

Beta-hydroxy-beta-methylbutyrate, also known as HMB, is a metabolite of the amino acid leucine, which is one of the branched-chain amino acids. The term metabolite might sound complicated, but it is essentially the leftover portions of a chemical reaction in your body. For example, carbon dioxide is a metabolite of respiration. This means that HMB is one of the leftovers after your body utilizes leucine. Leucine is used extensively by skeletal muscle to build new muscle tissue.

When skeletal muscle utilizes leucine, the byproducts are often shipped out of the muscle tissue and sometimes end up in the liver. The liver takes some of these byproducts and then turns it into HMB, which is then used by the body (Holeček, 2017). HMB is used as a supplement because it is believed to have anabolic (meaning building a bigger thing from smaller things) properties, meaning it might help grow muscle tissue.

What Is It Claimed to Do?

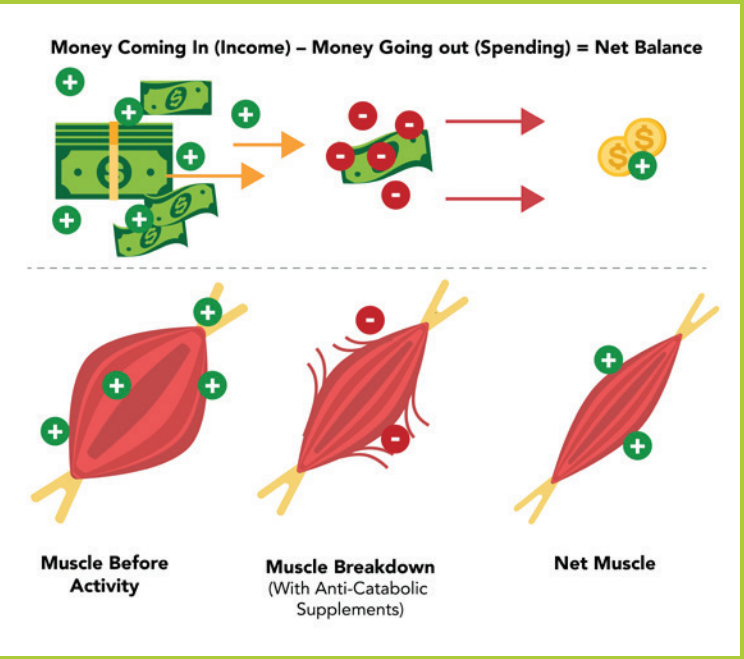
HMB became popular as a supplement because it was reported to help individuals build muscle. While it is often touted as a supplement with anabolic effects, it actually appears to work more as an anti-catabolic supplement. This means that its primary effect is actually to help prevent the breakdown of muscle tissue, which should in theory make it easier to gain muscle.

DIGGING DEEPER

Muscle tissue is a very dynamic tissue, and muscle growth is not a one-sided process. In fact, muscle tissue is always undergoing repair and has two processes that occur: muscle protein synthesis and muscle protein breakdown.

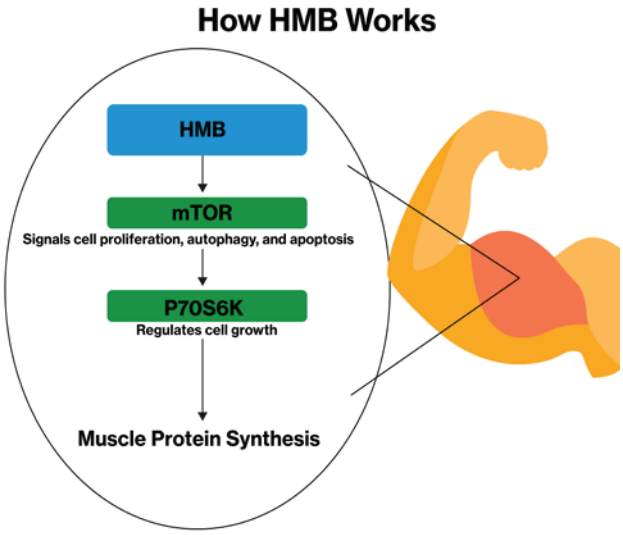
Think about it like your bank account. You have money coming in and you have money going out and the difference between earning money and spending money is the net balance on your account. Your muscle tissue works the same way.

This means that actions that are considered anti-catabolic can help you build muscle tissue because they decrease the muscle protein breakdown. This would be the same as saving money instead of spending it; your net balance on your account can go up because you have decreased your spending.



How Does It Work?

HMB works by turning on the signals in your muscles that reduce protein degradation and increase muscle protein synthesis. Specifically, it is involved in activating the mTOR pathway, which is one of the main regulators of muscle repair and growth. It also works by increasing the activation of genes involved in insulin-like growth factor-1 (IGF-1), which has anti-catabolic effects (Kaczka et al., 2019).



What Is the Evidence?

The evidence on HMB is a bit of a mixed bag, meaning that it is not clear how effective it actually is. On one hand, virtually all studies that look at HMB show that it activates all the molecular machinery it is believed to activate, especially when you have proper dosing (Smith et al., 2005; Wilkinson et al., 2013). Despite that, the outcomes regarding muscle mass growth in humans are inconsistent. For example, a meta-analysis on randomized trials of HMB found that there was no significant difference between HMB and placebo for lean mass gains (Jakubowski et al., 2020).

It might be that HMB works as it is claimed to work, but the effect of it is so small that it is hard to measure the effectiveness of it without tracking results for years. It would be hard to find a difference of <0.5 kg of lean body mass without a very large-scale study.

Dosing

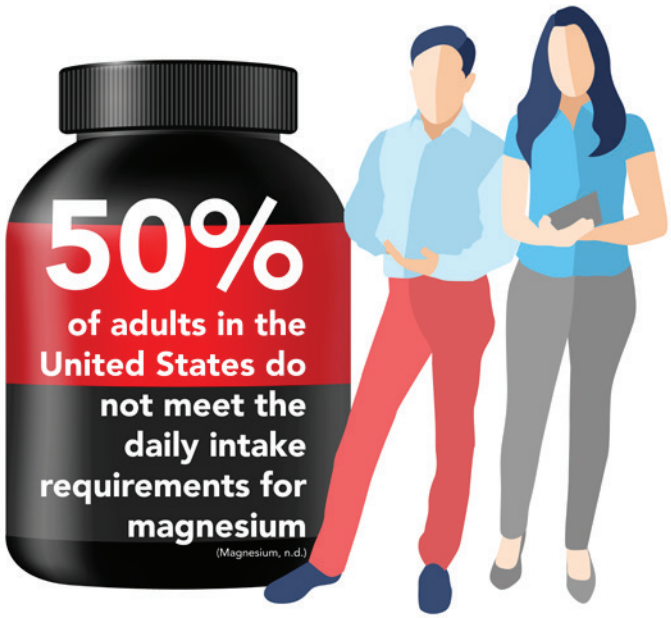
HMB is often dosed between 1.5 and 3 grams per day. While there is not a lot of clear evidence on dose-response, some evidence suggests that 3 grams is definitely more effective than 1.5 grams. Doses higher than 3 grams have not been well-studied and it is not known if going above 3 grams would provide better results. Some studies have gone as high as ~6 grams, but those have been focused mainly on safety and not on muscle growth (Gallagher et al., 2000).

Side Effects

HMB does not have any clear side effects and has not recorded any adverse events in the randomized trials performed on it. Anecdotal reports have suggested that in some rare instances some people might experience GI distress. HMB is often taken alongside creatine, protein powders, and other supplement stacks and does not appear to have any direct conflict with them.

Magnesium

Magnesium is an essential mineral that our bodies need to survive. It is one of the most widely used minerals in our body, being involved in over 300 reactions. It is involved in everything from protein synthesis to blood pressure control to muscle contraction (Jahnen-Dechent & Ketteler, 2012). We often consume magnesium in the foods we eat, but it is also a popular ingredient in many supplements and can be found as a standalone supplement.



Unlike most supplements listed here, the basis for consuming magnesium as a supplement is not intended to enhance physical performance, stamina, or recovery, but rather to correct a deficiency. In fact, it is estimated that more than 50% of adults in the United States do not meet the daily intake requirements for magnesium (*Magnesium*, n.d.).

Magnesium has become a relatively popular supplement and there are many different forms of magnesium, such as magnesium citrate, magnesium sulfate, magnesium glycinate, and many other forms. Magnesium citrate is perhaps the most common form because it is often the cheapest to manufacture and is absorbed quite easily by the body.

What Is It Claimed to Do?

Magnesium affects almost every system in the body, but as a supplement, magnesium is claimed to help improve insulin sensitivity, lower blood sugar, lower blood pressure, and] help people sleep better. It is also often used as an electrolyte to help with hydration.

How Does It Work?

Magnesium might help improve insulin sensitivity and lower blood sugar through two mechanisms. The first is that magnesium can increase the body's ability to release insulin from the pancreas (Guerrero-Romero & Rodríguez-Morán, 2011). The second is that magnesium has been shown to increase insulin sensitivity of muscle tissue and fat tissue, which increases the uptake of blood sugar into those tissues (Oost et al., 2022).

Magnesium might help lower blood pressure among people who are deficient in magnesium in a manner similar to blood pressure medications, specifically ACE inhibitor medications. Magnesium might inhibit the effects of angiotensin II, which directly affects blood pressure (Atarashi et al., 1990; Guerrero-Romero & Rodríguez-Morán, 2009).

With regard to the effects of magnesium on sleep, it is believed that magnesium works to promote sleep by reducing the effect of NMDA on the brain (NMDA affects memory and regulates sleep) and increasing the effect of the inhibitory transmitter GABA (Mah & Pitre, 2021).

What Is the Evidence?

There is quite a bit of evidence to suggest that magnesium supplementation helps lower blood sugar and improves insulin sensitivity among people who have high blood sugar and who are deficient in magnesium (Veronese et al., 2016). This finding appears to be consistent across many meta-analyses, which adds to the evidence base that magnesium can have a beneficial effect on blood sugar (Veronese et al., 2021).

The evidence for magnesium supplementation lowering blood pressure is not quite as strong as it is for blood pressure. Not all randomized trials show a benefit of magnesium supplementation. However, when you pool dozens of trials together, there does appear to be a consistent finding that magnesium lowers blood pressure by ~1 to 1.5% (~2 mm Hg). This is not a large improvement, but it is enough to consider it a benefit (Kass et al., 2012).

While magnesium is quite heavily marketed as a sleep aid, there is not a lot of evidence to suggest that magnesium meaningfully improves sleep among people without sleep disorders (*e.g.*, insomnia). Even then, the evidence for magnesium supplementation as a sleep aid among people with insomnia is quite weak (Mah & Pitre, 2021).

As an electrolyte, magnesium is often included alongside sodium and potassium and can work synergistically with those minerals to help with hydration. However, as a standalone electrolyte, there is little evidence to suggest it is effective at enhancing hydration.

Dosing

Magnesium dosing varies from person to person as some individuals tolerate it well and others do not. Most of the benefits of magnesium come from ensuring individuals are not below recommended levels. Any deficiencies should be determined and diagnosed by a licensed health professional. The standard dosing that is considered effective but safe and well tolerated is ~300 to 400 grams per day from supplemental sources.

Side Effects

There are minimal side effects reported at low doses (less than 300 mg). However, gastrointestinal distress has been noted as one of the main side effects. Specifically, nausea, diarrhea, and abdominal cramping might occur among some people.

BCAAs

Branched-chain amino acids, known as BCAAs, are a type of protein supplement containing three specific amino acids: leucine, isoleucine, and valine. They are known as the branched-chain amino acids because of their specific chemical structure. These three amino acids also happen to be essential amino acids, meaning our body does not create them and we must consume them in our diet.

What Is It Claimed to Do?

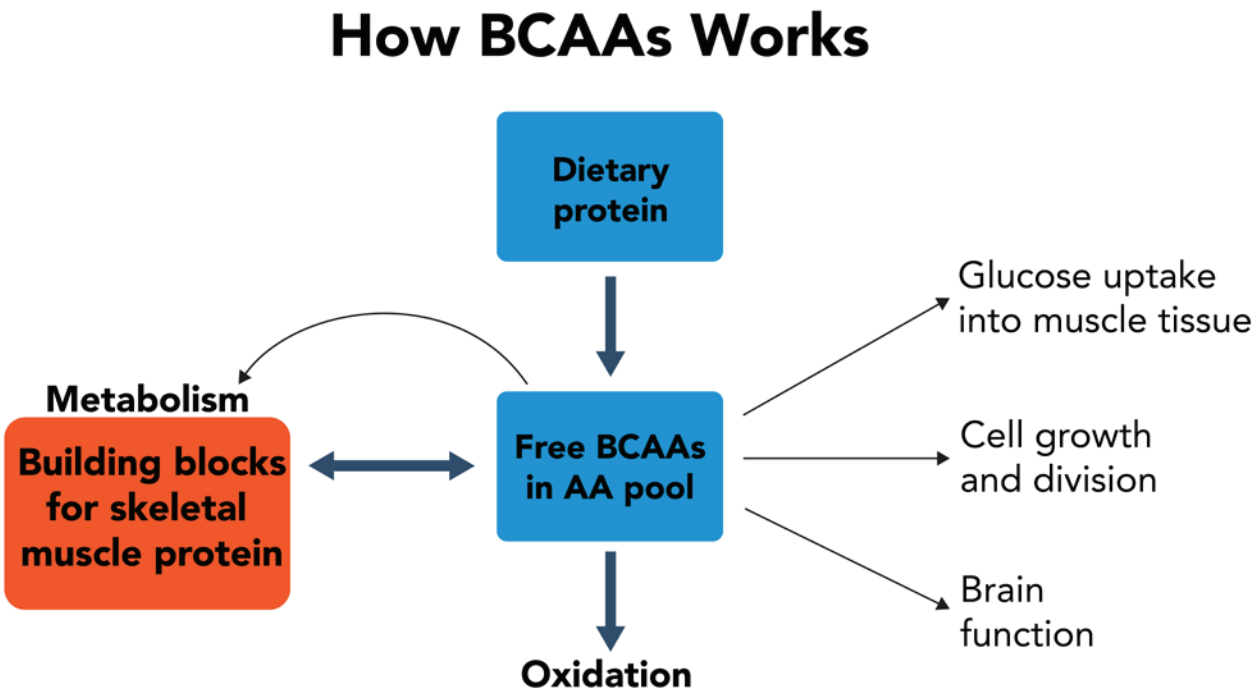
BCAAs began initially as a supplement that was supposed to help you build muscle, or at least keep you from losing muscle. Specifically, people consuming BCAAs take it primarily for the leucine which at doses of ~3 grams or higher promotes muscle growth.

Over the decades, they have also been linked to glucose and they might help with body fat loss. Specifically, isoleucine has been shown to increase how much glucose gets taken up into muscle tissue, while valine and leucine have been shown to increase the body's conversion of that glucose into glycogen, the stored form of carbohydrates in muscle.

While we consume BCAAs in our diet, most foods do not contain high concentrations of BCAAs. This is the reason for BCAA supplements: they provide a higher-than-normal concentration of these specific amino acids that help regulate muscle growth and nutrient metabolism.

How Does it Work?

BCAAs work in two main ways. The first is that they provide key building blocks for skeletal muscle protein. The second is that each of the BCAAs (leucine, isoleucine, and valine) are known to be signals for specific actions in the body. Leucine works to stimulate muscle protein synthesis, isoleucine can increase glucose uptake into muscle tissue, and valine works similarly to leucine but is considered less effective.



What Is the Evidence?

There is no strong evidence to suggest that BCAAs as a supplement provide any meaningful benefit for muscle growth, especially when people are consuming a moderate to higher protein diet. Most adults obtain a "saturated" level of BCAAs when they are consuming adequate amounts of protein. Meta-analyses on BCAA supplementation have found that as a supplement, they do not provide any measurable benefit for muscle growth or recovery (Doma et al., 2021; "The Effect of Branched-Chain Amino Acids Supplementation in Physical Exercise: A Systematic Review of Human Randomized Controlled Trials," 2022). However, they might have a very small effect on reducing markers of muscle damage and soreness that occurs during exercise (Fedewa et al., 2019).

Dosing

Dosing for BCAAs vary quite substantially from person to person and supplemental BCAA consumption is often based on body weight. The recommended dose of BCAAs for the average grown adult is ~20 grams per day, through both diet and supplementation. When looking at supplemental BCAAs alone, ~7.5 to 15 grams per day is considered a normal dose.

Side Effects

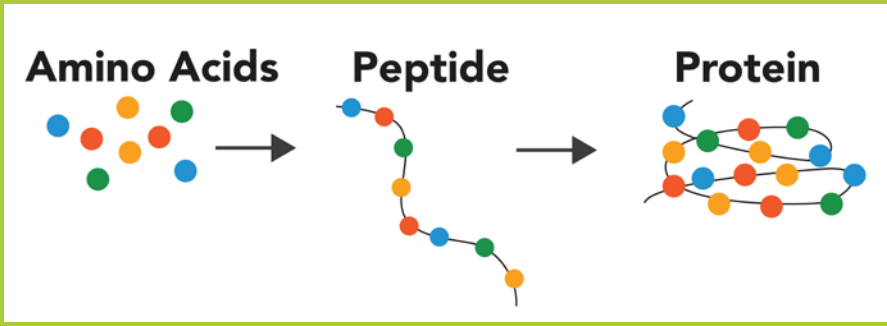
There are minimal side effects reported from BCAA consumption and people appear to tolerate BCAA supplementation quite well. Individuals with amino acid metabolism disorders should consult with a physician prior to consuming BCAAs as a supplement.

Creatine

Creatine is a naturally occurring peptide that is found primarily in your skeletal muscle, but is also found in your brain, heart, and other organs. The average adult body contains ~100 to 150 grams of creatine. Creatine as a supplement has been one of the most widely studied supplements and is one of the most popular supplements in the entire world, with over $250M per year in sales. While you do consume creatine through your food, specifically animal meats, supplementation with creatine is a highly effective way to obtain creatine.

GETTING TECHNICAL

Peptides are molecules that are two or more amino acids linked together. Once peptides get long enough or there are multiple peptides together, they become proteins.



What Is It Claimed to Do?

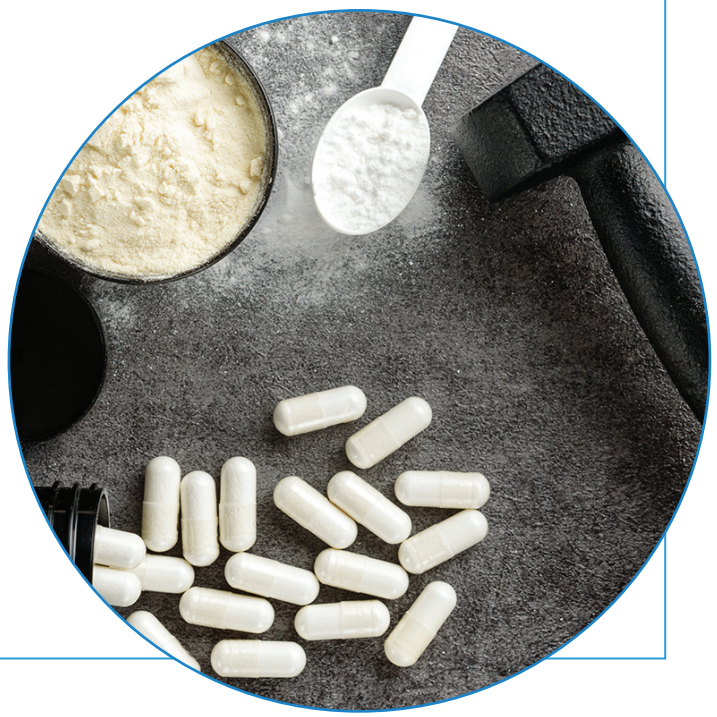
Creatine is claimed to be an ergogenic aid and to help increase lean body mass. There are also claims about what specific form of creatine (creatine monohydrate, creatine hydrochloride, creatine nitrate, etc.) are more effective than others.

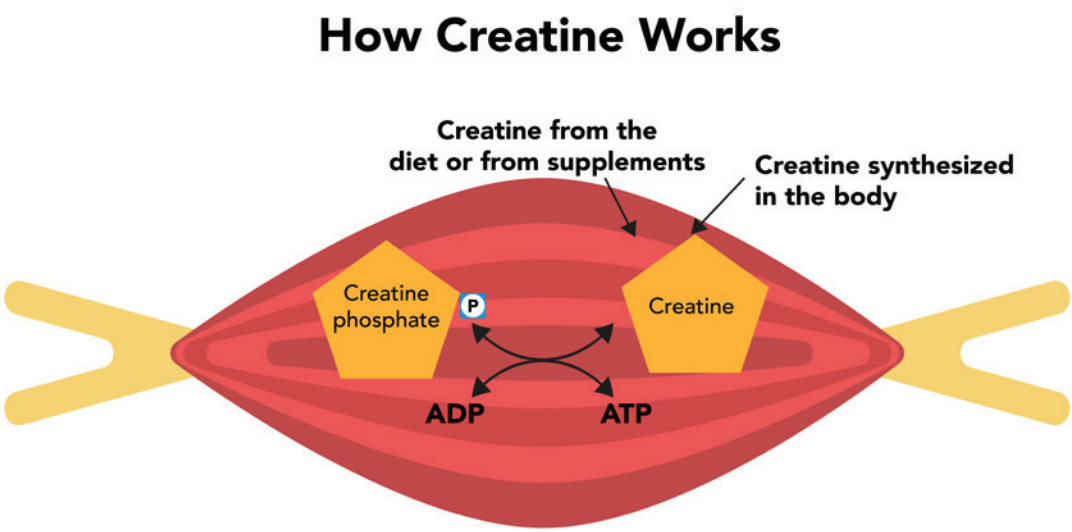
DIGGING DEEPER

You might hear the term ergogenic aid more than once in this guide, and you will likely hear it again somewhere else. The term "ergogenic aid" simple means anything that is intended to enhance physical performance, stamina, or recovery.

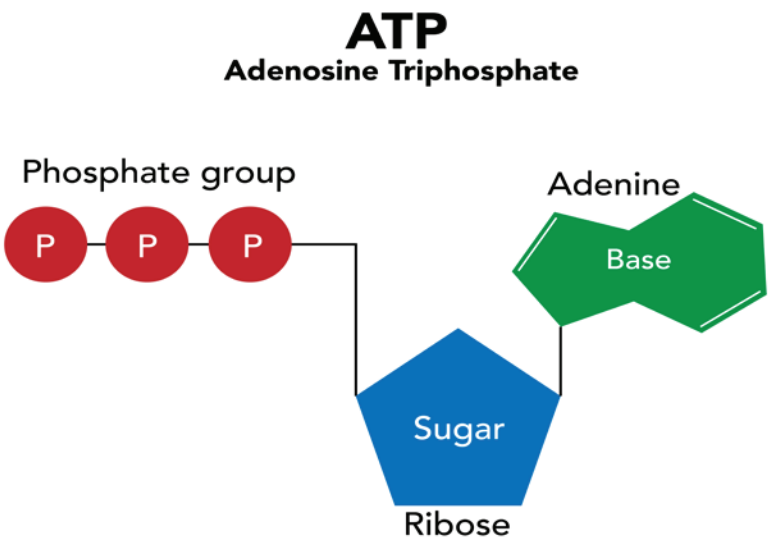
How Does it Work?

Creatine works by increasing the body's capacity to do work. Specifically, supplementing creatine increases the capacity of one of the body's main energy systems: the phosphagen system. The phosphagen system is responsible for providing energy for short bursts, high intensity activity, and for energy when oxygen is not present. It works by using creatine as a phosphate donor to turn ADP back to ATP.





By providing the body with more creatine, it increases the capacity to store more creatine phosphate and allows the body to generate more ATP during the early phases of exercise or during higher intensity exercise. This allows the body to do more work, and by doing more work, the body can build more muscle tissue.



What Is the Evidence?

Creatine might be the most studied and researched supplement, or at least a close second to protein supplements. In fact, there are more than 2,500 studies referencing creatine supplementation in the National Library of Medicine. As an ergogenic aid, the evidence overwhelming supports its utilization for short-burst, high-intensity activity and repeated bouts of activity (Glaister & Rhodes, 2022; Mielgo-Ayuso et al., 2019). As such, there is good evidence that creatine supplementation can improve anaerobic metabolic capacity (*i.e.*, sprinting, jumping, heavy lifting).

Creatine also appears to be effective for increasing muscle strength and muscle hypertrophy (growth of muscle cells) as a secondary outcome of increased work capacity. Creatine appears to be effective for increasing total workload done during strength training sessions, especially when individuals engage in moderate-to-higher intensity training (Rawson & Volek, 2003). There is also some evidence that creatine might help increase maximal strength as well (Lanhers et al., 2016). Muscle growth also is improved through creatine supplementation (Burke et al., 2023). This is most likely due to other factors such as genetics, diet, and how imprecise measuring small amounts of muscle growth can be.

While there are many forms of creatine, there does not appear to be any meaningful advantage to one form or another. Creatine nitrate, creatine hydrochloride, buffered creatine, and creatine monohydrate all provide similar results.

Dosing

Creatine is often dosed at 5 grams per day and it takes anywhere from one to four weeks to have an effect. This is due to the fact that creatine works on the principle of bioaccumulation, meaning that creatine stores have to increase over a few weeks before there is enough of an effect to be observed. Dosing can be effective at lower doses (~3 grams per day) for smaller individuals. Conversely, dosing might need to be higher (~7 to 10 grams per day) for much larger individuals.

You can speed up the bioaccumulation process by going through a "loading" phase. This often includes consuming higher doses of creatine (~20 grams per day) for the first week and then moving to the maintenance dose (~5 grams per day) after that.

Additionally, while creatine is often marketed as a "pre-workout" ingredient, it is not necessary to consume creatine before a workout. Since it works through bioaccumulation and it takes days to have an effect, you can consume it at any time during the day.

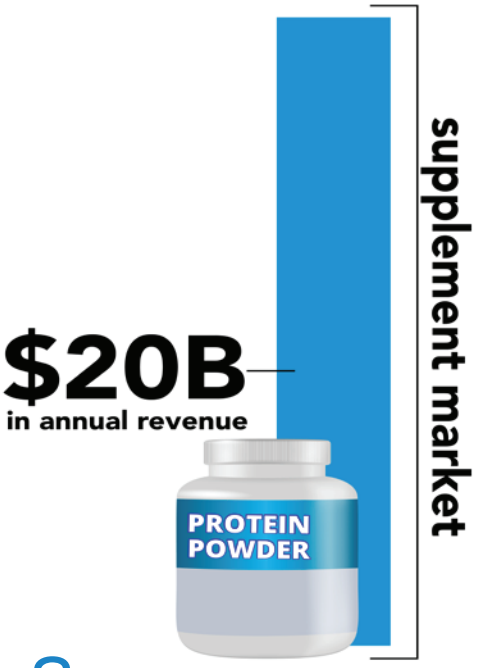
Side Effects

There are well-documented side effects from creatine, but they are relatively minor and occur in a small portion of people. The most common one is weight gain. This is the result of your body holding more water along with the creatine inside your muscle tissue. The second side effect is gastrointestinal distress. This is usually a result of consuming creatine without adequate water, which can often be eliminated or reduced by breaking the ~5 grams per day into two or three smaller servings and consuming it alongside plenty of water.

Protein Supplements: Whey, Vegan, and Casein

Protein supplements have become a massive market, with some estimates putting the protein supplement market above $20B in annual revenue. This represents roughly 20 to 30% of the entire supplement market. One of the primary reasons that protein supplements are so popular is that they are often convenient tools to help individuals meet their daily protein needs, especially in the modern era where life is often lived on-the-go.

The average adult in North America weighs ~180 pounds, which means that the ideal protein intake would be ~120 to 180 grams of protein per day, with the minimum requirement being ~70 grams per day. For most people, getting this through food alone can be difficult. This leads to protein supplements being a part of many individuals' daily food consumption in the form of protein bars, protein shakes, or other protein supplements. These protein supplements can be derived from animal sources, such as whey or casein proteins, or they can be derived from plant sources, such as rice or pea protein.



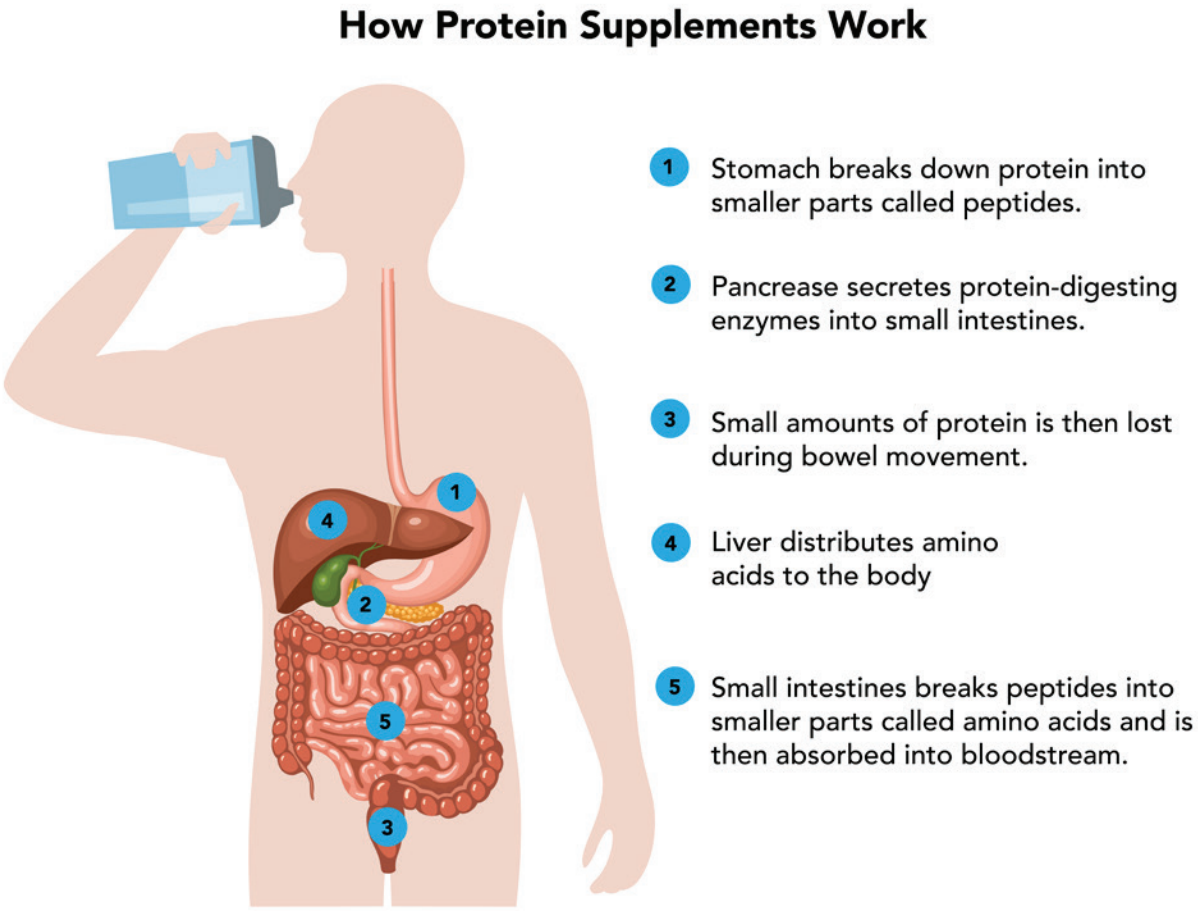
What Is It Claimed to Do?

While protein supplements have many uses, they are primarily marketed for three different reasons. The first reason is that they help you build muscle. The second reason is that they can help you recover faster from training. The third reason is that they can help you lose weight.

How Does It Work?

Protein supplements are possibly the most straightforward of all supplements as they simply provide a concentrated source of protein. While we often think about them as a "supplement", in most cases they are essentially concentrated forms of protein. For example, whey protein is a dairy-based protein

that has been concentrated from a dairy source to contain almost entirely just the protein component. The extra protein in your diet provides extra amino acids for muscle growth and repair, while the higher protein content in your diet increases satiety and leads to lower calorie intake.

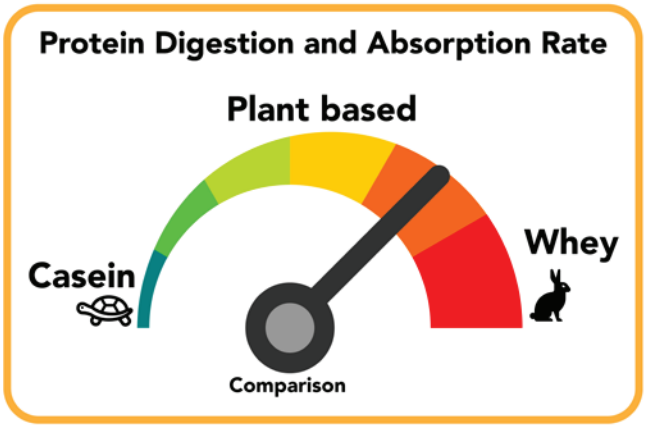


What Is the Evidence?

Protein supplementation (regardless of the exact type) does increase your body's ability to grow muscle tissue, especially when combined with resistance training (Cermak et al., 2012). However, there is a limit to this as protein intake above 1.6 g/kg or 0.8 g/lb. does not appear to convey any more benefit for muscle growth (Garlick, 2001; Morton et al., 2018). There is one caveat here: you do not necessarily *need* to consume protein in a supplement form to get these benefits, but consuming protein in a supplement form is often convenient and easy to help people hit their protein targets.

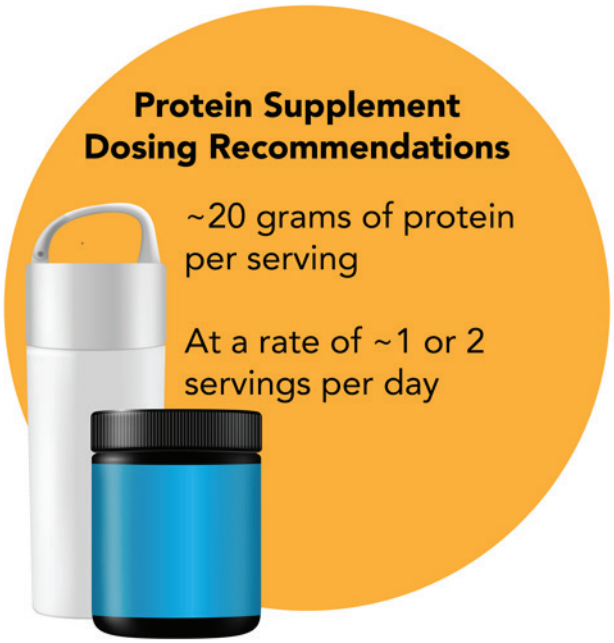
Protein supplementation also has good evidence supporting its use as a weight loss aid. Several meta-analyses have shown that protein supplementation leads to meaningful weight loss in adults, especially adults who have obesity or are overweight (Sepandi et al., 2022; Wirunsawanya et al., 2018). While the evidence does not suggest you have to use protein supplements as a meal replacement, the data suggest that they are more effective when they are used as a meal replacement and used in conjunction with lifestyle modification.

There are some differences between the different types of protein, specifically plant versus animal proteins and within the animal proteins, whey and casein. Whey protein, an animal protein, is digested and absorbed a bit faster than plant-based proteins like soy. Casein, another animal protein, is digested quite slowly and is digested slower than both whey and soy. In general, animal proteins are slightly more anabolic than plant proteins; however, when it comes to actual muscle growth, they are largely the same (Messina et al. 2018). This means that plant-based protein supplements are roughly equal for muscle growth as animal-based protein supplements.



Dosing

Dosing for protein supplements is not quite as straightforward as other supplements, as these are often taken in the context of the overall diet. However, most protein supplements should be consumed with ~20 grams of protein per serving and are often consumed at a rate of ~1 or 2 servings per day as supplementation and in addition to food-based protein sources. There is not a clear "upper limit" for how much protein people can consume in a single sitting and still get a muscle growth response. However, doses above ~40 grams in one serving begin to have very marginal benefits and going above 40 grams is unlikely to result in any meaningful benefit.



Side Effects

There are minimal side effects from protein supplements, but individuals should choose the type they consume (animal or plant) based on specific food restrictions or dietary choices they make. Potential side effects include GI issues, including increased gas and bloating. Individuals who are looking to increase their protein intake should slowly increase their daily intake over the course of a few weeks or months to allow their GI system to adapt.

Healthy adults have no contraindications for protein supplements. However, individuals with liver or kidney issues should consult with a physician prior to consuming a protein supplement.

Beta-alanine

Beta-alanine is what is known as a precursor supplement. This is because beta-alanine is not actually the "target" of this supplement, but rather the goal is to have the body turn beta-alanine into another molecule called carnosine. Beta-alanine is the rate-limiting ingredient for the body-producing carnosine, and when you consume higher amounts of beta-alanine, your body will manufacture more carnosine.

Carnosine has two major roles in the body. First, it helps the body maintain acid-base balance during exercise and other periods of anaerobic metabolism. This can help delay fatigue as increasing acidity is one of the main reasons you feel fatigue and "the burn" during exercise. Second, it works as one of the major intracellular antioxidants in the body. Intracellular antioxidants are primarily responsible for preventing oxidative stress, which leads to damage inside your cells.

GETTING TECHNICAL

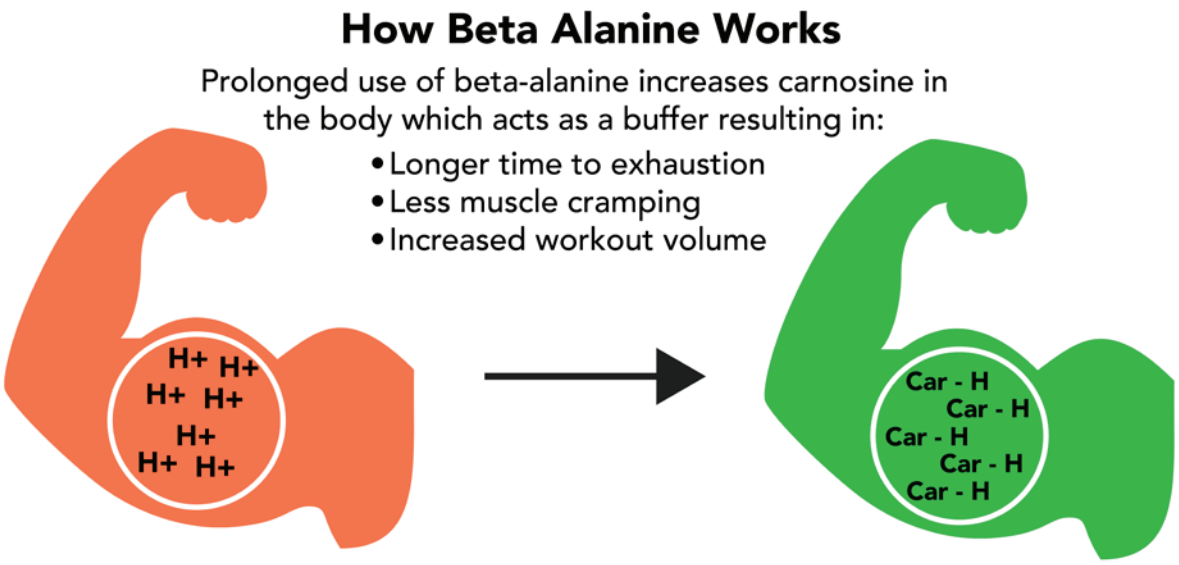
Your body has a lot of reactions that are known as rate limiting. This means that there is usually one specific part of the reaction that keeps it from continuing to run. Think about it like making chocolate chip cookies. You have enough butter, sugar, flour, and eggs to make 3 dozen cookies, but you only have enough chocolate chips to make 2 dozen cookies, which means you can only make 2 dozen cookies. If someone were to bring you another bag of chocolate chips you could make the last dozen.

What Is It Claimed to Do?

Beta-alanine is claimed to delay or decrease muscle fatigue during exercise and increase exercise capacity. Secondarily, it is also claimed to be an antioxidant and improve immune function.

How Does It Work?

Beta-alanine works by increasing your intracellular stores of carnosine, specifically stores in your muscle tissue. However, carnosine levels are also higher in your brain and heart tissue, suggesting that it exerts its antioxidant effects in those tissues as well.



Carnosine acts as a type of molecular sponge to help maintain acid-base balance inside cells. Effectively, it holds onto hydrogen ions that are produced during anaerobic metabolism, specifically glycolysis (the process of converting sugar/glucose into energy). It also functions as an antioxidant by scavenging free radicals, which are unstable atoms that can damage cells and cause aging and disease.

What Is the Evidence?

There is clear evidence that beta-alanine supplementation does increase intramuscular stores of carnosine (Derave et al., 2007; Harris et al., 2006; Hill et al., 2007). Importantly, the increases in the stores of muscle carnosine are quite large, with some studies showing up to 80% increases in muscle carnosine concentrations after ~10 weeks of supplementation (Hill et al., 2007).

Beta-alanine has been shown across numerous studies to improve exercise performance. One meta-analysis found that beta-alanine supplementation improved exercise capacity during exercise that lasted ~60 to 240 seconds, which is considered glycolytic and acid producing, but did not improve exercise that was <60 seconds (Hobson et al., 2012). The increased exercise capacity usually results in you being able to exercise longer and do more total volume. In some cases, it can increase the intensity of your exercise. Another independent meta-analysis found the same thing, where beta-alanine improved exercise that related to glycolysis and acid production, but not to exercise that was not related (Saunders et al., 2017).

On the other hand, the effect of beta-alanine as an antioxidant is less studied and there is limited evidence to suggest that supplementing with beta-alanine does much to convey benefit with regard to oxidative stress (Oxidative stress occurs when there are too many unstable atoms that can cause damage to cells, which can result in aging and disease.)

Dosing

Similar to creatine, beta-alanine is effective when taken in doses of ~5 grams per day over long periods of time. It takes ~4 weeks for carnosine stores to increase to a meaningful degree and to begin to see the performance benefits of beta-alanine supplementation. However, many people report a tingly feeling on their face, hands, and other parts of their body when consuming all 5 grams at once. This can be avoided by consuming the 5 gram dose in multiple, smaller servings throughout the day.

Side Effects

You might notice a "tingly" feeling when taking beta-alanine as a supplement at doses ~5 grams. This is known as paresthesia and usually lasts less than an hour. While it can often be unpleasant, it is not necessarily a dangerous side effect and it does not appear to cause any health issues. This ingredient is one of the main reasons why many pre-workouts can give you the itchy-face or tingly feeling.

Citrulline Malate

Citrulline malate is a form of the amino acid citrulline. It is the combination of the amino acid L-citrulline with malic acid, which supposedly makes it more effective than citrulline alone. Citrulline is found in the human body naturally and is involved in the same metabolic pathway (sequence of chemical reactions in the body) as another popular supplement, L-arginine. Citrulline plays a role in nitric oxide metabolism and ammonia cycling. Supplementation with citrulline malate is believed to increase nitric oxide metabolism, which can affect blood flow and nutrient delivery.

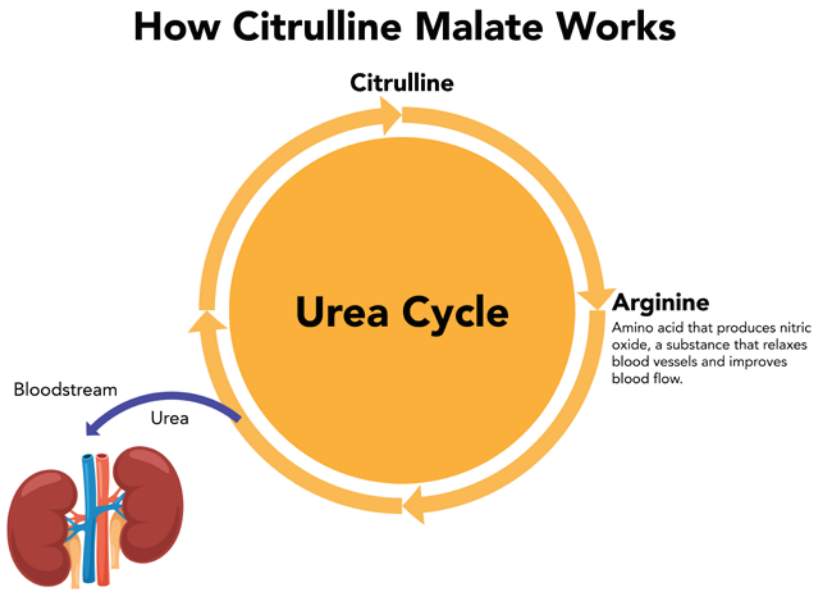
What Is It Claimed to Do?

Citrulline malate is claimed to increase blood flow and to improve exercise performance, reduce soreness, and make it easier for you to get what bodybuilders refer to as "the pump". There have also

been claims that it can lower blood pressure due to it increasing blood flow and changing vascular tone. The increased blood flow allows your body to carry more oxygen and nutrients to your muscle tissue and carry more waste products away from your muscle tissue which should, in theory, allow you to exercise harder for longer.

How Does It Work?

Citrulline malate increases levels of arginine in the blood, which in turn increases nitric oxide. Nitric oxide is one of the main vasodilators (blood vessel dilators) which increases blood flow around your body, which might help with delivering more nutrients to your muscle tissue.



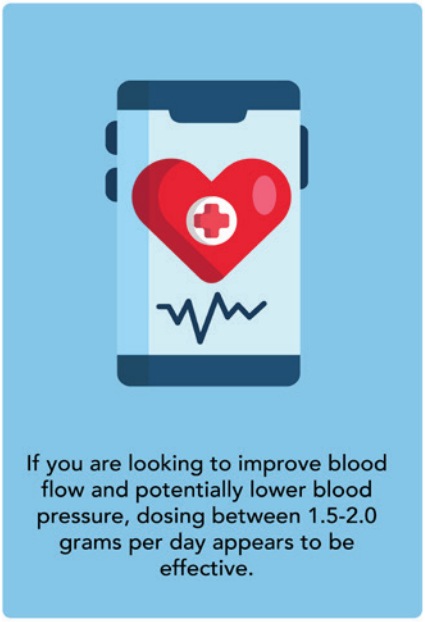
What Is the Evidence?

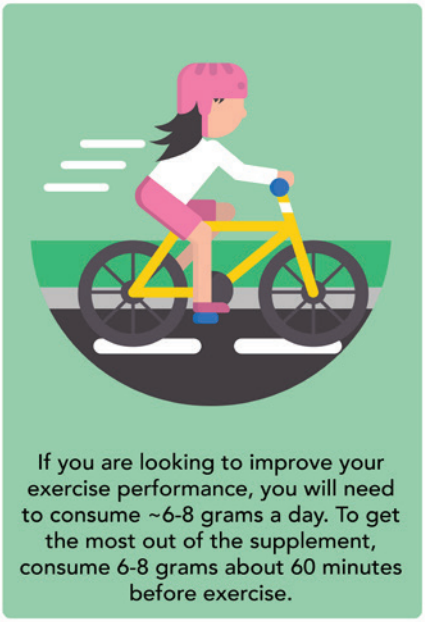
The evidence for citrulline malate increasing exercise performance is fairly consistent but shows very minor improvements. For example, a meta-analysis on citrulline malate found a very small improvement on strength and power during high-intensity exercise (Trexler et al., 2019). However, the individual studies themselves showed a wide range of outcomes and had some pretty big uncertainties in the studies themselves, suggesting that a much larger sample size is needed to fully understand its effects. It also might affect individual people very differently, to the point where you might not benefit from it but someone else might.

Citrulline malate does have good evidence that it does affect blood flow. However, the effects are quite small. One meta-analysis of 17 randomized trials found that supplementation with citrulline improved vasodilation by less than 1% (Smeets et al., 2022). In total, if you choose to supplement with citrulline malate, there might be very small effects on performance and blood flow and you might not notice it.

Dosing

Dosing of citrulline malate depends on the outcome that you are looking for. If you are looking to improve blood flow and potentially lower blood pressure, dosing between 1.5 to 2 grams per day appears to be effective. If you are looking to improve your exercise performance, you will need to consume ~6 to 8 grams a day. To get the most out of the supplement, consume 6 to 8 grams about 60 minutes before exercise.





Side Effects

Citrulline malate appears to be well-tolerated by most people and does not appear to have any of the gastrointestinal side effects that often come with arginine. Individuals with already low blood pressure should consult a physician before taking it.

Sodium Bicarbonate

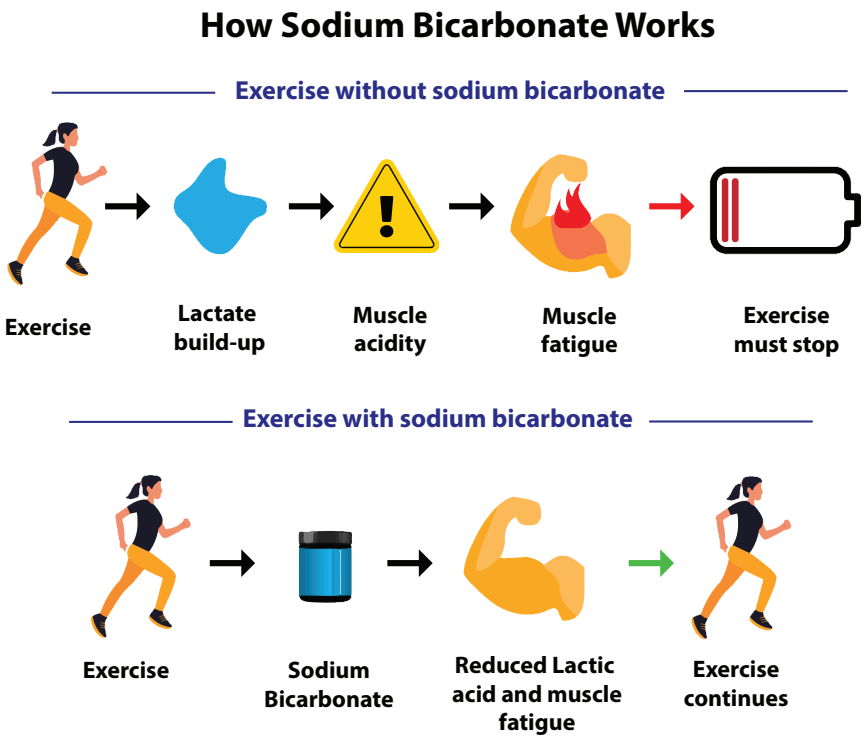
Sodium bicarbonate is commonly found in most households in the form of baking soda. From a dietary perspective, sodium bicarbonate provides a dietary source of bicarbonate. Bicarbonate is a molecule found naturally in the body, primarily in the blood, and helps to maintain pH by reducing the acid load in the blood. As acid increases and pH decreases due to exercise, your body's ability to continue exercising decreases and you begin to experience fatigue (acid accumulation is one component of fatigue). Sodium bicarbonate allows your body to handle more acid load before pH drops and fatigue sets.

What Is It Claimed to Do?

Sodium bicarbonate is claimed to improve exercise performance during exercises that create large metabolic strain and induce metabolic acidosis, such as repeated sprints or moderate duration (30 seconds to 10 to 12 minutes) high-intensity exercise.

How Does It Work?

Sodium bicarbonate works by increasing the amount of bicarbonate in the blood. When you exercise at higher intensity for extended duration, your body produces hydrogen ions, which lowers pH which contributes to fatigue and decreases your body's ability to exercise. Bicarbonate absorbs the hydrogen ions that are produced during exercise and raises your pH back into normal range, which reduces fatigue, and allows you to continue exercising.



What Is the Evidence?

There is clear evidence that sodium bicarbonate can increase the buffering capacity of your blood. For example, sodium bicarbonate is used quite extensively in healthcare, especially in critical care medicine. Intravenous sodium bicarbonate is often given to people with metabolic acidosis because it is highly effective for raising pH and managing metabolic acidosis (Yagi & Fujii, 2021). When sodium bicarbonate is used as a supplement, it is often consumed orally and at much smaller doses than those given via IV injection in a medical setting, but the premise is the same.

When consumed as a supplement, sodium bicarbonate has been shown to effectively increase buffering capacity and, as a result, increase exercise capacity. This has been shown to hold true across many different forms of exercise, including rowing, sprinting, and cycling (Lino et al., 2021; Nielsen et al., 2022).

While the data consistently shows that you do benefit from sodium bicarbonate supplementation, the size of the effect appears to vary greatly from sport to sport and athlete to athlete. You might experience a fairly large and noticeable effect, or you might be possible to experience a very small, unnoticeable effect.

Dosing

In the context of exercise performance, consuming ~200 to 300 mg/kg about an hour or so before exercise appears to be the optimal dose. You can also take a "bioaccumulation" approach, similar to creatine, and you can consume 500 mg/kg per day over a 3- to 7-day period and obtain similar benefits as acute dosing. Importantly, you can use standard baking soda found at your local grocery store as branded supplement forms are the exact same thing.

Side Effects

The most common side effect is gastrointestinal distress. Specifically, diarrhea, nausea, and flatulence. This is quite common especially when doses exceed 200 mg/kg. One way to reduce the likelihood of these side effects is to dilute in water and sip slowly over the course of an hour.

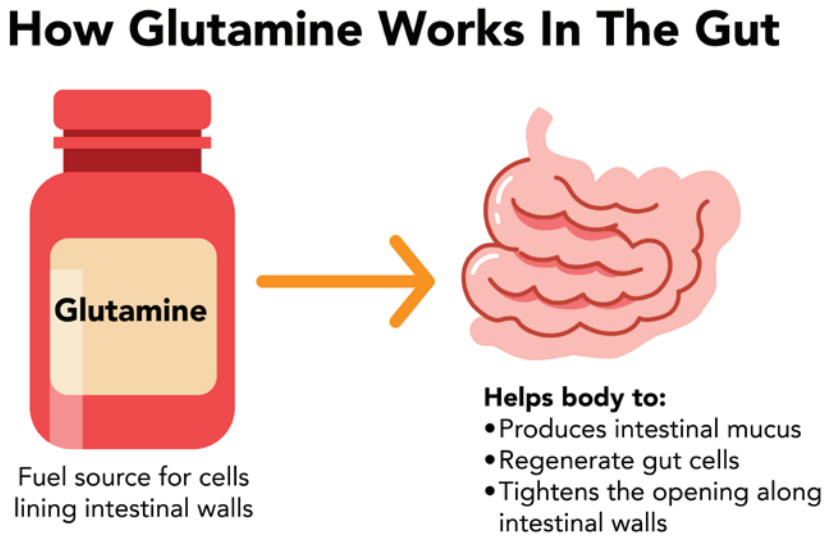
Glutamine

Glutamine is one of the 20 amino acids and is considered one of the "conditionally essential" amino acids. This means that under normal circumstances your body produces enough glutamine on its own, but during periods of stress, injury, or illness; it might not be able to produce enough and must be consumed in your diet. Glutamine is found in organ meats, beef, milk, yogurt, cheeses, eggs, dark leafy greens, nuts, and seeds. Most adults consume relatively high amounts of glutamine in their regular diet, but it can be supplemented as well.

Glutamine plays many roles in the body, but some of the more well-known roles involve maintaining the integrity of the gut lining and in maintaining immune function. There have been some suggestions that it plays a role in exercise recovery as well.

What Is It Claimed to Do?

Glutamine is claimed to do three main things. The first is that glutamine can improve gastrointestinal issues. The second is that glutamine can help boost the immune system during periods of stress. Lastly, glutamine has been claimed to help with muscle growth.



How Does It Work?

Supplementing with glutamine simply increases the amount of glutamine available to the body and allows the body to have more glutamine available to use than it would if it only manufactured it on its own. Additionally, your body does not necessarily "store" extra glutamine; instead, it converts it to other amino acids it needs if it is overconsumed.

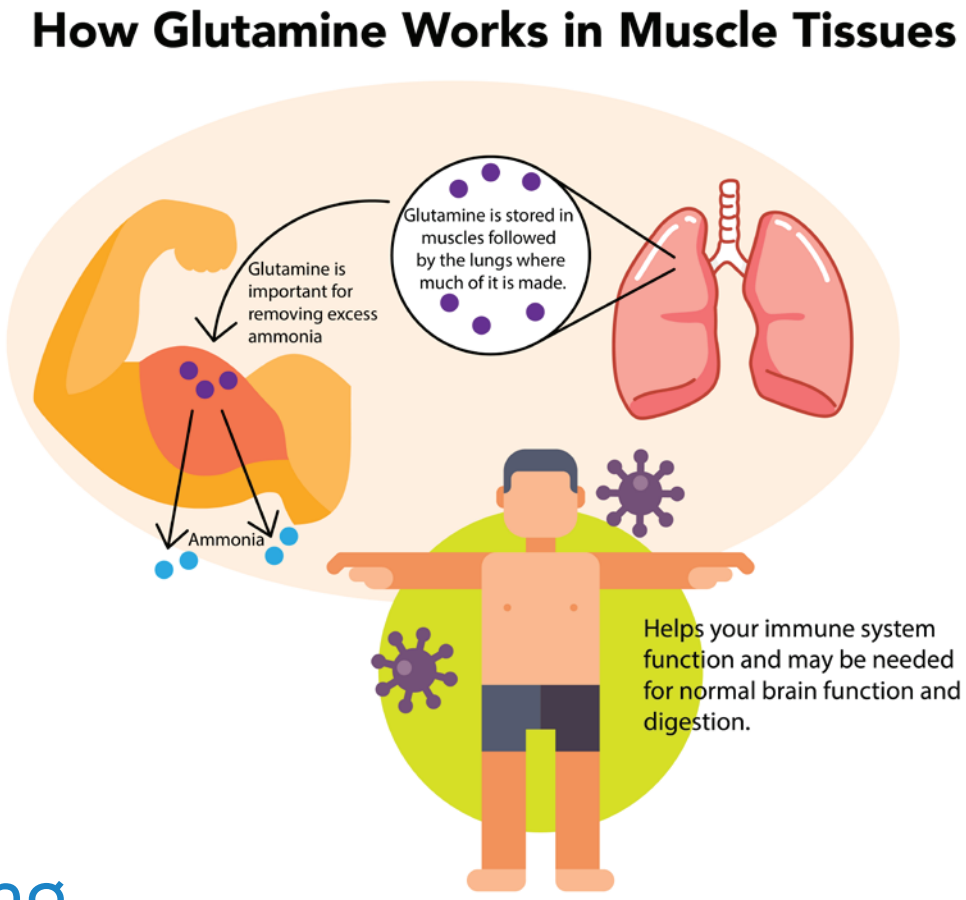
What Is the Evidence?

There is some evidence that supplementing with glutamine provides benefits to some individuals who experience irritable bowel syndrome or have other gastrointestinal issues. For example, glutamine has been shown to enhance the efficacy of dietary interventions among individuals with irritable bowel syndrome (Rastgoo et al., 2021). Glutamine has also been shown to reduce inflammation and improve gut integrity in people following abdominal surgery (Shu et al., 2016). In totality, the evidence does suggest that if you have irritable bowel syndrome or issues with a "leaky gut", glutamine supplementation might provide you with some benefit.

Athletes who engage in high volumes of exercise or who experience overtraining can have altered immune function and have a higher likelihood of getting sick (Chung et al., 2021; Kreher & Schwartz, 2012). It was initially believed that glutamine supplementation could help bolster immune function in athletes since many immune cells use glutamine as a food source. However, the evidence is lacking.

In fact, a meta-analysis of 47 different studies found that there was no meaningful effect of glutamine supplementation on immune function (Ramezani et al., 2019). As such, you are unlikely to see any real immune-boosting benefits from consuming glutamine as a supplement.

Lastly, there is also very little evidence that supplementing with glutamine helps with muscle growth. A meta-analysis found that there was no real benefit to glutamine on lean body mass (Ramezani et al., 2019). When you drill down even deeper, a randomized trial that added glutamine to resistance training programs also found that there was no real benefit to glutamine supplementation on muscle growth (Candow et al., 2001).



Dosing

Given that glutamine supplementation is largely ineffective for outcomes outside of improving gastrointestinal symptoms, dosing should be based on those studies. Most evidence suggests you should consume at least 5 grams per day to see any benefit.

Side Effects

There do not appear to be any meaningful side effects and glutamine is well-tolerated. While higher doses are not recommended, it does appear to be safe in doses upwards of 50 grams per day taken for several weeks at a time (Garlick, 2001).

Conclusion

Supplements are a massive industry and they have quickly become a major component of health, fitness, wellness, and dieting culture. Most gym chains have relationships with supplement manufacturers, professional athletes have launched supplement companies, and even professional and academic conferences are sponsored by supplement companies. This has made it difficult to navigate on the many supplements offered.

Many supplements do have benefits, and, when used correctly, can provide a lot of utility. However, many supplements are sold based on marketing claims that have little to no evidence to support them. Understanding the actual evidence behind each supplement, their intended use, proper dosing, and potential side effects can help you make the most educated decisions for yourself. This guide should allow you to determine the supplements that might benefit you in reaching your fitness goals and determine which ones just don't make the cut.

What You Can Do Now

The primary goal of this guide was to help you make educated decisions about the top 10 supplements on the market, whether or not they align with your goals, and if there is good evidence to support their use. Use the matrix below as a summary tool to decide which supplements, if any, might make sense for you.

Supplement	Claims	What the Science Says	Evidence Level	Effect Size	Dosing	Side Effects
Caffeine	Stimulant/ anti-fatigue	Effective stimulant/ anti-fatigue	High	High	~3 to 6 mg/kg per day	Might increase blood pressure and heart rate
	Increase exercise capacity	Effective for increasing exercise capacit	High	Moderate		Might increase anxiety among people with established anxiety disorders
	Fat-loss enhancer	Minimal effect on fat loss	High	Small		
HMB	Enhance muscle growth	No measurable effect	High	Small to none	1.5 to 3.0 grams per day	No known side effects

Magnesium	Improve insulin sensitive/ glucose control	Improves insulin sensitivity and blood sugar	High	Moderate	300 to 400 grams per day from supplemental sources	Diarrhea, nausea, and abdominal cramping are note at doses above 300mg per day
	Lower blood pressure	Can lower blood pressure among people deficient in magnesium	Moderate	Small		
	Improve sleep	No real evidence for benefits on sleep	Moderate	None		
BCAAs	Increase muscle growth and decrease muscle breakdown	No evidence for muscle growth	High	None	~7 to 15 grams in supplemental form	No known side effects in otherwise healthy adults
		Decreases markers of muscle damage and soreness	Low	Small		
Creatine	Increase exercise performance	Strong evidence for increasing exercise performance in short duration, high intensity, and repeated bouts of exercise	High	Moderate	~5 grams per day	Weight gain and gastrointestinal distress
	Increase lean body mass	Strong evidence for strength and muscle growth	High	Small	Loading period can include ~20 grams per day for 3 to 7 days.	
Protein Supplements	Increase muscle mass and improve recovery	Strong evidence for increasing muscle mass and improving recovery	High	Moderate	~20 grams per serving used in conjunction with whole foods to reach daily protein intake targets	No side effects in otherwise healthy adults
	Aid in weight loss	Robust evidence as a weight-loss aid when used in conjunction with lifestyle modification	High	Large		
Beta-alanine	Decrease exercise fatigue and increase exercise capacity	Strong evidence that it Improves exercise capacity during exercise that lasted ~60 to 240 seconds, which is considered glycolytic and acid-producing	High	Moderate	5 grams per day	Paresthesia (itchy/ tingly feeling) is a common side effect at doses ~5 grams and higher
	Increases antioxidant capacity	No real evidence it increases antioxidant capacity	Moderate	None	Might be broken into smaller portions throughout the day	Can be avoided by consuming smaller doses throughout the day

Citrulline Malate	Increase blood flow Improve exercise performance	There is evidence for increased blood flow Some evidence shows it provides increases in exercise capacity	Moderate Moderate	Small Small	1.5 to 2.0 grams per day for blood flow 6 to 8 grams taken 60 minutes before exercise for improvements in exercise capacity	No known side effects Individuals with low blood pressure should consult a physician before using
Sodium Bicarbonate	Increased exercise capacity	Strong evidence for increased exercise capacity across moderate-to-high intensity sports	High	Moderate	200 to 300 mg/kg an hour before exercise	Diarrhea, nausea, and flatulence are common side effects at doses above 200 mg/kg
Glutamine	Improve gastrointestinal issues Increase immune function during periods of stress Enhance muscle growth	Glutamine can improve gastrointestinal issues in many populations Does not meaningfully improve immune function No evidence for enhanced muscle growth	High High High	Small-to-moderate Small-to-none None	5 grams or more per day	There do not appear to be any meaningful side effects and it is well-tolerated

Online Resources

Want to learn more about nutrition? Here are a few places to find reliable information and insight about nutrition and healthy eating behaviors.

- NASM Certified Nutrition Coach Certification (NASM-CNC)
- NASM Blog
- NASM YouTube Channel

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