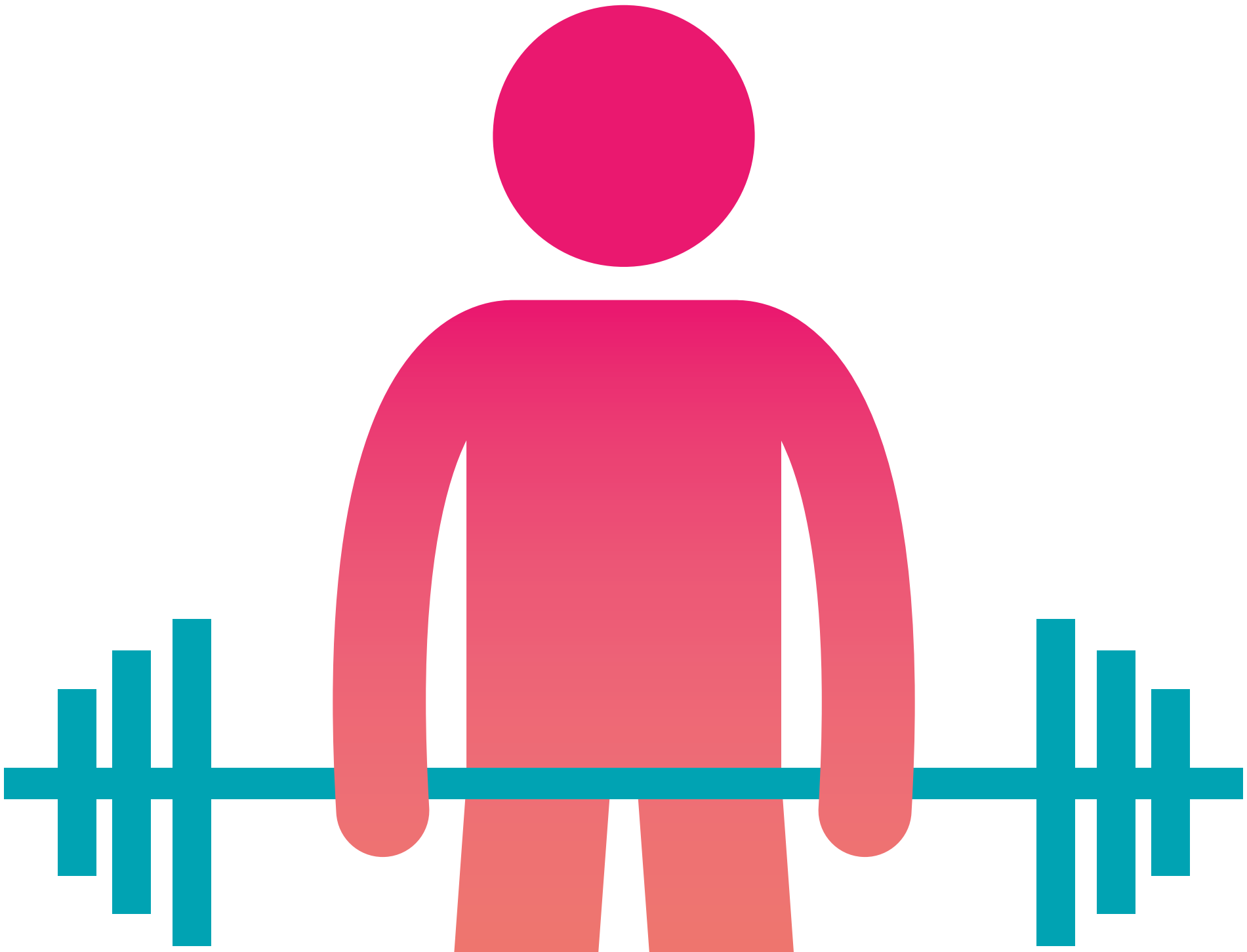
Examine.com

Muscle Gain & Exercise Performance Supplement Guide



Written by the editors of Examine.com

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Medical Disclaimer

This guide is a general-health document for adults over 18. Its aim is strictly educational. It does not constitute medical advice. Please consult a medical or health professional before you begin any exercise-, nutrition-, or supplementation-related program, or if you have questions about your health.

This guide is built on scientific studies, but study outcomes are never homogeneous: individual results do vary. If you engage in any activity or take any product mentioned herein, you do so of your own free will, and you knowingly and voluntarily accept the risks. While we mention major known interactions, it is possible for any supplement to interact with other supplements, as well as with foods and pharmaceuticals.

A product may not contain the exact compounds and amounts listed on its label. Before you decide whether to take it, investigate it and its manufacturer. More than isolated compounds, herbs are prone to batch-to-batch variability, which can alter their efficacy and safety.

For evidence supporting the claims mentioned in this guide, please visit Examine.com.

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How to Use This Guide

The Examine.com team has been publishing research on nutrition and supplementation since March 2011. Drawing from all we've learned, we've designed this Stack Guide to help you figure out which supplements can help you reach your health goal, and which can hinder you or just waste your money.

Core supplements have the best safety-efficacy profile. When used responsibly, they are the supplements most likely to help and not cause side effects.

Primary options may provide substantial benefit, but only in the right context. A primary option is not for everyone, but if you read the entry and find that you meet the criteria, consider adding the supplement to your stack.

Secondary options have less evidence for their effects. They could work or be a waste of money. Keep them in mind, but think twice before adding them to your stack.

Promising supplements are backed by tradition or by mechanistic, animal, epidemiological, or anecdotal evidence, but not yet by convincing human trials.

Inadvisable supplements are either potentially dangerous or simply ineffective, marketing claims notwithstanding. Do not add them to your stack. At best, they'll be a waste of money; at worst, they can cause you harm.

Now that you've been presented with various supplements worthy of your interest, the time has come to combine them based on your objective. We'll guide you in **assembling your stack**.

Then comes the **FAQ**, in which we cover common questions that may arise when assembling your stack.

Lastly, we include information on **precautions and troubleshooting**.

With all this combined, you should be able to identify and assemble the supplement stack best suited to your objective.

Core Supplements

Creatine

Why it's a core supplement

Creatine monohydrate is backed by strong evidence for both its safety and its ability to increase power output and anaerobic endurance.

Supplementing creatine monohydrate increases the body's creatine stores, which are located primarily in the skeletal muscles. Your cells use creatine to regenerate *adenosine triphosphate* (ATP), life's energy currency, before they turn to burning glucose. In short, more creatine helps your muscles perform better under pressure (it helps you knock out those last few reps).

Creatine was also investigated for its effects on androgens, with most studies concluding that it had none. Moreover, the increase in testosterone reported by two studies (22% and 22.7%) is too small to have much of an effect on muscle gain or exercise performance. A lone study noted a 40–56% increase in dihydrotestosterone (DHT) with no change in testosterone — a puzzling result that has yet to be replicated.

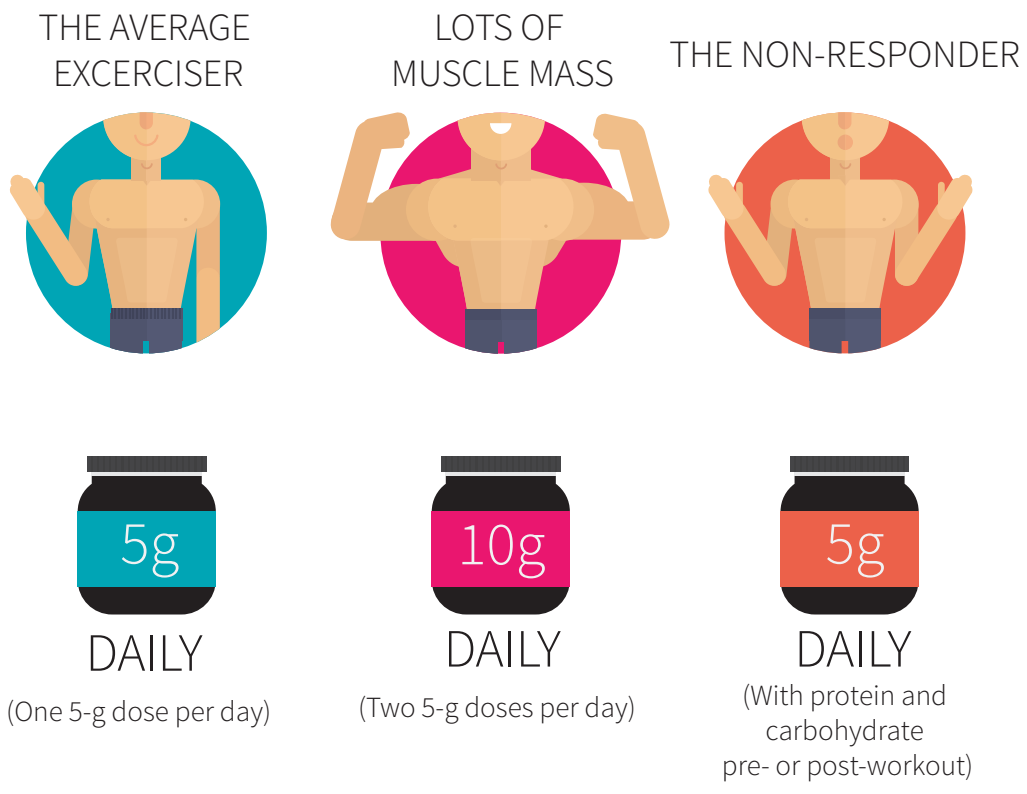
Decades of research vouch for creatine's safety. Its only potential side-effects are nausea, stomach cramps, and diarrhea from too large a dose. Creatine causes some water retention, but if you exercise, with time the proportion of added muscle to added water will increase.

How to take it

Take **creatine monohydrate**. Other forms of creatine may be more *expensive*, but studies have not found them to be more *effective*. Should you find yourself particularly sensitive to creatine's digestive side-effects, which include nausea and cramping, try drinking more water. You can also split your daily dose and take it with meals. Finally, you could try *micronized* creatine monohydrate, which also has the advantage of being more soluble.

The standard daily dose is 5 g/day. This is enough to improve power output. People with more muscle mass may benefit from as much as 10 g/day, but this claim is not fully supported by the evidence. To supplement 10 g/day, take 5 g twice a day.

Figure 1: Creatine dose troubleshooting



Loading creatine means taking a high daily dose for a few days (e.g., 5 g five times a day for 5 days) before moving down to a smaller maintenance dose, which can be taken indefinitely. This is not necessary for effective supplementation, however; benefits may be felt sooner through loading, but they normalize after a few weeks.

Some people are creatine nonresponders: The creatine they ingest largely fails to reach their muscles. Alternate forms of creatine (such as creatine ethyl-ester) have been marketed as addressing this issue, but they lack scientific support. Currently, the best way to lessen creatine nonresponse is still to take creatine with a meal high in both protein and carbohydrate, preferably close to a time of muscle contraction (i.e., before or after your workout, if you work out).

Note that even if supplemental creatine fails to enter your muscles it can still benefit you in other ways, such as by improving your body's methylation status.

If you are not a creatine nonresponder, you need not worry about timing supplementation, though you should remember that taking your dose with a meal lowers the risk of an upset stomach. Creatine can be added to any liquid (even hot coffee or tea), but it must be drunk within the day, as creatine in liquids degrades into creatinine over time (the higher the temperature and the lower the pH, the faster the degradation). Do not buy liquid creatine products.

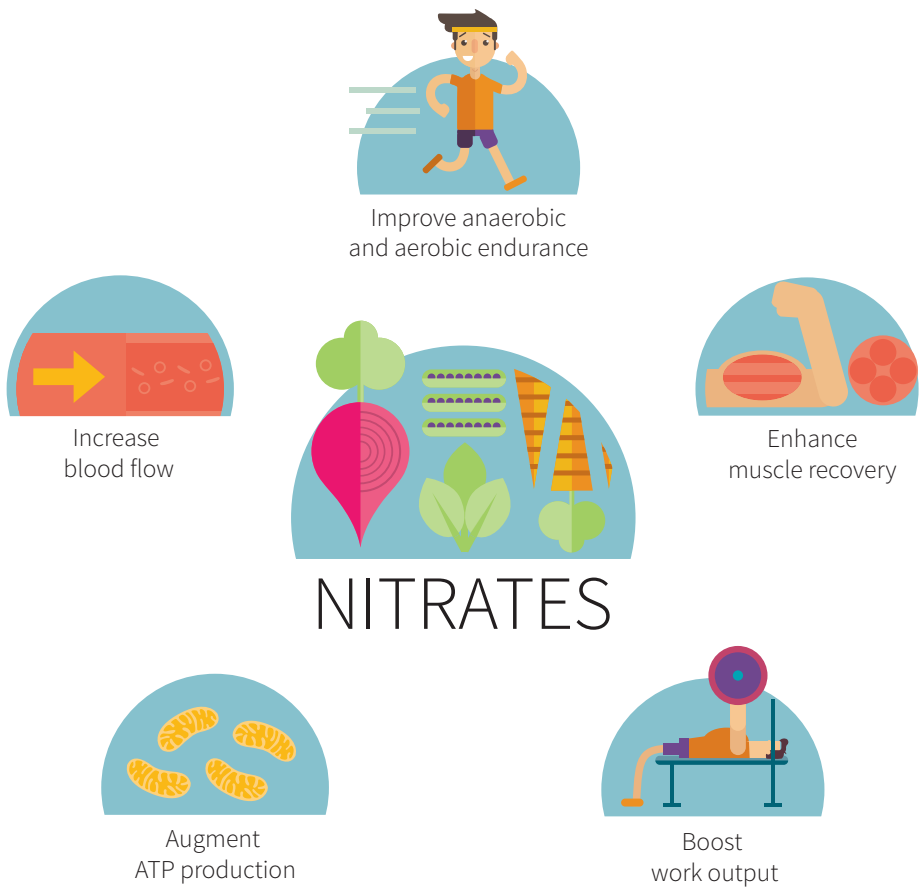
Nitrates

Why they're a core supplement

Nitrates can be found in different foods, notably beetroot and leafy green vegetables. Nitrates break down into nitrites, which circulate in the body and are turned into *nitric oxide* (NO) as needed. Elevated NO levels during exercise provide a variety of benefits.

Nitrate supplementation has been shown to improve aerobic endurance, energy output, blood flow, and muscle recovery between bouts of exercise. It may also benefit anaerobic endurance, especially in beginners. Nitrates improve the body's ability to produce adenosine triphosphate (ATP) from food. As aforementioned, ATP has been called life's energy currency: It powers your cells, including those composing your muscles.

Figure 2: Exercise-related benefits of nitrates



Nitrates do not exist as isolated dietary supplements, unfortunately, because of regulations against high quantities of sodium nitrate (a food additive frequently added to meat products). Instead, nitrate supplementation should take the form of a pre-workout meal incorporating leafy greens or beetroot.

Most studies on the performance-enhancing properties of nitrates used beetroot juice. Beetroot powder is also an option (⅛ the weight of raw beetroot), but not in capsules, as you would need to take too many.

Leafy greens are often rich in vitamin K_1, a fat-soluble vitamin that helps with blood clotting and so might decrease the effectiveness of blood thinners, especially anticoagulants (such as warfarin/Coumadin). If you take a blood thinner, you should consult with your doctor before consuming a lot of leafy greens.

Due to their goitrogen content, cruciferous vegetables can reduce thyroid hormone production if regularly consumed in high amounts, such as those needed for nitrate supplementation. If you eat a lot of cruciferous vegetables (such as cabbage, collard greens, or kale), make sure to also get enough iodine — through iodine-rich foods (such as cod, shrimp, milk, yogurt, or cottage cheese), iodine-fortified foods (such as iodized salt), or supplements (75–150 mcg/day).

How to take them

Aim for 6.4–12.8 mg of nitrates per kilogram of body weight (2.9–5.8 mg/lb).

Table 1: Nitrate intake

Body weight	2.9 mg/lb (6.4 mg/kg)	5.8 mg/lb (12.8 mg/kg)
100 lb (45 kg)	290 mg	580 mg
150 lb (68 kg)	435 mg	870 mg
200 lb (91 kg)	580 mg	1,160 mg
250 lb (113 kg)	725 mg	1,450 mg

TTable 2: Nitrate-rich vegetables

Nitrate-rich vegetables	Content per 100 g			
	Nitrates (mg)	Oxalate (mg)		Vitamin K_1 (mcg)
		Total	Soluble	
Arugula/rocket	362.4	7.1	< 0.5	108.6
Turnip greens	346.7	50	?	251
Dill	259	159	60	0
Collard greens	254.5	450	?	437.1

Spinach	248.5	656	542.6	482.9
Swiss chard	236.3	964	207.7	830
Turnips	217.4	210	?	0.1
Rhubarb	199.9	805	223	29.3
Beetroot	199.2	121	74.9	0.2
Celery	196.4	17.5	< 0.5	29.3
Mustard greens	187.5	128.7	?	257.5
Radish	177.3	9.2	< 0.5	1.3
Lettuce	168.9	13.6	< 0.5	126.3
Watercress	164	10	< 0.5	250
Bok choy	162	2	?	45.5
Kale	137.5	20	?	704.8
Parsley	130.4	136	76	1640

This table is composed of averages from multiple samples. Farming techniques, transport, storage conditions, and cooking methods can all greatly affect the actual nitrate and oxalate content of your food.

Adapted from Jackson et al. *Nutr Res Rev*. 2017 Dec, Lidder et al. *Br J Clin Pharmacol*. 2013 Mar, Griesenbeck et al. *Nutr J*. 2009 Apr, Siener et al. *Food Chemistry*. 98;2. 2006, Tamme et al. *Food Addit Contam*. 2006 Apr, Hönow and Hesse. *Food Chemistry* 78;4. 2002 Sep, Santamaria et al. *J Sci Food Agric*. 1999 Oct, Oxalic Acid Content of Selected Vegetables (1984). ARS, USDA, Dr. Duke's Phytochemical and Ethnobotanical Databases. ARS, USDA, and USDA Food Composition Databases. ARS, USDA.

Consuming those vegetables in liquid form will increase the rate of nitrate absorption, since solid food particles take longer to digest. Drink your juice, shake, or purée a couple of hours before exercise.

Since the bacteria in saliva play a role in activating dietary nitrates, do not use an antibacterial mouthwash too often, and especially not shortly before consuming nitrate-rich foods. Moreover, the cooking time, if any, should be brief: although cooking reduces the oxalate content more than the nitrate content, the loss of nitrates after fifteen minutes of cooking can still exceed 50%.

Table 3: Vegetables sorted by nitrate content (mg per 100 g)

Nitrate content	Vegetables
Very high (250+)	Arugula/rocket, collard greens, dill, turnip greens
High (100 to <250)	Beetroot, bok choy, celeriac, celery, kale, kohlrabi, lettuce, mustard greens, parsley, radish, rhubarb, spinach, swiss chard, turnip, watercress

Moderate (50 to <100)	Broccoli, cabbage, cauliflower, endive, savoy cabbage
Low (20 to <50)	Chicory, eggplant, fennel, green beans, green onion, leek, pumpkin/squash
Very low (<20)	Artichoke, asparagus, broad bean, brussels sprouts, carrot, cucumber, dry beans, garlic, lima beans, maize, mushroom, onion, peas, pepper, sweet potato, tomato, white potato

Adapted from Jackson et al. Nutr Res Rev. 2017 Dec, Hord et al. *Am J Clin Nutr*. 2009 Jul; 90(1): 1–10, and Jones. *Sports Med*. 2014 May; 44 Suppl 1: S35–45.

Most vegetables rich in nitrates are also rich in oxalate, which can increase the risk of kidney stones. People already at an increased risk of forming kidney stones, as well as people with oxalosis or hyperoxaluria, should keep their oxalate intake to a minimum.

Other people need not ban all oxalate from their diet, but if you consume high amounts of nitrates (and the dosage range in this guide certainly qualifies) more than twice a week, favor oxalate-poor vegetables. And if you do eat oxalate-rich foods on occasion, consider cooking them and/or pairing them with calcium-rich foods, in order to reduce oxalate absorption.

Table 4: Vegetables sorted by oxalate content (mg per 100 g)

Oxalate content	Vegetables
Very high (100+)	Beetroot, collard greens, dill, mustard greens, parsley, rhubarb, spinach, swiss chard, turnips
High (10 to <100)	Cauliflower, celery, kale, lettuce, turnip greens
Moderate (2 to <10)	Arugula/rocket, asparagus, carrot, radish, sweet potato, watercress
Low (<2)	Bok choy, cabbage, radicchio

Because glutathione may slow down the rate of NO breakdown in the bloodstream, adding 200 mg of N-acetylcysteine (NAC) to your nitrates might prove synergistic.

Protein

Why it's a core supplement

Any protein found in food or supplements is called dietary protein. The protein you ingest is digested into amino acids, which are then recombined as muscle fibers, among other things. Some amino acids (chiefly leucine) are especially important for muscle growth.

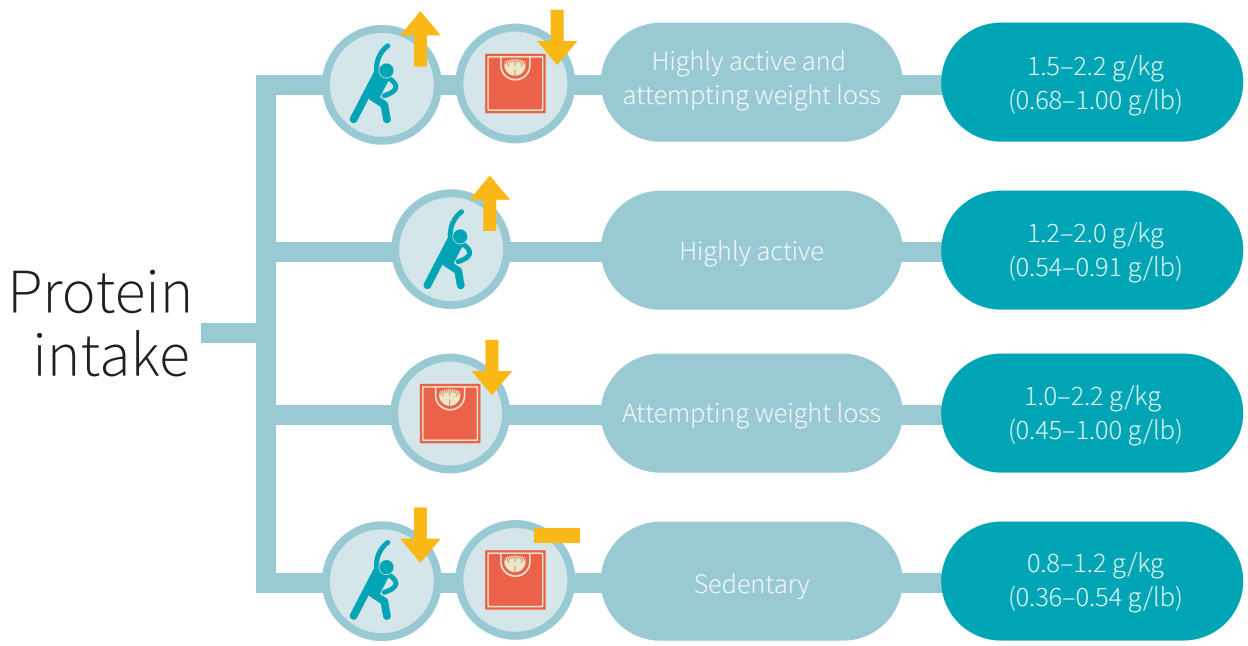
To maximize muscle growth and exercise performance, you need to consume enough protein. Whole food is best, but if your food intake does not cover your daily protein needs, you could add a supplement, preferably a powder.

Whey protein and casein powders are both derived from milk protein (which is 20% whey and 80% casein). Whey protein digests quickly, whereas micellar casein digests slowly, so a case could be made for drinking the former around your workout (to quickly feed your muscles) and the latter before bed (to keep your muscles fed overnight). If you'd rather buy only one type of protein powder, however, milk protein isolates are available, but a whey protein concentrate that is at least 80% protein will be much cheaper and the best bang for your buck.

But what if you are lactose intolerant or vegan? Fortunately, you can still supplement protein powders. Whey protein isolates contain very little lactose. For vegans, two popular options are soy protein, a complete protein, and a 70:30 pea:rice protein blend, which is seen as the vegan alternative to whey protein due to their similar amino acid profiles. Depending on processing techniques, the estrogenic isoflavone content can be greater in a soy protein isolate than in a soy protein concentrate, but it is still too small to elicit any significant hormonal response when as much as 200 g of soy protein isolate is consumed each day.

How to take it

Figure 3: Protein intake guide



1) If your BMI is more than 30, use your goal weight for calculations.

2) 0.8 g/kg may not be sufficient for elderly people losing muscle.

3) A higher protein intake does not seem to have negative health effects in people without kidney issues.

In the United States, the Recommended Daily Allowance (RDA) for protein is 0.8 g per kilogram of body weight (0.36 g/lb/day), but more recent research suggests that 1.2 g/kg (0.54 g/lb) is a safer minimal daily intake for sedentary adults wishing to maintain muscle mass without losing or gaining weight, whereas people with fitness goals can benefit from 1.4–2.0 g/kg/day.

Table 5: Daily protein intake

Body weight	0.36 g/lb (0.8 g/kg)	0.54 g/lb (1.2 g/kg)	0.64 g/lb (1.4 g/kg)	0.91 g/lb (2.0 g/kg)
100 lb (45 kg)	36 g	54 g	64 g	91 g
150 lb (68 kg)	54 g	81 g	96 g	137 g
200 lb (91 kg)	72 g	108 g	128 g	182 g
250 lb (113 kg)	90 g	135 g	160 g	228 g

Adapted from Thomas et al. *J Acad Nutr Diet*. 2016 Mar; 116(3): 501–28.

Unless you have a pre-existing condition that affects your liver or kidneys, the intakes in the above table will not harm those organs. However, if you have a BMI of more than 30, you may want to calculate your protein requirements based on your goal body weight rather than your current body weight, so as to avoid overeating.

Consume 20–40 g of protein per meal, starting with breakfast.

Consume 20–40 g of protein within the 2 hours preceding or following your workout to help stimulate muscle growth. If you take your protein after your workout or within the 30 minutes leading to it, favor a protein that digests quickly, such as a whey protein concentrate.

Consume 20–40 g of protein before bed to help stimulate muscle growth (or at least reduce muscle breakdown) while you sleep. A protein that digests slowly, such as micellar casein, should be ideal at that time.

As we age, our muscles can develop a resistance to dietary proteins' anabolic signals. Larger doses can partially compensate for this resistance, so if you're over forty, aim for the higher half of the above ranges — i.e., aim for 1.7–2.0 g/kg/day (0.77–0.91 g/lb/day), including 30–40 g per meal, before bed, and either before or after your workout.

Sugars and Other Carbohydrates

Why they're a core supplement

Sugars are quickly digested carbohydrates. In addition to providing your muscles with readily usable energy, they cause a sharp rise in insulin, which improves blood flow and the effects of nitric oxide — two benefits that contribute to peak physical performance.

Sugars are especially beneficial to anaerobic exercise, such as weightlifting or sprints, but they can also fuel the longer endurance events, such as marathons. Workouts of mild intensity and duration, however, can simply be fueled by other carbohydrates consumed throughout the day.

How to take them

You can use the chart below to help set your total daily carbohydrate intake (in grams) according to your body weight (in kilograms or in pounds).

Table 6: Daily carbohydrate intake

Intensity	Activity	g/kg	g/lb
Low	Skill-based or general activities	3–5	1.4–2.3
Moderate	Exercise program (1 hr)	5–7	2.3–3.2
High	Endurance program (1–3 hr)	6–10	2.7–4.5
Very high	Extreme commitment (4–5+ hr)	8–12+	3.6–5.4+
Strength athletes	Resistance training (weightlifting, bodybuilding, etc.)	4–7	1.8–3.2

Adapted from Thomas et al. *J Acad Nutr Diet*. 2016 Mar; 116(3): 501–28.

Athletes can use the table below to optimize the timing of their carbohydrate intake. Other people can just remember the following sugar protocol: If you exercise for 45 minutes to 2 hours, aim for 30–60 g/hr; if you exercise longer, aim for 60–90 g/hr.

Table 7: Carbohydrate intake timing

	Situation	Time	Carbohydrates
Before	Loading	36–48 hr before the event	4.5–5.4 g/lb/day (10–12 g/kg/day)
	Pre-event	1–4 hr before the event	0.5–1.8 g/lb (1–4 g/kg)
During	Brief exercise	≤45 min	Unnecessary
	Sustained high-intensity exercise	45–75 min	Sugars: ≤30 g/hr
	Endurance exercise, including stop-and-start sports such as basketball, soccer, etc.	60–150 min	Sugars: 30–60 g/hr
	Ultra-endurance exercise	>150 min	Sugars: ≤90 g/hr
After	Speedy refueling	≤10 hr between two fuel-demanding sessions	0.5 g/lb/hr (1.0–1.2 g/kg/hr) for the first 4 hours then resume normal intake
	Typical refueling	>10 hr between two fuel-demanding sessions	0.5–0.7 g/lb (1.0–1.5 g/kg) over the first 30 minutes then resume normal intake

Adapted from Thomas et al. *J Acad Nutr Diet*. 2016 Mar; 116(3): 501–28.

Athletes should be careful not to overdo their sugar consumption before a game or competition. Too much at once may cause temporary reactive hypoglycemia, a short period of low blood sugar, which could hurt sports performance. If this is something you regularly experience, switching to a pre-game carb source with a low glycemic index value (GI) may provide you with a more even source of energy.

As a general rule, eating a high-carb meal before exercise decreases the need for a sugary drink during exercise. Conversely, the less carbohydrate in your regular diet, the greater the performance-enhancing effects of a sugary drink during exercise.

During exercise, drinking a mix of two or more sugars or other simple carbohydrates (glucose, fructose, maltose, etc.) may help increase the rate

at which they are absorbed and oxidized for energy. Although maltodextrin is not a simple sugar, its absorption rate is similar to that of dextrose (D-glucose), so it can be used as part of your mix.

Your exercise beverage should be 6–8% carbohydrate (a lot less than most sports drinks) to optimize absorption and oxidation and minimize the risk of an upset stomach. Also to avoid stomach discomfort, no more than half your mix should be fructose, and you should steer clear from sodas, since their carbonation and acidity can cause gastrointestinal upset during exercise.

The main factors to influence muscle glycogen resynthesis are: carbohydrate type, ingestion rate, intake timing, coingestion of carbohydrate and protein, and caffeine intake. Ingesting a high-GI food or beverage at a rate of 1.0–1.2 g/kg/hr (0.5 g/lb/hr) for the first 4 hours following exercise will help maximize the speed of glycogen resynthesis. Adding protein (at a CHO:PRO ratio of 3:1 or 4:1) and/or caffeine may slightly increase the speed of glycogen resynthesis, too.

The speed of glycogen resynthesis matters mostly for people who exercise more than once a day. As a rule, carbohydrate supplementation during and after exercise is more of a concern for endurance athletes than for strength athletes; the latter should focus on consuming adequate carbohydrate throughout the day and before exercise. For both types of athlete, the shorter the rest between workouts, the more important intake timing becomes.

Primary Options

Beta-Alanine

Why it's a primary option

When ingested, the nonessential amino acid beta-alanine binds with the essential amino acid histidine to create carnosine. Carnosine has anti-aging and antioxidant properties; it also buffers lactic acid during exercise, which delays muscle fatigue. Essentially, beta-alanine supplementation can improve endurance.

But there's a catch. Beta-alanine only helps with intense exercise, in which lactic acid kicks in after about a minute. Imagine running a fast lap around the track or doing a volume set of squats that feels like the longest sixty seconds of your life. Beta-alanine supplementation will mostly benefit athletes who exercise hard in the 1–4-minute range.

How to take it

Take 4–6 g/day.

If you have a long workout planned, aim for the higher end of that range. It is better to take this supplement even on rest days, but skipping one or two days a week is not a major issue. While beta-alanine can be taken at any time of the day, it may be better absorbed with a meal.

A common side-effect of beta-alanine is paresthesia (a tingling sensation, as when your leg "falls asleep"). Taking smaller doses throughout the day or using time-release formulations can help reduce the prickling sensation on the skin (especially the face). Paresthesia is harmless, if unpleasant.

Caffeine with Theanine

Why it's a primary option

Caffeine can block different adenosine receptors in the brain, with varying effects. By blocking the A_1 receptor, caffeine can stave off sleepiness and

increase endurance. By blocking the A_{2A} receptor, caffeine can raise the brain's levels of dopamine and epinephrine (a.k.a. adrenaline) and thus increase focus and power.

Dopamine and epinephrine are two neurotransmitters responsible for the euphoric feeling you remember from your first-ever cup of coffee. Unlike the A_1 receptor, however, the A_{2A} receptor gets desensitized: your production of dopamine and epinephrine downregulates until you need caffeine just to regain your original neurotransmitter levels.

In other words, you become *dependent* on caffeine when you become *tolerant* to some of its effects. Then if you stop taking caffeine, you can experience symptoms of withdrawal, such as fatigue, irritability, headaches, and — ironically — sleeplessness. In addition, eliminating all caffeine from your diet can cause your lithium levels to rise. If you are on lithium, talk to you doctor before you consider any drastic change in caffeine intake.

Of the other issues associated with caffeine, we can only mention a few. Caffeine interacts dangerously with several pharmaceuticals, notably tizanidine and a type of antidepressant called *monoamine oxidase inhibitors* (MAOIs). It can also interfere with glucose metabolism, raise blood pressure, raise heart rate, and increase urination (and so the risk of dehydration during exercise), but those four effects fade away as your tolerance to caffeine develops.

You might already be consuming more caffeine than you think. When you calculate your daily intake, consider all your beverages, foods, and supplements. Bear in mind that caffeine can be "hidden" in a product — for instance, if you read "guarana seeds" on a label, remember that those are richer in caffeine than coffee seeds.

Theanine (the amino acid L-theanine) can tame the overexcitability associated with caffeine without reducing caffeine's stimulatory effect. In fact, the improvements in concentration (focus and attention span) from caffeine and theanine respectively are synergistic. Thus, whereas theanine on its own does little to enhance exercise performance, it becomes a primary option when combined with caffeine.

How to take it

For a boost in **aerobic** performance, take 100–200 mg of caffeine (up to 400 mg/day) with an equal dose of theanine half an hour before exercise.

For a boost in **anaerobic** performance, take 400–600 mg of caffeine with 300 mg of theanine half an hour before an especially strenuous workout, no more than twice a week. If tolerance starts to set in, drop down to once a week.

Taking caffeine on an empty stomach can increase the rate of absorption, but it can also cause gastrointestinal upset.

Caffeine in the evening, or even in the afternoon, can disrupt your sleep. Even if it does not prevent you from falling asleep, it can impair the *quality* of your sleep. In healthy adults, the average half-life of caffeine falls between 5 and 6 hours, but this number can vary greatly between individuals, because of genetics and other factors — heavy smoking can double the rate of caffeine metabolism, pregnancy can halve it, etc.

Secondary Options

Ashwagandha

Why it's a secondary option

Adaptogens are supplements that can reduce the mental and physical effects of stress, including fatigue, depression, and anxiety. The most popular and well-researched adaptogens are ashwagandha (*Withania somnifera*), *Panax ginseng*, and *Rhodiola rosea*. These herbs have been the subjects of many studies, but rarely in the context of increased muscular power and never as pre-workout supplements. Preliminary evidence suggests that they can lower the perception of fatigue when taken before exercise, but more research is needed to confirm this effect.

Most studies on ashwagandha used KSM-66. This water-based extract standardized to 5% withanolides has been shown to lower cortisol levels and increase strength and muscle mass.

How to take it

To supplement **ashwagandha**, take 300 mg of the KSM-66 extract twice a day (i.e., 600 mg/day), including one dose 30–60 minutes before exercise. Alternatively, take your whole 600-mg daily dose 30–60 minutes before exercise. Should you purchase another extract standardized for withanolide content, aim for 30 mg of withanolides per day. If you only have access to the root powder, try 5 g/day.

To supplement ***Panax ginseng***, take 200–400 mg of an extract containing 1–3% ginsenosides 30–45 minutes before exercise.

To supplement ***Rhodiola rosea***, take 80–160 mg of SHR-5 (an extract standardized to 3% rosavins and 1% salidroside) 30–45 minutes before exercise. Up to 500 mg can be taken in anticipation of a particularly stressful event.

BCAAs

Why they're a secondary option

Branched-chain amino acids (BCAAs) are three of the nine amino acids essential to humans. Since you ingest BCAAs each time you ingest protein, supplementing BCAAs in isolation is mostly redundant. For example, 100 g of a whey protein concentrate can contain 11 g of leucine, 6 g of isoleucine, and 6 g of valine, so 23 g of BCAAs (the numbers vary between supplements).

Many studies have investigated the effects of BCAA supplementation on exercise, and these effects proved minimal. Mostly, BCAAs were found to relieve cognitive fatigue during exercise lasting more than 2 hours. This could be useful for athletes who need to maintain hand-eye coordination over a long game (hockey or football players, for instance). In novices, the reduction in mental fatigue might also translate into an increase in physical endurance.

On the whole, BCAAs have only two potential advantages over protein powders. **First**, they are less likely to cause cramping or nausea when consumed before exercise. **Second**, they are free of tryptophan (an amino acid that might promote exercise-related fatigue).

How to take them

To supplement BCAAs, take 10–20 g before exercise, in water or a sugary drink. A ratio of 2:1:1 (leucine:isoleucine:valine) is often recommended based on two studies that actually used a 2.3:1:1.2 ratio. Both studies compared this 2.3:1:1.2 mix to a placebo (dextrin); different ratios were not compared, so the ideal ratio is unknown.

Cholinergics

Why they're a secondary option

A supplement is said to be cholinergic when it increases the activity of acetylcholine, a major neurotransmitter involved in memory formation and muscle contractions. Elevated acetylcholine levels in neurons are associated with stronger muscle contractions, but cholinergics themselves are not well-researched in this context. There is currently no strong evidence that cholinergics increase muscular power output.

Both alpha-GPC and CDP-choline can provide the brain with the choline it needs to produce more acetylcholine (choline bitartrate is much cheaper, but little of it seems to reach the brain). There is some preliminary evidence that alpha-GPC can increase power output, but this result has yet to be replicated.

Huperzine-A can inhibit acetylcholinesterase, an enzyme that breaks down acetylcholine. Its half-life exceeds 24 hours, so it accumulates in the body when taken daily, which is problematic since long-term studies are scarce. There is a possibility that, over time, the body could adapt by producing more acetylcholinesterase, which would lead to reduced acetylcholine levels and a withdrawal period after huperzine-A supplementation has ceased. While the doses used in the studies (0.2–0.99 mg) were deemed safe in the short term, long-term supplementation cannot be recommended.

How to take them

To supplement **alpha-GPC**, take 300–600 mg 30–45 minutes before exercise.

To supplement **CDP-choline**, take 250–500 mg 30–45 minutes before exercise.

HMB

Why it's a secondary option

Beta-hydroxy beta-methylbutyrate (HMB) is a product of the amino acid leucine thought to be anti-catabolic (to help prevent muscle breakdown), mostly during periods of caloric restriction, inadequate protein intake, or heavy exercise. For that purpose, HMB might be twenty times as potent as leucine (gram for gram).

By reducing muscle damage, HMB may allow for faster recovery times both during and between workouts, leading to faster increases in performance. People just starting to exercise and people undertaking high volumes of work are most likely to benefit from HMB. It is uncertain, however, whether HMB has any effect in people who consume enough leucine-rich protein.

Calcium HMB is the most common form of HMB. While another form, known as HMB free acid (HMB-FA), has shown some promise in a few recent

studies, the drastic difference in potency between the two forms — from inconsistent benefits for calcium HMB to near steroid-like effects for HMB-FA — needs to be confirmed by additional research.

How to take it

Take 3 g of HMB (calcium HMB or HMB-FA) per day. On workout days, take the whole daily dose 1 hour before exercise.

Note that it may take you up to 2 weeks to feel the full effects of HMB, particularly if you are engaging in high-intensity workouts.

Nitric Oxide Boosters

Why they're a secondary option

Elevated *nitric oxide* (NO) levels are associated with improved blood flow, muscle growth, and more efficient energy production. NO boosters form a category of supplements meant to increase NO levels in the body. Some common NO boosters are arginine, citrulline, and agmatine. Nitrates from beetroot and leafy green vegetables are not included in this category.

Unfortunately, arginine, citrulline, and agmatine all have issues. Absorption of arginine by the intestines is limited, and much is eliminated from the body before it can reach the muscles. Citrulline is better absorbed and is converted into arginine in the kidneys, but in a controlled manner (rather than a huge spike in NO levels, you can expect a steady increase of lesser magnitude). Agmatine is a newer, promising supplement, but one that lacks human evidence for its effects.

Today's NO boosters have been marketed based on promising initial evidence, but their effects are unreliable at best. They should only be considered for supplementation if dietary nitrates are not an option. Should it be the case, citrulline is the best alternative among bad ones.

Note: NO boosters should not be taken with yohimbine, as they counteract the effects of this fat burner (unlike nitrates, which increase NO through another pathway).

How to take them

Half an hour before exercise, take one of these:

0.5–1.5 g of **agmatine**.

6 g of **arginine**. Arginine supplementation can cause diarrhea, so start with 3 g before working your way up. Concomitant consumption of caffeine increases the risk of diarrhea.

6 g of **citrulline** (or 10 g of citrulline malate). Thanks to better absorption rates, intestinal side-effects are less likely than with arginine.

Because glutathione may slow down the rate of NO breakdown in the bloodstream, adding 200 mg of N-acetylcysteine (NAC) to your nitrates might prove synergistic.

Inadvisable Supplements

Glutamine

Glutamine is an amino acid that plays an important role in muscle cells. In fact, *in vitro* studies (studies done in a test tube or a petri dish) require glutamine to keep cells alive. When glutamine is added to muscle cells *in vitro*, protein synthesis increases.

The problem is getting glutamine to muscle cells in the first place. After ingestion, glutamine does not reach the muscle directly. Instead, it is taken up by the intestines, then transported to the liver, which releases it to other tissues in the body on an as-needed basis.

Therefore, while glutamine supplementation could benefit the digestive system and the liver, it will not cause an increase in muscle protein synthesis and thus cannot be recommended for inclusion in a performance-enhancing stack.

Sodium Bicarbonate

Sodium bicarbonate, also known as baking soda, can improve muscular endurance. Alas, it can also cause severe stomach upset if supplemented improperly. Keep in mind that one dose is 300–400% of the daily recommended sodium intake. Sodium bicarbonate and beta-alanine have similar effects, but taking both at once will not be more effective than taking beta-alanine by itself.

Due to the relatively high potential for side-effects, sodium bicarbonate cannot be recommended as a primary or secondary option.

Taurine

The amino acid L-taurine gave its name to Red Bull (*taurus* is Latin for "bull") and can also be found in other energy drinks. There is precious little evidence, however,

to support its use to enhance exercise performance, except maybe in people with heart failure. Otherwise, the most you *might* gain from taurine supplementation is a reduction in the muscle cramping associated with fat burners.

If you choose to supplement taurine, do not take more than 3 g/day.

Testosterone Boosters

There is precious little human evidence to support the efficacy of testosterone boosters. Studies are seldom replicated, and when replicated seldom draw the same conclusions. Furthermore, even if a supplement can coax your body into producing more testosterone, it can only do so within your physiological limits — do not expect steroid-like effects.

Some supplements claiming to boost testosterone — including maca, fenugreek, and *Tribulus terrestris* — actually enhance libido. This effect can translate into increased confidence, maybe directly (increased libido = increased confidence), more probably indirectly (increased libido = a feeling that the supplement is working = increased confidence).

The positive influence of confidence on exercise performance has been noted in several dedicated studies, so if libido boosters improve your power output due to improved energy and mood, they may have a role to play in your stack.

Assembling Your Stack

Incorporating Core Supplements

The core supplements in this stack are creatine monohydrate, dietary nitrates, protein, and carbohydrates.

A couple of hours before exercise, take your dietary nitrates (6.4–12.8 mg per kilogram of body weight, so 2.9–5.8 mg/lb) and 5 g of creatine monohydrate. Consume protein throughout the day (1.4–2.0 g per kilogram of body weight, so 0.64–0.91 g/lb/day), with the help of protein powders if necessary.Consult the Sugars and Other Carbohydrates entry to set your carbohydrate intake.

The core supplements are recommended for most people; their efficacy and safety are backed by a significant body of evidence. Take them for a couple of weeks before you consider making any modification, such as adding one of the following options.

Incorporating Options

For weightlifters (muscle growth and power)

In addition to the core supplements, take caffeine (400–600 mg) with theanine (300 mg) half an hour before an especially strenuous workout, no more than twice a week. After one month, consider adding either alpha-GPC (300–600 mg) or CDP-choline (250–500 mg). Optionally, either of these two cholinergics can be taken every day (still half an hour before exercise).

For athletes who exercise for 1 hour or more (alertness and endurance)

In addition to the core supplements, take BCAAs (10–20 g) before exercise. You can also take beta-alanine (5 g/day), with food. You can also take caffeine (100–200 mg) with an equal dose of theanine half an hour before a bout of *aerobic* exercise.

For people undergoing intense training, such as HIIT

In addition to the core supplements, take beta-alanine (5 g/day) with food and ashwagandha (600 mg of the KSM-66 extract) about one hour before exercise. Soon after exercise, eating or drinking a mix of protein (0.15–0.25 g/kg, so 0.07–0.11 g/lb) and carbohydrate at a CHO:PRO ratio of 3:1 or 4:1 will help replenish glycogen stores and promote muscle recovery.

Other options

If you work out in a fasted state, 20–40 g of protein within the 2 hours following your workout will help preserve muscle mass. If you fail to get enough protein during the day, 3 g of HMB or 10–20 g of BCAAs can also help you preserve muscle mass.

People with *a lot* of muscle mass can increase the creatine dose from 5 to 10 g.

Should you find it impractical to consume a lot of nitrate-rich vegetables, you could try 6 g of citrulline (or 10 g of citrulline malate) instead. Because glutathione may slow down the rate of nitric oxide breakdown in the bloodstream, adding 200 mg of N-acetylcysteine (NAC) to your nitrates or citrulline might prove synergistic.

Adaptogens have not been shown to negatively interact with any compound listed in this guide. They can be added to any stack if mental fatigue is a problem during or after a workout.

FAQ

Can I add to my stack a supplement not covered in this guide?

Supplement your current stack for a few weeks before attempting any change. Talk to your doctor and research each potential new addition in advance. Check for known negative interactions with other supplements in your current stack, but also for synergies. If two supplements are synergistic or additive in their effects, you might want to use lower doses for each.

Can I modify the recommended doses?

If a supplement has a recommended dosage range, stay within that range. If a supplement has a precise recommended dose, stay within 10% of that dose. Taking more than recommended could be counterproductive or even dangerous.

Should I take my supplements with or without food? And at what time?

Answers are provided in each supplement entry whenever the evidence permits. Too often, however, the evidence is either mixed or absent. Besides, a supplement's digestion, absorption, and metabolism can be affected differently by different foods. Fat-soluble vitamins (A, D, E, K), for instance, are better absorbed with a small meal containing fat than with a large meal containing little to no fat.

Starting with half the regular dose can help minimize the harm a supplement may cause when taken during the day (e.g., tiredness) or in the evening (e.g., insomnia).

I have an iron stomach. I have never felt nauseous from supplements. Do I still need to take precautions to avoid gastrointestinal upset?

If you have never had any issues with nausea or vomiting, you may have an easier time ingesting large doses of certain supplements. Nevertheless, it is not a good idea to disregard the warnings on a product.

How long does it take for caffeine tolerance to set in? And how long do I need to go without caffeine for this tolerance to fade away?

It varies, in both cases, depending notably on dosage (amount and frequency) and genetics. Some people become tolerant in days, others in weeks. Some people can reset their tolerance in a week, whereas others may need a couple of months.

In the end, you'll have to experiment to find what works for you. Should you wish to reset your tolerance, take at least two weeks off caffeine, then try a small dose (50–200 mg). If you find the stimulation acceptable, you can resume using caffeine more often; if you don't, take another week off, then try a small dose again.

Do not attempt to fight caffeine tolerance with higher and higher doses. It would be not only dangerous, but also counterproductive

I thought creatine and caffeine negated each other, so why are they in the same stack?

Although not all studies agree, a high dose of caffeine (5 mg per kilogram of body weight, so about 2.3 mg/lb) might partially negate the benefits of creatine, but only when both supplements are co-ingested during a creatine loading phase. This potential issue can be sidestepped by consuming your creatine and caffeine several hours apart or by skipping the optional creatine loading phase.

Can I take caffeine without theanine, or vice versa?

Caffeine is an effective stimulant on its own. Adding theanine will enhance your focus. Theanine by itself provides no exercise-related benefit.

Why do you have entries for BCAAs and HMB but not leucine?

BCAAs might alleviate cognitive fatigue when taken before a game, so they have a niche to fill. There is some evidence that HMB could be as anti-catabolic as twenty times the same amount of leucine when calories are restricted, in which case it would also have a niche to fill. With regard to anabolism, increasing your protein intake is more likely to help than leucine alone, so leucine doesn't really have a niche to fill.

Since the body makes carnosine out of beta-alanine and histidine, should I also supplement histidine?

It isn't necessary. If you consume enough protein, your muscles already have all the histidine they need to produce more carnosine.

Still, why beta-alanine? Wouldn't it be simpler to supplement carnosine directly?

Since carnosine simply gets digested into beta-alanine and histidine, and since your muscles already have enough histidine, carnosine supplementation has no advantage over beta-alanine supplementation — especially since beta-alanine is cheaper.

Why take NAC to make glutathione? Why not take glutathione directly?

Oral glutathione gets digested into its constituent amino acids: cysteine, glycine, and glutamic acid. Of those three, cysteine is the rate-limiting factor in endogenous glutathione production. Oral N-Acetylcysteine (NAC) is simply a more efficient (and cheaper) way of providing your body with cysteine. Multiple studies have reported greater increases in circulating glutathione from oral NAC than from (an equal dose of) oral glutathione.

Can I get enough nitrates from fruit?

In short, no. Even "nitrate-rich" fruits, such as melons and strawberries, pale in comparison to most vegetables. Compare, for instance, 100 g of beetroot (199.2 mg of nitrates) with 100 g of melon (32.5 mg), strawberries (17.2 mg), banana (7.6 mg), apple (2 mg), or orange (0.9 mg).

Precautions and Troubleshooting

Stack components are seldom studied together. The safest way to add supplements to your daily routine is one at a time, at least a couple of weeks apart, to better assess the effects (and side effects) of each new addition. Start at half the regular dose for a week, then slowly increase to the regular dose if you are not experiencing the desired effects.

Be aware that core-intensive exercises, supplementing on an empty stomach, dietary protein, and too much carbohydrate (especially fructose) can all increase the risk of gastrointestinal upset. Any stack that prevents you from maximally exerting yourself because of nausea or stomach pain is counterproductive.

To reduce the risk of gastrointestinal upset, take your supplements with enough water and (if possible) a small meal with a little fat and a higher-than-average carbohydrate content. You could also let more time pass between the moment when you take your supplements and the beginning of your workout.

Athletes should ***never*** take a supplement for the first time before a game or competition. Always try the supplement during practice first. Taking a seat on the bench to calm your stomach is much easier when you don't have to worry about winning a game.