



MENNO HENSELMANS

— Science to master your physique —



SUPPLEMENTS

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*Note: Supplements marked with a * are of special interest due to their popularity or effectiveness.*

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➤ Lecture [optional]

[Supplements that work](#)

Dietary supplements are the driving force of the fitness industry. Other than gym equipment, gym clothing and information, there isn't much to sell. Since only the intellectual elite care about information as a product (yes, that's you) and gym managers are the only ones seriously in the market for gym equipment, that leaves pills and branded gym clothing. Almost the entire athlete sponsorship phenomenon revolves around supplements. Supplements that these athletes themselves often don't take.

Why are supplements so popular? Everyone wants the magic pill. When it really comes down to it, many people will take a pill that improves their physique, even if it's unhealthy and expensive. Ironically, even oral anabolic-androgenic steroids (AAS) aren't the magic pill most people are interested in due to the many side-effects. And compared to AAS, supplements aren't in the same ballpark, not in the same league, they're not even the same sport. (+1 if you know which movie that analogy came from.)

Still, for many supplements you can find some positive research supporting their use. So why are we so skeptical about supplements? The answer is publication bias. When researching supplements, you must realize there is considerable publication bias and therefore the standard of proof should be higher for supplements than for exercise or nutrition science, where funding and statistical power are often lacking.

Publication bias

The mildest form of bias is positive publication bias. Research that doesn't find anything often doesn't get published. You can't prove a negative and from the perspective of a journal, it also makes sense to preferentially publish research with significant findings. They tend to draw more attention than studies that basically amount to the journals saying: "Look, we debunked another supplement that you probably didn't even know existed."

Another bias is personal bias. If research is directly funded by a supplement manufacturer or someone with a vested interest in the supplement, they have a rational incentive to show positive results. Normally, this is listed in the acknowledgements section at the end of the article, but sometimes you have to dig into the authors' affiliations. Most bias is subtle, probably even subconscious, not intentional fraud, though that happens too occasionally with a public scandal when it comes out. If you've taken statistics classes, you know how easy it is to 'fudge' the statistical analysis a bit by deleting 'an outlier' or shifting your statistical parameters around a bit. You can also bias the sample without reporting it. Put everyone that looks prone to a placebo effect in your test group and put your hardgainers in the control group. Maybe you 'let it slip' that people are in the placebo group. As a result, you get no placebo effect in the placebo group and then in the study group even a placebo effect will come out as a significantly positive effect from the supplement.

Given that the supplement industry is one of the primary sources of research funding for supplements, the level of total publication bias for positive results is high. As such, here it makes sense to somewhat ignore the rule that "absence of evidence isn't evidence of absence". If there is no positive research on a supplement that's been around for a while, it's quite likely it has been researched and it didn't turn out to be effective, but this research just wasn't published. This is especially true if there's

literature on animals showing positive results. Animal research is normally the first step for supplement developers, because it's cheap and it's easier to get ethical approval for it. Only when animal research is promising, do human trials normally start. From this perspective, lots of promising research in animals followed by years without human research suggests unpublished human trials didn't live up to the hype.

When you've been in the fitness industry a while, you'll have seen many promising new supplements become popular and then forgotten within a few years. Most supplements don't stand the test of time scientifically or anecdotally.

With the above skepticism in mind, you'll see most supplements discussed in this module get debunked. There is no magic pill. Yet some supplements *are* effective. They just have to be used in the right situation by the right people. It's worth knowing these.

For more details on the supplements listed here, Examine.com and Wikipedia are great sources. Just beware that Examine.com tends to shine an overly positive light on supplements and sometimes relies heavily on animal and *in vitro* (isolated cells in a lab) data. This isn't surprising, as they are inherently biased, even if only subconsciously: there's nothing to be gained telling people 99% of supplements suck. Wikipedia is surprisingly informative and accurate in the case of most supplements, but Examine.com has clearly surpassed it in terms of detail and references. Of course, as always, personal research trumps all third-party materials. Systematic reviews and meta-analyses are particularly useful to check for publication bias.

Before going into specific supplements, here is some general advice.

Supplement shopping rules

- If a supplement doesn't list the ingredients, don't buy it. Only babies put unknown substances in their mouth.
- If a supplement contains more than one ingredient, don't buy it, unless it's a multivitamin or you don't care about the cost. Buying single ingredients is almost universally cheaper, not to mention multi-ingredient [supplements are quite often 'spiked' with other substances](#). [A 2017 review of 23 studies](#) found that 12-58% of supplements were contaminated with prohormones, stimulants or other shady doping substances. Another [2016 review](#) found "90% of sports supplements contain traces of estrogenic endocrine disruptors, with 25% of them having a higher estrogenic activity than acceptable. About 50% of the supplements are contaminated by melamine, a source of nonprotein nitrogen."
- Buy only from reputable brands with scientific research or third-party lab work establishing their legitimacy. To check a product's reputation, you can use [LabDoor](#) (free but now sells supplements) or [ConsumerLabs](#) (paid). If you can't find a good brand, try to buy a generic one. Generics are cheaper and seem less likely to be diluted or spiked.
- Try to buy in bulk. It's cheaper.

Bioavailability

Bioavailability is a highly neglected aspect of nutrition. Many people think that what they eat is what the body receives. In truth, very few substances are 100% bioavailable: not all of what you consume is digested, absorbed and actively available for use in the body. Bioavailability is generally defined as “[the extent by which a nutrient can be absorbed and transported to systemic circulation or the site of physiological activity](#).” This definition is standard in pharmacology, but note that in nutritional circles some researchers use variants of it. Many minerals have a bioavailability below 50%, so the body can utilize less than half of what you consume. Unless fast absorption is desirable or the supplement degrades in the stomach, you should consume most supplements with large, mixed meals to improve bioavailability. Fat particularly seems to benefit bioavailability since many substances are fat soluble, in addition to that fact that fat slows down digestion, giving the body more time to absorb everything.

Measurement Units

When it comes to supplements, it is crucial to know the right dose to supplement with. Misreading the dose or confusing the measurement units can cause you to buy under-dosed bunk, or worse: overdose. Most supplements contain active ingredients in the microgram to gram range.

Grams (g): You can measure amounts in grams using a kitchen scale, measuring spoons or scoops provided with the supplement.

Milligrams (mg): 1,000 mg equals 1 g. It is much more difficult to measure amounts in milligrams than grams. If a supplement dose is several hundred milligrams, then it is possible to measure this amount with scoops provided with the supplement, but not with a regular kitchen scale and certainly not without a specific measurement instrument. Quantities below a few hundred milligrams can be only measured in laboratories using very sensitive scales. For this reason, supplements with active ingredients in this range often contain bulking agents to make supplement handling easier.

Micrograms (µg or mcg): Not to be confused with milligrams, 1 milligram equals 1,000 mcg. Supplements containing such low doses of active ingredients have to be mixed with bulking agents and are usually only available as tablets or capsules.

Now let's get to specifics. We've ordered the supplements in the following categories. Any supplements not discussed in this document aren't worth looking into.

1. Health & Wellbeing
2. Muscle Growth & Performance
3. Fat Loss

Using the Bookmarks/Navigation panel on the left or the search function (ctrl + f) will help you retain overview in this document.

Health & Wellbeing

Spirulina

What is it?

Spirulina, also called *Arthrospira platensis*, is often referred to as blue-green algae, but technically it's a blend of cyanobacteria. Spirulina is highly nutritious and is often labeled a 'superfood' or nutraceutical, as it has health promoting effects that in some cases may rival those of pharmaceuticals. It's a particularly rich source of protein and iron, although its macro- and micronutrients may not be particularly relevant, as most people only consume a few grams of it.

What does it do?

Like most nutritious plants, spirulina boasts a large number of health promoting effects with antioxidant, anti-inflammatory, antihypertensive (ACE inhibiting), antitumor, antiviral and antibacterial activities. [A 2018 meta-analysis by Huang et al.](#) found that spirulina supplementation reduced LDL-cholesterol and systolic and diastolic blood pressure without significant effect on bodyweight or HDL-cholesterol. There was also a reduction in fasting blood glucose levels but no effect on average total blood glucose levels (A1C). The benefits were more pronounced after 12 weeks and with dosages of at least 2 grams of spirulina per day.

While spirulina's benefits look impressive on paper, most research is on unhealthy populations. There's far less evidence that spirulina supplementation benefits already healthy individuals. Moreover, given that spirulina is essentially food, it's likely that part of the benefits of spirulina supplementation can be obtained via an overall healthy diet. Thus, lean, fit and overall healthy individuals may not see any relevant health improvements from supplementing spirulina. In line with this, despite the promising

evidence, [the US National Institute of Health as of 2021 still rejects that spirulina supplementation offers any significant health benefits, other than a possible reduction in blood pressure.](#)

How to take it

There is little research on the dose-response of spirulina supplementation, but you likely need a dosage of at least 2 grams per day and there's no compelling evidence of benefits above 8 grams per day.

Menno's verdict: Strongly worth considering for individuals with chronically high cholesterol or blood pressure, including AAS users. Probably not worthwhile for already healthy individuals.

Ashwagandha root extract

What is it?

Ashwagandha root extract is an herbal extract from the *Withania somnifera* plant. It's popular in Ayurveda, a form of Indian folk medicine.

What does it do?

Mechanism: Named 'smell of horse' in India for its smell and ability to give someone the 'vitality of a horse', science hasn't come much further than that in identifying exactly how it works. The extract functions like an adaptogen: it protects various systems in the body from damage under stress. [Based on rodent research, ashwagandha has GABAnergic effects](#), like phenibut and alcohol.

Benefits: [Ashwagandha supplementation has been found to reduce stress levels of highly stressed individuals, with associated health and wellness benefits \[2\]](#). It seems particularly effective against anxiety related stress. [Ashwagandha supplementation has also been found to improve sleep quality, especially in people with sleep disorders](#). According to [some Indian, industry-sponsored research using BIA and girth measurements](#), supplementing ashwagandha may improve muscle strength and growth from strength training. However, it's worth noting that almost all positive research on ashwagandha comes from India and an [American supplement company](#) and may therefore not be unbiased.

How to take it

Dosage: Benefits are generally found with a dosage of 300 mg root extract, standardized to 5% withanolides, taken twice daily. Due to the lack of dose-response research, you should experiment with less (in case of side effects) and more (for more effect).

When to take it: The supplement should be taken in combination with meals. It is somewhat stimulatory by some, so you may want to avoid it before bedtime.

Version to buy: Ashwagandha root extract is the preferred version of ashwagandha supplementation.

Menno's verdict: May be worth trying for highly stressed or anxious individuals. For physique benefits, I wouldn't bother with it, but it's worth keeping an eye on the supplement for high-quality studies from reputable labs to replicate the findings from the Indian studies.

Cannabidiol (CBD)

What is it?

CBD is an extract of cannabis AKA marijuana, which in turn comes from hemp plants. It's not to be confused with tetrahydrocannabinol (THC), the primary psychoactive substance in cannabis. [CBD does not convert to THC](#).

What does it do?

CBD acts on the CB2R cannabinoid receptor, which the body has because it also produces some cannabinoids itself. In contrast to THC, CBD has low affinity for the CB2R cannabinoid receptor and partial antagonism. CBD can also act weakly on opioid and serotonin receptors. The effects of this cocktail of receptor activity are mostly sedative with anxiolytic (anxiety reducing) and analgesic (painkilling) effects, which make CBD potentially therapeutic for [psychosis](#), anxiety disorders, [addiction rehab](#), epilepsy and chronic pain [2, 3, 4]. CBD also appears to have antioxidant effects, which make it anti-inflammatory and potentially neuroprotective.

Unless you have one of the above conditions, the best recreational use for CBD is arguably its anxiolytic effect. For example, [CBD has been found to reduce fear of public speaking](#).

CBD is not psychotropic like THC, meaning it does not get you high. [CBD also does not affect sleep architecture or quality](#).

CBD oil does not seem to promote neuromuscular recovery, regardless of delivery method. There's also no clear mechanism of action for how it would.

[Cochrane-Snyman et al. \(2021\)](#) found no effect of 150 mg per day of CBD oil on recovery from muscle damage. [Garcia et al. \(2019\)](#) found no effect of topical CBD oil

on muscle soreness. [Hatchett et al. \(2020\)](#) found no effect of a single post-workout dose of sublingual CBD oil on muscle soreness. (The authors erroneously interpreted regression to the mean as a benefit due to higher post-exercise soreness in the CBD group, but the recovery trajectory over 4 days was nearly identical for all groups.)

[Isenmann et al. \(2021\)](#) did find tentative evidence that consuming 60 mg CBD helps with post-workout recovery, but there was only an effect for 1 of the 2 performance measures and muscle damage markers and only at 1 of the 3 assessed time points. At this time point (72 hours), none of the values were significantly different from baseline, so the between-group difference is not strictly interpretable: essentially the results say that at this time the values were no different from baseline yet still different from each other. That's not logically possible, so this study should be viewed as tentative evidence.

[CBD appears to be safe in humans up to 1500 mg per day](#), but long-term research on potential side-effects related to fertility, appetite stimulation and hormonal effects are needed.

How to take it

CBD can be inhaled, generally with vapers, or orally consumed, generally in the form of CBD oil. [CBD seems to have an inverted U-shaped dose-response curve with anxiolytic effects at 300 mg but not at 100 mg or 900 mg.](#)

Menno's verdict: Worth considering if you have problems with anxiety or one of the above conditions but currently extremely overhyped.

Curcumin

What is it?

Curcumin is an extract of the turmeric plant, commonly known as an ingredient of curries. It has a distinct orange-yellow color due to its pigments.

What does it do?

Curcumin exhibits potent anti-inflammatory activity, but it has very poor bioavailability in humans – almost none – due to its instability and poor solubility, i.e. Curcumin causes multiple modes of assay interference, which makes it seem like it's an active drug in research, whereas in reality it's a false positive. This has led to an enormous amount of research being done on curcumin with very disappointing results. [A 2017 review of over a hundred studies on curcumin concluded](#): “No double-blinded, placebo controlled clinical trial of curcumin has been successful. This manuscript reviews the essential medicinal chemistry of curcumin and provides evidence that curcumin is an unstable, reactive, non-bioavailable compound and, therefore, a highly improbable lead.”

It's also worth noting that [at least 29 papers showing positive findings of curcumin supplementation from Indian researchers, in particular Bharat Aggarwal, have been retracted](#) due to fraud.

[Some research finds promising effects of curcumin supplementation as an anti-inflammatory painkiller for \(osteo\)arthritis patients](#); however, much of the research is authored or sponsored by the supplement industry.

Given the very poor bioavailability and complete lack of endorsement from any official medical institution, curcumin supplementation is not advisable. However, [multiple ways](#)

[have been developed to improve curcumin's bioavailability](#), making it potentially useful. The most promising form is arguably the addition of piperine, black pepper extract. By inhibiting glucuronidation, [piperine raises curcumin's bioavailability from unmeasurable to measurable levels](#). The exact bioavailability percentage of curcumin with added piperine does not seem to be reported anywhere. There are also multiple patented, proprietary formulas, including Meriva and BCM-95, but given the notoriety of proprietary supplement formulas, we cannot endorse those until we have much more independent evidence.

Even if you can make curcumin bioavailable, it's questionable if you want to as a strength trainee, because [curcumin inhibits anabolic signaling, including mTOR activity](#). Combined with its anti-inflammatory activity, it's plausible that curcumin supplementation would impair muscle growth and strength development.

How to take it

A common dosage is 500 mg curcumin with 5 g piperine 3 times daily.

Menno's verdict: Since it's possibly detrimental for your gains, its mechanistic basis is highly questionable and there seems to be enormous publication bias, I don't recommend it for anyone except perhaps people with arthritis.

Milk thistle

What is it?

Milk thistle is a medicinal herb used in the treatment of liver damage. Its active ingredients are Silymarins.

What does it do?

Milk thistle may increase the rate of protein synthesis in liver cells and encourage subsequent repair after injury to the cells. Its effectiveness is highly controversial, but since strength training by itself can elevate liver enzymes (albeit asymptotically) and liver damage is extremely serious, it may be worth a shot when suspecting liver damage, like after binge drinking and when taking hepatotoxic substances like oral androgenic anabolic steroids.

How to take it

Dosage: A daily dosage equivalent to 300 mg of silymarin (in three divided doses) is a good guideline, depending on the severity of liver damage.

When to take it: After intoxication.

Versions to buy: Milk thistle extract (in ethanol) with a high Silymarin component is frequently used as a supplement.

Menno's verdict: An advisable precaution for heavy alcohol consumers and oral AAS users.

Berberine

What is it?

Berberine is an organic compound (alkaloid) found in many herbs.

What does it do?

Mechanism: Berberine interacts with a nutrient sensor protein (AMPK), which is the target of several anti-diabetes drugs.

Benefits: This is an effective supplement for people with elevated blood sugar levels to keep blood glucose within the normal range and reduce inflammation. Other benefits generally fall in the 'poor cost-benefit ratio' category.

How to take it

Dosage: 900-2000 mg a day, divided into 3-4 doses.

When to take it: Take it with a meal or shortly after.

Version to buy: Berberine can be obtained in capsule form online.

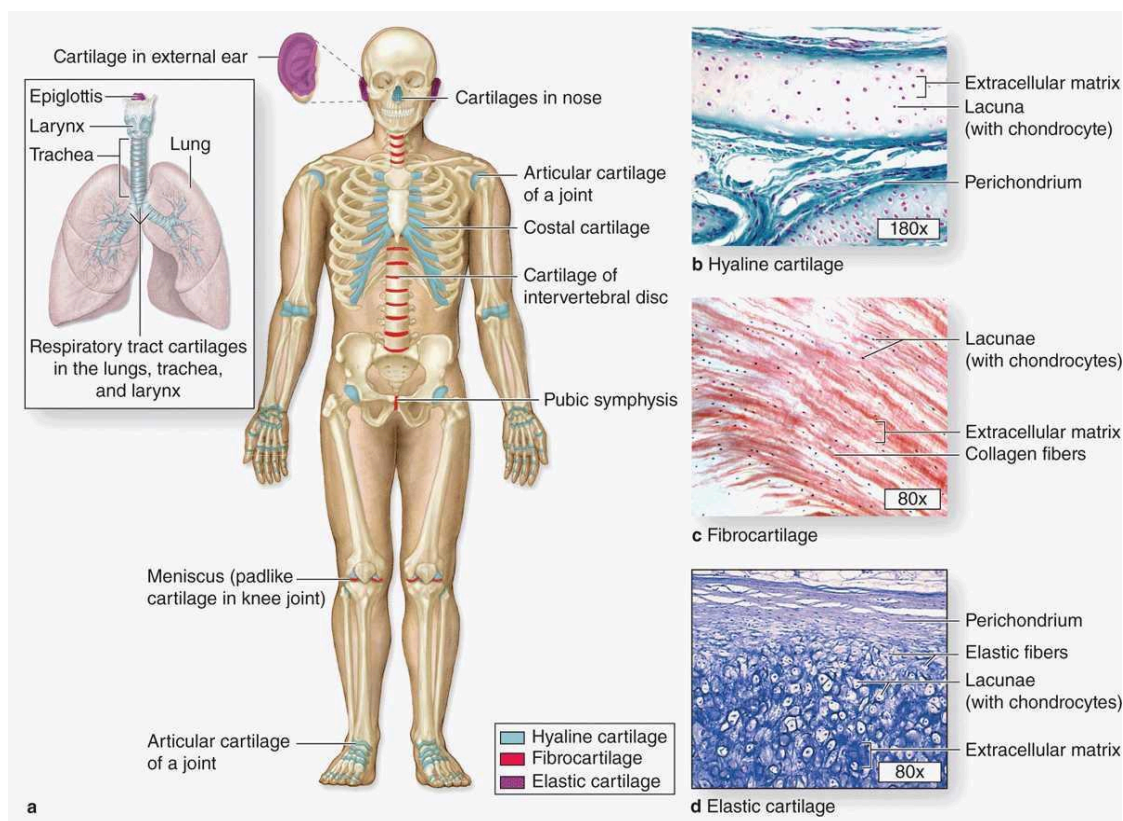
Menno's verdict: May be worth it for individuals with metabolic syndrome until they've leaned down and increased their muscle mass to make insulin sensitivity a non-issue.

Collagen*

What is it?

Collagen is a peptide that is a part of your connective tissues, including your joints, skin, tendons, ligaments, bones and cartilage. There are many different types of collagen. In the human body, types I, II and III are most common. Cartilage, the elastic padding of our bones, is composed primarily of type II collagen.

Extracted collagen from animals is called gelatin. Gelatin can be hydrolyzed further to create a supplement we then call collagen/gelatin hydrolysate or hydrolyzed collagen/gelatin. Gelatin will contain a mixture of different types of collagen, depending on the source tissue.



The distribution of cartilage in the human body.

Source: [Junqueira's Basic Histology: Text and Atlas](#)

There are 2 common types of collagen supplements:

- Hydrolyzed collagen AKA hydrolyzed gelatin is absorbed by the body and might be used to synthesize collagen in our body's own connective tissues.
- Undenatured type II collagen is purported to reduce auto-immunity to the body's own collagen and is therefore more commonly used for patients with osteoarthritis (OA).

What does it do?

Mechanism: The common theory is that the supplemented collagen is taken up by the body to form more collagen and thus promote connective tissue protein balance, protecting your connective tissues against injury. While this theory may sound straightforward, it doesn't make as much sense when you think about it. Collagen is not absorbed intact by your connective tissues. Collagen is a protein, so just like other protein sources, it's broken down into its constituent amino acids and [some peptides](#) during digestion. Thus, it's mechanistically unclear why collagen would be superior to our standard protein sources, which have a higher protein quality and include all the amino acids that collagen does. Collagen does have very high concentrations of hydroxyproline and glycine, which are conditionally-essential amino acids used in the construction of the body's own collagen, and it's possible that the optimal protein intake for muscle growth does not fully optimize the intakes of these amino acids for connective tissue synthesis. However, many of the studies on protein intake measured total lean body mass or protein balance, which includes connective tissue, so these studies indirectly refute any benefits of additional (collagen) protein supplementation. Collagen does have some peptides that are absorbed intact, but with enough protein and vitamin C, the body can produce its own collagen.

Interestingly, it's controversial in the literature if collagen supplementation even increases collagen or connective tissue synthesis in the first place. Some studies did find benefits, most of them industry-sponsored by Gelita AG, but multiple other independent studies in humans did not find beneficial effects. Studies seemed to be more likely to find positive effects of collagen (or protein) supplementation when it was combined with vitamin C, which the body needs to produce its own collagen, and when the training intervention stressed connective tissues significantly (e.g. high-intensity).

- [Aussieker et al. \(2024\)](#) found that a blend of 25 g whey and 5 g collagen blend only stimulated muscle connective tissue protein synthesis rates at rest, not post-exercise.
- [Nulty et al. \(2024\)](#) found a dose-response of 0 vs 15 vs 30 g hydrolyzed collagen supplementation on post-workout collagen synthesis (based N-terminal propeptide of type 1 pro-collagen (PINP)) but not breakdown (based on β -isomerized C-terminal telopeptide of type 1 collagen (β -CTX)). The collagen powder was enriched with vitamin C, so the results could be due to either the extra protein or vitamin C intake rather than collagen per se.
- [Kirmse et al. \(2024\)](#) found no effect of 2 x 15 g daily hydrolyzed collagen supplementation on muscle connective tissue or myofibrillar protein synthesis rates during a week of strength training and calisthenics. There was also no effect on muscle soreness vs placebo. Protein intake was ~1.4 g/kg per day in both groups.
- [Balshaw et al. \(2023\)](#) found no effect of 15 g daily bioactive collagen peptide supplementation over a placebo on patellar tendon adaptations to strength training. After 15 weeks of serious lower body strength training, the collagen supplementation did not augment tendon size growth (CSA or aponeurosis area), tendon stiffness (incl. Young's Modulus), strain reduction or any other mechanical property.

- [Aussieker et al. \(2023\)](#) found 30 g post-workout collagen did not significantly differ from placebo in terms of muscle connective tissue or myofibrillar protein synthesis, nor whole-body collagen synthesis or breakdown (as measured by P1NP and CTX-I, respectively).
- An industry-sponsored study by [Berger et al. \(2023\)](#) found that just 5 g daily collagen peptide supplementation significantly increased the tendon CSA growth from strength training compared to a placebo. The study did not report protein or vitamin C intakes.
- [Lee et al. \(2023\)](#) found that 30 g but not 15 g collagen supplementation increased serum PINP, a biomarker of whole-body collagen synthesis, after high-intensity squatting. There was no effect on collagen breakdown, as measured by beta-CTX. Vitamin C was added to the hydrolyzed collagen supplement, which is necessary for the body to synthesize its own collagen, so it's unclear if the benefits came from the collagen or the combination of protein and vitamin C. The study had no conflicts of interest.
- [Prowting et al. \(2020\)](#) also found no effect of supplementing 15 g collagen on any collagen turnover biomarker. The collagen supplementation did seem to improve neuromuscular recovery compared to placebo, suggesting that it was broken down for use as regular protein for the muscles rather than used for collagen synthesis.
- [Lis & Baar \(2019\)](#) studied how various vitamin C-enriched collagen forms affected N-terminal peptide of procollagen (PINP) levels, an indirect measure of bone collagen synthesis, after exercise. None of the collagen preparations significantly differed from placebo in effect. 15 g hydrolyzed collagen did not significantly affect PINP levels. 15 g gelatin resulted in a trend for an increase ($p = 0.06$) in an unadjusted t-test, but the overall analysis of variance was insignificant. A combination of the two in gummy form resulted in a non-significant decrease in PINP levels.

- [Shaw et al. \(2017\)](#) found that supplementing 15 g of vitamin C-enriched gelatin increased collagen levels in engineered ligaments and blood PINP levels in healthy humans compared to a placebo. 5 Grams did not have a significant effect. Gelatin did not affect the mechanical properties of the engineered ligaments, so [it's plausible the vitamin C rather than the gelatin was responsible for the benefits](#). Since vitamin C is required for the body to produce collagen, [vitamin C supplementation can increase collagen synthesis](#). Alternatively, it may just have been the additional 15 g protein intake, as the placebo contained no protein.
- An industry-sponsored study in mice by [Oesser et al. \(1999\)](#) found that orally consumed gelatin hydrolysate ended up in the mice's bodily cartilage.

Benefits: [Undenatured type II collagen may be able to decrease joint pain and improve physical functioning in individuals with osteoarthritis \(OA\)](#) [2, 3], probably by reducing systemic inflammation, akin to reducing auto-immunity. However, virtually all positive data come from industry-sponsored studies. Moreover, [the results do not show a dose-response effect or beneficial effect of longer treatments](#), which is very questionable. [Collagen hydrolysate supplementation can also reduce pain and improve functionality in individuals with osteoarthritis](#) (OA) [2, 3], although the latest meta-analysis concluded [the long-term practical significance of collagen supplementation for OA is questionable](#). Even if collagen supplements may benefit OA, that doesn't mean they're beneficial for injuries in strength athletes. Research on OA is commonly cited to support collagen as a supplement for injury healing in strength trainees, but OA is a fundamentally different pathology than a musculoskeletal injury in a healthy trainee. OA is a chronic, degenerative disorder affecting joints, primarily cartilage, from the inside out, not a simple case of musculoskeletal overuse. Many strength training injuries are not even in cartilage but in tendons.

For joint pain in individuals without OA, findings are mixed.

- In an independent study by [Bongers et al. \(2020\)](#), supplementing 10 g hydrolyzed collagen peptide per day for 12 weeks did not improve knee pain, knee performance or inflammatory-, cartilage- and bone (bio)markers, including PINP, compared to placebo in physically active, healthy individuals with knee pain.
- A semi-independent study by [Bruyere et al. \(2012\)](#) found tentative but conflicting support for 12 g per day collagen supplementation to improve joint pain over 6 months, with next to no effect at 3 months, suggesting any benefits take over 3 months to manifest.
- An industry-sponsored study by [Kviatkovsky et al. \(2023\)](#) compared a placebo vs 10 g and 20 g collagen peptide supplementation, spread over 2 daily dosages, for 9 months, on self-reported measures of pain and functioning. The participants were in chronic pain, but it was unclear if they had osteoarthritis, and they were physically active in some way for at least 4 h per week, but the type and duration of physical activity were not controlled, because it was a free-living study design. Despite the researchers trying very hard to make it sound like there were significant effects of the collagen, there was no significant effects of time from baseline to study end on the main survey results – The Knee Injury & Osteoarthritis Outcome Score (KOOS) and the Veterans Rand 12 (VR-12) – and therefore logically no effect of supplementation. The data were all over the place. Indeed, the study data had multiple serious statistical problems, including non-normal data, heterogeneous variance and a very high attrition rate. Also, macronutrient intakes did not significantly differ between the groups, so the collagen groups consumed more total daily protein.
- There are [5 studies which we've summarized here](#) that suggest collagen supplementation also aids the recovery of sports injuries. However, all of them are sponsored by a manufacturer of collagen supplements, often Gelita.

If we have to believe the [research on collagen with industry funding](#), 15 g of collagen supplementation can miraculously stimulate pounds of muscle growth even when the control group consumed significantly more total protein. In contrast, [independent research on mice](#) found collagen is not taken up by skeletal muscle tissue in the first place and [in human research](#), collagen peptides are worse at increasing both myofibrillar and sarcoplasmic muscle protein synthesis than lactalbumin. [Other research](#) found collagen protein supplementation does not significantly increase muscle protein synthesis at all, neither at rest or post-workout, in contrast to whey protein [2, 3], and [collagen supplementation is correspondingly worse at stimulating muscle growth than whey protein, even when the collagen is enriched with leucine](#). Even [1 other Gelita industry funded study](#) confirmed that 15 g daily collagen supplementation did not affect body recomposition. Thus, there appears to be large sponsorship bias in the collagen research.

Moreover, none of the studies finding benefits reported dietary protein or vitamin C intakes. Collagen is composed of amino acids and the body can synthesize collagen on its own with a sufficient intake of vitamin C and protein. [Consuming enough high-quality protein can thus increase the level of collagen precursor amino acids in the blood just as well as gelatin or hydrolyzed collagen](#). Unsurprisingly then, [collagen supplementation is more effective in people with low protein intakes](#) and [vitamin C consumption can increase body collagen production](#), so it's doubtful if collagen supplementation has any benefits in individuals that are already consuming enough protein and vitamin C.

Lastly, all studies relied on subjective, self-reported measures, mainly pain, which is susceptible to placebo effects when the design is imperfectly blinded.

Overall, unless you have osteoarthritis, it's very doubtful if collagen supplementation will do anything to recover from strength training injuries in individuals that are already consuming enough vitamin C and protein.

How to take it

Dosage: Hydrolyzed collagen mechanistically seems to require a dose of 15 g to be potentially effective. Undenatured type II collagen's standard dose is much lower with 40 mg once daily.

Collagen is also found in significant concentrations in gelatin and bone broth. However, [most bone broths are too low in collagen precursor amino acids to be therapeutic](#). You have to consume a lot of very gelatinous broth to potentially get effects similar to 15+ g hydrolyzed collagen supplementation. [One study](#) found that 52 g of amino acids from a remarkably concentrated home-made bone broth was approximately equivalent in effectiveness to 20 g of amino acids from gelatin or collagen supplements to raise collagen precursor amino acid levels in the blood (glycine and proline).

When to take it: Both collagen types can be taken with meals; however, undenatured type II collagen intake may theoretically be more beneficial on an empty stomach.

Menno's verdict: If you're already consuming enough protein and vitamin C, collagen supplementation is probably only beneficial for individuals with osteoarthritis.

Glucosamine sulfate, [methylsulfonylmethane \(MSM\)](#) and [chondroitin](#) *

What are they?

These 3 supplements are commonly purported to benefit joint health. Glucosamine and chondroitin are components of animal joints. Glucosamine supplements are derived from shellfish. Chondroitin sulfate is a crucial component of cartilage.

MSM is commonly added to the stack and is thought to have anti-inflammatory properties.

What does it do?

Mechanism: Glucosamine is a precursor for glycosaminoglycans, notably chondroitin, which is a component of cartilage. So the theory was that glucosamine promotes cartilage growth. However, it appears that [the amount of glucosamine that actually ends up in cartilage cells \(chondrocytes\) is far too low to stimulate chondroitin synthesis. Moreover, cartilage cells can easily synthesize far larger amounts of glucosamine from glucose than the cells can absorb from supplementation.](#)

Direct chondroitin supplementation was thought to achieve the same benefit as glucosamine: increase cartilage production. However, [chondroitin supplements do not appear to reach the joint space in effective amounts.](#)

Unsurprisingly then, [there is no evidence that glucosamine or chondroitin supplementation can help prevent joint injuries in athletes, nor does glucosamine supplementation speed up the recovery of injured joints in athletes in terms of pain experience or functional outcomes](#) [2].

[Glucosamine and chondroitin supplements do seem to be somewhat effective to reduce symptoms of osteoarthritis, but the evidence is weak and inconsistent \[2\]](#). There is also strong industry sponsorship bias and many studies are of poor quality for both chondroitin and glucosamine. [A large meta-analysis concluded that chondroitin and glucosamine supplements did not provide any clinically meaningful relief of osteoarthritis](#). Any benefits may be due to reduced auto-immunity to the body's own connective tissue, rather than an increase in connective tissue healing speed, just like for collagen (see section on collagen).

There is also [research indicating that any benefits of glucosamine, MSM and chondroitin are entirely unrelated to the supplements themselves but come from the attached sulfur, which can correct for a sulfur deficiency](#). This would explain why some but not other people seem to respond to treatment. MSM in particular seems to have little mechanism of action independent of sulfur, as it is virtually biologically inert itself. So MSM is basically a sulfur supplement. Since sulfur is easily obtained from several amino acids, MSM supplementation is likely redundant in a high protein diet.

All in all, strength athletes without osteoarthritis on a healthy diet will probably not experience any benefits from glucosamine, MSM or chondroitin supplementation above placebo.

How to take it

Dosage: 3,000 mg glucosamine in combination with up to 1,200 mg chondroitin, taken in several doses (e.g. 3 times per day).

When to take it: The supplements should be taken in combination with meals.

Versions to buy: Glucosamine sulfate salts are best, followed by glucosamine sulfate. Glucosamine hydrochloride is ineffective; N-Acetylglucosamine is a different supplement.

Menno's verdict: Only potentially worth trying for people with osteoarthritis.

D-aspartic acid (DAA)

What is it?

D-aspartic acid is an amino acid. It is another form of L-aspartic acid (or L-aspartate), one of the 20 dietary amino acids used for protein synthesis. Although the different amino acid forms (L- and D-) are built similarly, they have different geometric properties: like two hands, they look similar, but they are not identical, as it's impossible to overlap them.

What does it do?

Mechanism: DAA can increase testosterone production by aiding in the brain's regulation of the messenger signals to produce testosterone. However, it does not seem to increase testosterone levels if they are already within the physiological range. It may in fact be toxic to your testes in this scenario.

How to take it

The standard daily dose of d-aspartic acid is 2-3 g in tablet or powder form.

Menno's verdict: Stay away unless you're hypogonadal. Even then, it's probably not the real solution to the problem.

Garlic extract*

What is it?

The vegetable garlic (*Allium sativum*) releases allicin when crushed. Allicin has various positive effects on human health.

What does it do?

Garlic extract provides similar health benefits as eating large amounts of garlic. [The most notable benefits include a modest increase in HDL-cholesterol and decrease in LDL-cholesterol \(7.4-29.8 mg/dL decrease in total cholesterol\), a decrease in blood pressure \(7-16 mm Hg \(systolic\) and 5-9 mm Hg \(diastolic\)\) and improved immune system strength \[2, 3\].](#)

How to take it

You could eat a raw clove of garlic per day (4 g), but this produces high amounts of hydrogen sulfide, which in turn makes your breath and sometimes sweat smell of garlic. [With cooked garlic you'd need to consume severalfold more garlic.](#) Aged garlic extract provides similar health benefits without as much of the smell or need to consume lots of garlic every day and is therefore a convenient option. The conventional dosage range is 600-1200 mg garlic extract powder, but [there appear to be minimal benefits of increasing the dosage above 480 mg garlic extract and more digestive side-effects](#), so you may want to limit your intake to ~500 mg of garlic extract.

While aged garlic is often marketed as 'odorless', that's often not entirely the case and others may notice the smell even if you don't. It may also still cause digestive side-effects, such as bloating and gas. To reduce the inconvenience of these effects, supplementing the garlic extract right before you go to bed can minimize your experienced discomfort.

[You should consume garlic extract in the form of tablets without enteric coating, as tablets have higher bioavailability than capsules and enteric coating decreases allicin bioavailability, ironically.](#) It's probably best to take the garlic extract with a meal, as the meal will decrease stomach acidity (higher pH) and your [stomach acid may otherwise inhibit alliinase, which is needed to form allicin from alliin](#). If your supplement does have enteric coating, consume it with low protein, easily digestible meals, as delayed gastric emptying will expose the tablets to excessive stomach acid, which inhibits alliinase. The following products have been validated in research to have high bioavailability:

- GNC-1000, AKA Natural Brand Odorless Garlic 1000 from General Nutrition Corp (GNC).
- Kwai forte 300 from Klosterfrau.
- Odor Free Garlic from Nature's Bounty.
- Kwai from Lichtwer Pharma.
- Garlicin from Nature's Way Products also performs well despite having enteric coating, but not being able to consume it optimally with high protein meals can be inconvenient for strength trainees.

Menno's verdict: Certainly not a panacea, but it's one of the best supported supplements for cardiovascular health. Generally recommended for individuals with high blood pressure or cholesterol, including AAS users.

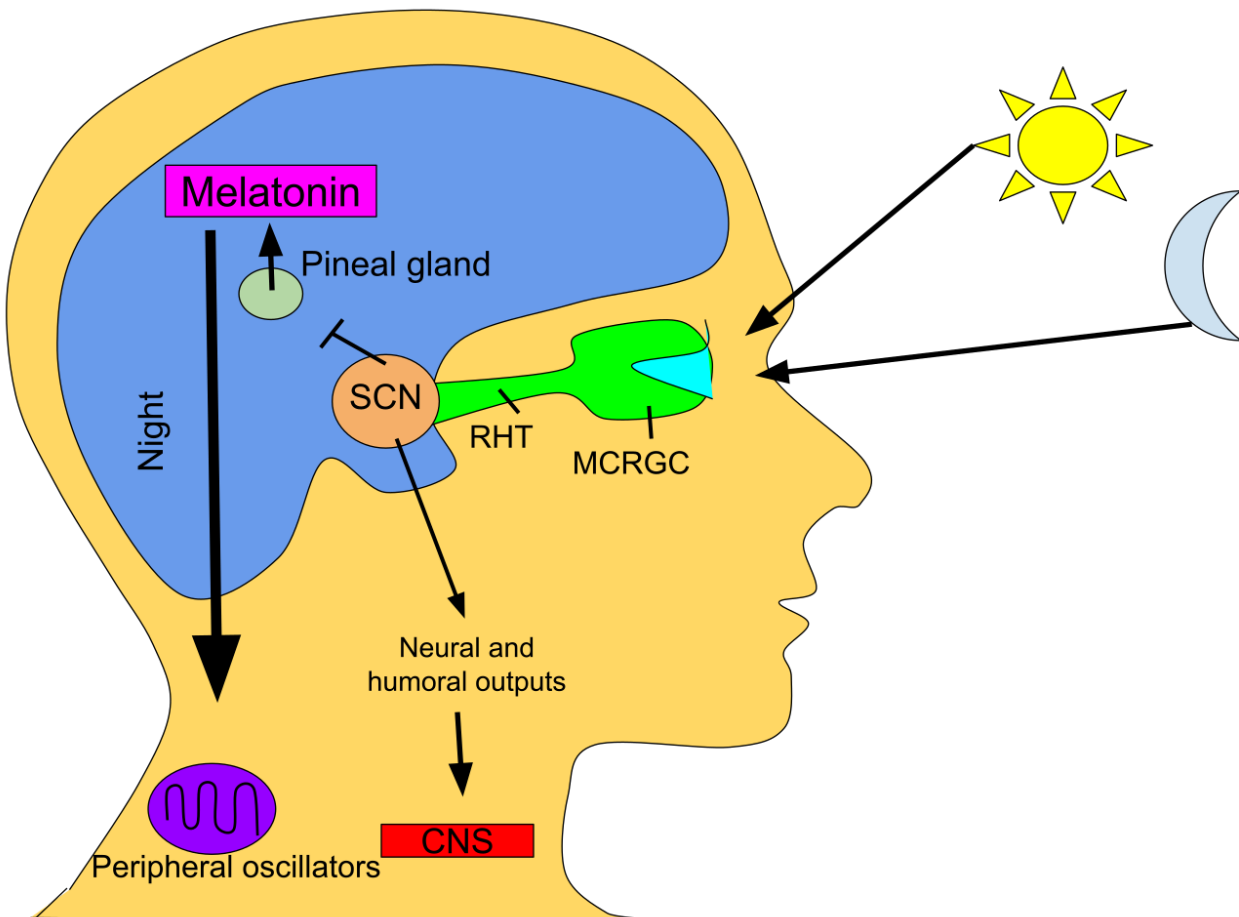
Melatonin*

What is it?

Melatonin is a peptide hormone and neurotransmitter.

What does it do?

Mechanism: Melatonin is made from serotonin, which is made from dietary L-tryptophan. It is produced in the human body in response to darkness to initiate sleep cycle.



Bright light exposure keeps melatonin levels low, preventing you from becoming sleepy.

Benefits: [Melatonin mainly helps you fall asleep, but it can also improve sleep efficiency and sleep duration slightly \[2, 3\]](#). Melatonin supplementation may be particularly useful for shift workers or jetlagged individuals. Irregular sleep patterns may cause health problems, premature ageing and worsen the recovery from resistance training.

In addition, [melatonin is an antioxidant \[2\]](#) and [exhibits anti-cancer properties \[2\]](#). [Melatonin supplementation has consistently demonstrated positive health effects in various contexts](#), although most of these may just be the effect of more sleep, not melatonin per se.

In contrast to what you'd expect from a sleeping aid, [melatonin has shown some promise as a post-workout or even pre-workout supplement in some research](#). During the daytime when you stay active, melatonin supplementation does not make you sleepy. However, it also doesn't benefit performance in the majority of studies, so any benefits for sports performance seem to be indirect effects of its anti-inflammatory and health-promoting effects. Moreover, some studies have found negative effects of high-dose pre-workout melatonin supplementation on physical performance. Since there's no clear mechanism of action of how melatonin supplementation would be beneficial for your gains either pre- or post-workout, it's best to stick with pre-sleep supplementation until we have more research.

[Melatonin is very safe \[2\]](#). In contrast to many other sleeping medications, [melatonin is not addictive, does not cause dependency and does not cause withdrawal effects](#). [Melatonin supplementation does not affect natural melatonin synthesis \[2\]](#). You can therefore supplement melatonin chronically.

How to take it

Dosage: [The commonly recommended clinical dosage for adults is 3-5 mg per day.](#) [Natural melatonin production is only 0.1-0.9 mg per day,](#) but [higher doses produce greater benefits on average in research.](#) [5 mg only appears to be more effective in individuals with low natural melatonin synthesis, such as cases of jetlag.](#) In some rare cases, higher doses can cause 'melatonin hangover' or night-time awakenings. Therefore, [some people respond better to physiological \(0.3 mg\) than supraphysiological doses \(1 mg\).](#) [These individuals may metabolize melatonin extremely slowly due to low cytochrome P450 enzyme CYP1A2 activity,](#) resulting in constantly elevated melatonin levels, instead of nightly peaks that help them fall asleep, when they take high dosages. For the same reason, [slow-release formulas are generally less effective and can have more side-effects than the conventional fast-release formulas.](#) You want a high spike in melatonin to fall asleep. In general, it's advisable to start with a physiological dose or 0.3 mg and only work up in dosage as needed to fall asleep rapidly.

When to take it: 30-60 minutes before going to bed.

Versions to buy: Any melatonin supplement from a reputable brand or a generic should be fine.

Menno's verdict: Very useful to deal with circadian rhythm related trouble falling asleep.

Modafinil

What is it?

Modafinil is an organic molecule that was designed to act against sleep-related disorders. It is the second most popular nootropic (smart drug) used by students and academics alike, behind methylphenidate.

What does it do?

Mechanism: It primarily acts as a non-stimulating, long-acting caffeine that reverses the effects of sleep deprivation.

Benefits: Besides counteracting sleep deprivation, it also has benefits comparable to methylphenidate (see fat loss section) in well rested individuals, namely appetite suppression, improved attentional focus and increased cognition/memory. Modafinil has an excellent safety profile with no significant addiction symptoms and or risk of tolerance.

How to take it

Dosage: The standard dose is 4 mg/kg. 100 mg will maximize benefits when well rested. 200 mg is enough for significant sleep deprivation. 400 mg is beneficial for pilots staying awake for days or people with narcolepsy. 600 mg is reserved for hardcore insomnia.

When to take it: Somewhat problematically, the half-life of modafinil is ~15 hours. It can interfere with sleep quality and send a person into a negative spiral of increased sleep deprivation and increased reliance on modafinil. It is advisable taking it immediately upon waking and reserving its use (especially dosages >100 mg) for times of sleep deprivation.

Versions to buy: In the US and Canada, modafinil is not commonly available over the counter without a prescription.

Menno's verdict: A powerful drug to uphold mental performance when you're sleep deprived, best limited to occasional 'emergency' use to avoid getting sucked into a negative spiral of sleep deprivation and increased reliance on modafinil.

Mucuna pruriens

What is it?

Mucuna pruriens is a dried bean powder that contains a high amount of L-dopa.

What does it do?

Mechanism: L-dopa is a direct precursor to the neurotransmitter dopamine that is responsible for the sensation of 'wanting'.

Benefits & downsides: Mucuna pruriens can increase all-round motivation, including sex drive. Some of the effects are hormonally mediated, including an increase in testosterone and growth hormone and a decrease in cortisol. While theoretically promising, the anecdotal effects in healthy humans are unconvincing.

How to take it

Dosage: 5 grams of dried powder is a good starting point.

When to take it: Mucuna pruriens can be absorbed best when taken on an empty stomach. However, some people experience digestive issues and nausea when taking it on an empty stomach. In such cases, it is advisable to consume it in combination with food.

Versions to buy: Mucuna pruriens can be obtained as beans or as powder. Beans contain protease inhibitors (like soy); for this reason, it is reasonable to soak and cook them. However, heat treatment also destroys L-dopa.

Menno's verdict: Worth keeping an eye on and potentially worth trying.

Phenibut*

What is it?

Phenibut is a developed pharmaceutical drug that is an analogue of the neurotransmitter GABA.

What does it do?

Mechanism: It regulates the excitability of the central nervous system. It is a depressant, which means that it can slow brain activity and lower neurotransmitter levels.

Benefits: Phenibut primarily increases motivation, attention and concentration with a weaker effect on memory and little effect on overall intelligence. It is a strong anxiolytic (anxiety killer). Phenibut is used to treat panic attacks, stuttering, Parkinson's disease, neuroses, vestibular (balance) disorders, spasticity, epilepsy, hyperactivity, insomnia and post-traumatic stress disorder.

In addition, Phenibut has mood enhancing effects. It has thymoleptic (anti-depressant) properties and can reduce irritability and fatigue. It is clinically used to treat asthenic-depressive syndrome.

These psychoactive effects are similar in mechanism to alcohol but without the depressant effects. In the upper/downer classification of drugs, alcohol is a downer, but Phenibut is neither. Phenibut improves focus and calm without the jitters of caffeine or the cloudiness of alcohol.

Phenibut has a few more effects that are particularly relevant for bodybuilders. Phenibut can increase resting and post-exercise growth hormone secretion. In a study

of weight training men, GABA supplementation increased resting growth hormone concentrations by 375%. Post-exercise growth hormone concentration rose by 175%. Baclofen, which works almost exactly the same as Phenibut, also increases growth hormone synthesis.

Phenibut is anti-hypoxic. When a muscle is trained intensely, it can't get enough oxygen anymore and become hypoxic. This metabolic stress mediates muscle hypertrophy. Phenibut may thus increase the tolerance to metabolic stress and allow to train harder.

Phenibut is neuroprotective and augments cell energy potential, again possibly allowing you to train harder.

Phenibut seems to work best in very lean individuals, since it can counteract the natural decrease in growth hormone production associated with being lean. This may help the joints stay healthy and keep the metabolism high. Phenibut's mood enhancing effects are also very beneficial here, as anyone who's ever been below 7% body fat will be able to tell.

Points to consider: Many people take much higher dosages for longer periods of time. This is the same 'more is better' fallacy that leads people to drastically overestimate [how much protein they need per day](#) and become [addicted to caffeine](#). Like caffeine, Phenibut feels great and seems harmless, so people consume high amounts of it on a regular basis. The result is addiction: tolerance to the good effects and withdrawal when ceasing supplementation. And they pay the price. Phenibut withdrawal is hell. When coming off 20 grams a day, [a person can literally become psychotic for a while](#). Tapering off the dose will minimize withdrawal symptoms, but my recommendation is to avoid becoming addicted in the first place.

How to take it

Dosage: [This calculator](#) can be used to determine the appropriate dose for an individual.

The majority of studies have only researched dosages up to 3 grams a day. At these dosages, no psychological side effects are found. Pre-workout dosage should be limited to a maximum of ~0.5 gram, the daily dosage to ~1 gram and it should never be consumed more than ~3 grams unless a person knows exactly what he/she is doing.

Phenibut's effects are highly mediated by stress and anxiety. So the personality type and the situation strongly determines how much benefit a person will experience from Phenibut. If a person is not in a stressful or social situation and has a naturally calm personality, this person may not feel anything from Phenibut unless when taking several grams. So experimentation and timing is everything to find the dosage that works for an individual. It's a drug, not some supplement one takes daily just to take it.

When to take it: Phenibut is better taken after than before workouts. Just 0.4 gram of Phenibut decreases motor cortex activity, muscle tone, coordination and body temperature.

Phenibut's effects can easily last the rest of the day, even though Phenibut's plasma half-life is only 5.3 hours. This is because Phenibut's action on the GABA receptors can linger long after the kidneys have excreted all the Phenibut.

Versions to buy: Phenibut can be purchased on eBay or [here](#).

Menno's verdict: One of the best supplements to reduce anxiety and possibly improve psychological stress-related recovery. Definitely worth trying for anxious individuals.

Piracetam

What is it?

Piracetam is a synthetic molecule that was designed to enhance brain function.

What does it do?

Mechanism: Piracetam enhances membrane fluidity.

Benefits: Piracetam [was found to improve the short-term verbal memory \(word recall task\) in students](#). As long as you don't get your hopes up about major memory improvements or even any noticeable effect at all, long term piracetam use can thus be an effective way to improve memory. [In people with cognitive impairments, like dementia, piracetam's effectiveness is much better established](#).

How to take it

Dosage: The standard dose for adults is between 1,200-4,800 mg a day, which is usually divided in 3 parts.

When to take it: Taking piracetam on an empty stomach increases its absorption.

Versions to buy: Piracetam is available in capsule and in powder form. Both forms can be purchased online.

Menno's verdict: Worth trying if your job is strongly reliant on your memory.

Piracetam is as good as it gets for that purpose, though that says more about the alternatives than about piracetam's effectiveness.

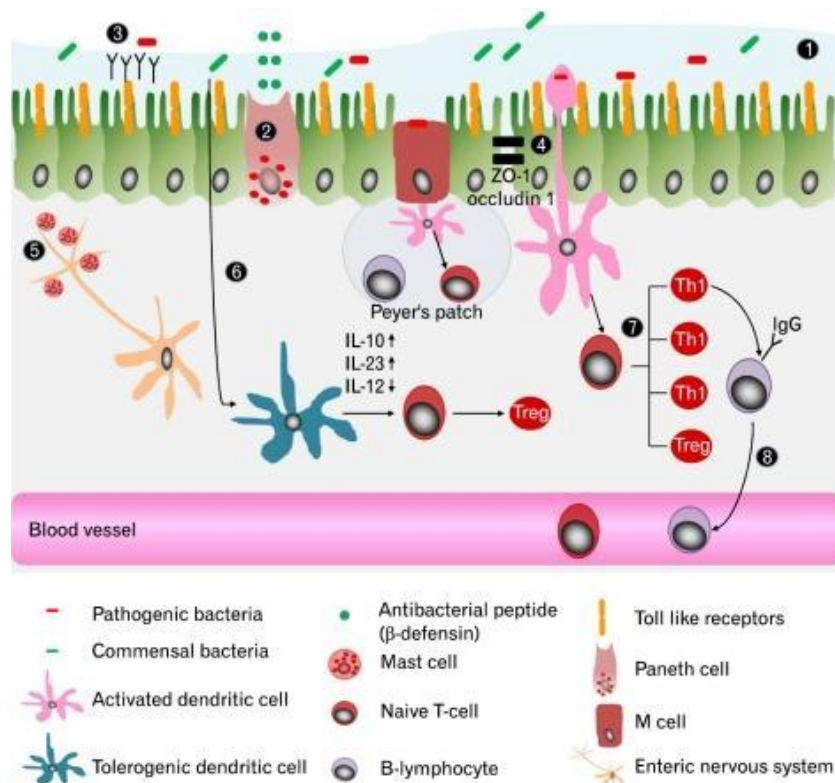
Probiotics*

What is it?

Probiotic bacteria are living microorganisms that can colonize the digestive tract and provide health benefits.

What does it do?

Probiotics improve gut health, particularly mucosal barrier function, and functioning of the immune system. [The intestinal mucosal barrier is like a wall with gates around the intestines that determines what gets absorbed from the gut into the blood and what gets shut out.](#) This not only includes ingested nutrients but also an enormous variety of microorganisms like bacteria.



Mucosal barrier function regulates what gets absorbed from the gut into the blood

([Source](#))

As such, gut health affects many other systems in the body. In fact, the brain is linked directly to the digestive tract via the vagus nerve, giving rise to the microbiota-gut-brain axis.

While it's easily arguable that [gut health is underrated in fitness circles and probiotics can be beneficial for the gut](#), [when it comes to supplementing probiotics, there are several major obstacles](#) for them to be truly beneficial.

First, supplementation formulations typically contain a relatively small amount and number of probiotics. The Human Microbiome Project has already identified over ten thousand different [microbial species in the human gut amounting to ~200 g of bacteria](#), whereas most pills contain no more than 5 species. Whole foods can be far richer in probiotics. [One independent analysis found that 60 g of traditionally fermented sauerkraut contained more probiotics than 8 bottles of a common probiotic supplement](#).

Second, the bacteria or other microorganisms in a probiotic supplement must survive the manufacturing process and human digestion. [It's estimated that only 20-40% of supplemented probiotics survive human digestion](#).

Finally, if the probiotics make it into the gut alive, they also must colonize the digestive tract. [Most probiotics just pass through the gut without colonization](#), which means they're a band-aid solution at best. [The human gut can also develop resistance to colonization from probiotics](#).

On the other hand, [some research finds that dead probiotics or 'postbiotics' can in some cases still offer health benefits](#). While postbiotics can logically not colonize the

digestive tract, they could still cause an immune system response or other bodily reactions.

As expected based on these obstacles, [probiotic supplements' health benefits are very unimpressive and inconsistent, whereas probiotic foods perform significantly better](#) [2, 3, 4]. [A 2021 meta-analysis by Hadi et al.](#) found that probiotic supplementation reduced total cholesterol in individuals with metabolic syndrome, but there was no effect on any other cardiometabolic biomarker. Any effects in healthy individuals are thus arguably trivial. [Even for probiotic foods, the evidence for clinically meaningful health benefits is scarce](#), but [eating more fermented foods has been found to notably increase microbiome diversity and reduce systemic inflammation levels](#). Kefir is the only specific probiotic food with [somewhat of a convincing literature supporting significant health benefits](#), especially to improve lactose tolerance.

[In the worst-case scenario, probiotic supplementation can significantly harm your gut.](#) We're not nearly at the point where we know what effects each microorganism will have in each situation.

[If there is any positive effect of probiotic supplementation on fat loss, it is very small](#) and it may be restricted to overweight individuals, likely because they generally have worse diets and gut health than lean, healthy individuals [2, 3, 4, 5, 6, 7]. [A 2021 meta-analysis by Hadi et al.](#) found no effect of probiotic supplementation on any body composition measure even in individuals with metabolic syndrome. [A 2023 Hungarian study](#) also found no significant effects of probiotic supplementation on the body composition of elite water polo players. Similarly, [a 2024 Taiwanese study](#) found no benefits compared to placebo on sports performance or body composition in exercising individuals. (Don't be fooled by the abstracts: check the post-intervention between-group measurements.) [Probiotic supplements also don't consistently affect](#)

[exercise performance](#) in other research [2], although [there are promising results in some studies](#).

Since [a healthy diet is enough to maintain good gut health](#), indiscriminate probiotic use without knowing which strains you're supplementing for what purpose is not advisable at this point. While it's tempting to think **probiotics** must always be beneficial, [some research](#) found that probiotic supplementation **delayed** gut healing after antibiotic use.

If you have irritable bowel syndrome (IBS) or other gut conditions, probiotics may be extra beneficial. [A 2024 meta-analysis](#) found that probiotic supplementation reduced IBS symptoms. However, there was significant variance in the results, likely due to different responses from different probiotics for different individuals. Not every probiotic is always beneficial.

How to take it

Probiotic supplementation should arguably be reserved for individuals supplementing specific strains for specific health conditions. If you're healthy and your diet already follows the course's health guidelines, you probably have little to gain from probiotic supplementation. For most people, the first priority for their gut health is consuming enough fiber, both soluble and insoluble, from whole foods, as discussed in the course module on carbohydrates. If there are still digestive problems present then, check for FODMAP or food intolerances, as discussed in the course module on health. If you want to optimize your gut health further, incorporate a variety of unpasteurized, fermented food in the diet.

The following are good fermented foods for gut health:

- Sauerkraut
- Kimchi
- [Kombucha](#)
- Kefir
- Natto
- Tempeh
- Certain cheeses
- Sourdough
- [Yogurts](#)
- Homemade ketchup

It's crucial that these foods contain live bacterial cultures, so the pasteurized stuff in the supermarket won't do much. You often have to either traditionally prepare these foods yourself or find a boutique shop that sells them after traditional preparation.

When to take it: The literature is divided over whether probiotics should be consumed with food or on an empty stomach. Some research suggests food is detrimental, as it prolongs the time the probiotics spend in the gut in possible contact with stomach acid. However, other research indicates food can protect the probiotics from stomach acid and provide substrate (food) for the probiotics to live on. The type of food you consume also matters. [Tompkins et al. \(2011\)](#) found 2 lactobacillus probiotics, naturally present in dairy, survived the passage through the digestive tract better when consumed before a meal or during a meal compared to after a meal, and that meals with milk resulted in higher survival than meals with water or apple juice. Another probiotic yeast not found in dairy, *saccharomyces cerevisiae boulardii*, was not sensitive to meal timing or composition. [Corcoran et al. \(2005\)](#) found lactobacillus probiotics survived better in the presence of glucose than without it, but the results

depended on the acidity of the environment. Overall, it's likely that probiotics survive best when they are consumed with a food they are naturally present in, so lactobacillus probiotics should be consumed with dairy.

Versions to buy: The choice of probiotic supplement should be based on stool testing and a consultation with a medical professional.

Menno's verdict: Unless you're supplementing specific bacterial strains for a specific gut pathology, don't bother. Instead, optimize your diet.

Rhodiola rosea

What is it?

Rhodiola rosea is a herb.

What does it do?

Compared to ashwagandha, rhodiola rosea seems to function more like an ergogenic (performance enhancer) and less like an anxiolytic (anxiety reducer). [Its primary proposed benefit is fatigue reduction, mentally as well as physically, but the evidence for this is weak and contradictory.](#) In fact, [some research finds Rhodiola rosea worsens mental fatigue](#) and [other research found rhodiola rosea supplementation decreases strength training work capacity, resulting in lower total repetition performance.](#)

How to take it

Dosage: 288 mg standardized to 3% rosavins and 1% salidroside (like the SHR-5 extract) should be an effective dose. It is advisable to start with as little as 50 mg and build up the dosage. Benefits have been reported at that dosage, and adverse effects (including a worsening of fatigue) have been found with higher dosages (680 mg).

When to take it: [30 min before stimulating effect is desired, which can last up to 4-6 hours.](#) For this reason, it is advisable not to take it in the evenings, as some individuals experience problems with sleeping when taking rhodiola rosea.

Versions to buy: A [research study](#) examining commercial rhodiola rosea supplements available in the UK found that most supplements don't contain the dosage they give on the label. They may be adulterated through dilution or additives.

Menno's verdict: Considering there's evidence it may be not just useless but even harmful, ashwagandha seems to be the superior choice if you're looking for an adaptogen.

Theacrine

What is it?

Theacrine is an alkaloid found in certain plants. It has a structure similar to caffeine.

What does it do?

Theacrine seems to influence the same signaling pathways (adenosinergic and dopaminergic neurotransmission) as caffeine, but theacrine's functional effects are [weaker](#) more comparable to green tea than caffeine: it doesn't make a person jittery but rather calm and focused while mildly stimulated at the same time. [Like caffeine, the mental effects seem to be mostly, if not purely, psychological with little to no actual improvement in cognitive functioning \[2\] or physical strength.](#)

Looking at [scores of mood and concentration profiles](#), theacrine also doesn't appear to do anything positive. It didn't decrease fatigue or energy intake via appetite suppression, as one would expect from any stimulant. It even *decreased* vigor at one time point. In [another study](#), it also slowed down reaction times. As such, it's worth keeping an eye out for more research on theacrine or experimenting with it, but it's not an evidence-backed supplement yet.

Theacrine may have a major advantage over caffeine, however. [Based on the preliminary research, which is industry sponsored, theacrine up to 300 mg per day appears to be perfectly safe and does not cause any habituation.](#) That means no withdrawal, no tolerance and no need for cycling.

How to take it

Dosage: 300 mg once daily

When to take it: Usually taken in the first half of the day ([after breakfast, before lunch](#)).

Versions to buy: Theacrine can be purchased online in powder or capsule form.

Menno's verdict: May be worth experimenting with for stimulant junkies.

Theanine*

What is it?

L-theanine is an amino acid that is found in tea. It does not belong to the 20 amino acids that are required for protein synthesis.

What does it do?

Mechanism: Theanine supplementation increases α -wave production within 30-45 minutes after supplementations. α -waves are associated with a state of relaxation, selective attention mechanisms and mental alertness.

Benefits: This amino acid slightly increases the capacity for attentional focus. Combined with a stimulant, it can prevent jitteriness and it keeps one calm. This is one of the reasons why tea is not as arousing as coffee.

How to take it

Dosage: The standard dose is 100-200 mg. 100 mg is a good starting point for individual experimentation (for comparison; [a cup of black tea contains about 25 mg; 8 mg for a cup of green tea](#)). Theanine is usually taken with caffeine.

When to take it: It takes about 30 minutes to start working. Taking it with food will delay the absorption.

Versions to buy: L-theanine can be purchased online in capsule or powder form.

Menno's verdict: It's not magic, but it can help to reduce anxiety and increase attentional focus, especially when combined with other stimulants, such as caffeine.

Muscle Growth & Performance

Sodium bicarbonate*

What is it?

NaHCO_3 , more commonly known as baking soda, is a very versatile molecule. This white powder is used during cooking as a leavening agent and baking powder and it's used for hygiene in various forms as an antifungal and antiseptic. Throughout recent years we've discovered that you can also consume it before a workout to improve physical performance.

What does it do?

Sodium bicarbonate consumption increases bicarbonate levels in the blood. This raises blood alkalinity (higher pH) and increases its buffering capacity against acidity. Specifically, alkaline blood can absorb hydrogen ions (H^+) better from our muscles. As you learned, hydrogen ion accumulation is a form of metabolic stress. Hydrogen ion accumulation causes neuromuscular fatigue by impairing actin-myosin cross-bridge formation, glycolysis and ATP resynthesis. So increasing the blood's alkalinity can improve work capacity.

While nice in theory, like most buffering agents, [the performance improvements of sodium bicarbonate for short-duration exercise are small and inconsistent](#). [A 2021 umbrella review of meta-analyses](#) concluded sodium bicarbonate supplementation is no more effective than placebo for power, strength and sprinting performance. The minimum duration of exercise that can benefit from sodium bicarbonate supplementation seems to be around 30 seconds, which means only high rep sets may benefit from it.

In the only study investigating if long-term sodium bicarbonate supplementation improves our gains, [Siegler et al. \(2018\)](#), there was no effect on maximal strength development.

Consuming sodium bicarbonate also frequently causes digestive side-effects, making it even more questionable if it's worth supplementing.

How to take it

The most established dosage used in research is 0.3 g/kg bodyweight consumed 1-3 hours pre-workout. Sodium bicarbonate may not combine well with caffeine: [some research](#) finds sodium bicarbonate negates the performance enhancing effect of pre-workout caffeine.

Menno's verdict: Unless you're a competitive strength-endurance athlete, I wouldn't bother with it.

Caffeine*

What is it?

Caffeine is a stimulatory compound extracted from coffee beans.

What does it do?

Caffeine antagonizes all adenosine receptors in humans, particularly A1 and A2, which are responsible for sleep-like effects. Thus, caffeine intake promotes wakefulness and very effectively reduces the effects of sleep deprivation.

Research in the 70s showed that caffeine consumption increases fat oxidation rates and spares muscle glycogen. This led to the theories that A) caffeine is an effective fat loss supplement and B) caffeine is an ergogenic aid (performance enhancer) that increases your body's ability to burn fat for energy. Caffeine's primary mechanism of action, however, is not metabolic. Rather, [caffeine primarily functions as an adenosine receptor blocker](#). Adenosine has fatiguing effects on the nervous system, so caffeine effectively acts as a sympathetic nervous system stimulant and it increases adrenaline levels.

So how does caffeine act as an ergogenic? Everyone knows caffeine increases your mental energy level and can increase your performance, but it's unclear if caffeine only has motivational effects or also physical effects on performance. The mental, subjective effects of caffeine are much more noticeable than its physical effects on objective performance. Multiple studies have found caffeine supplementation induces significant mental effects, such as increased vigor and motivation to exercise, without any significant objective effects on performance compared to a placebo supplement [1, 2] or with very small and inconsistent ergogenic effects [3]. Confirming caffeine's placebo effects, [Tinsley et al. \(2017\)](#) found that 300 mg caffeine subjectively improved

fatigue, focus and energy levels compared to not consuming anything, yet these effects were also observed in a placebo group and neither supplement group achieved objective improvements in physical performance. In other words, giving people a sugar pill and telling them it has 300 mg caffeine can have the same effects on somebody as actually giving them the caffeine.

In line with these findings, [participants in blinded experiments are often unable to correctly guess if they received high-dose caffeine supplementation or placebo](#), both in the placebo and the caffeine groups, suggesting most of the effects of caffeine are placebo effects. For example, in a study by [Ferreira et al. \(2019\)](#), 87% of subjects couldn't correctly guess if they were in the placebo group or the group receiving a whopping 5 mg/kg caffeine (~5 cups of coffee at once). In fact, [the effect of falsely believing you've supplemented caffeine can improve performance more than actually being on 6 mg/kg caffeine without realizing it](#) (~5 cups of coffee).

Caffeine is so well known to 'give you more energy' that a placebo control might not suffice in research. [Caffeine induces a strong placebo effect: the placebo effect is greater when people falsely believe they consumed actual caffeine \(as opposed to an unknown placebo\) and it even shows a dose-response effect: people experience a greater placebo effect when they falsely believe they consumed a higher dosage of caffeine compared to a lower dose](#) [2, 3, 4]. Ironically, caffeine does not actually have a physical dose-response effect in most research, as we'll cover in a minute.

Nevertheless, there are still many studies showing caffeine supplementation can objectively improve performance compared to a placebo, whether people realized it or not, and [meta-analyses confirm caffeine's ergogenic effects compared to a placebo](#). Thus, not all caffeine's effects are placebo, but they may still not be neuromuscular either. [Caffeine can motivate you to train harder, especially if you're sleep deprived](#) [2],

so this could explain why people can perform better on caffeine: the caffeine helps them push themselves a bit more than they usually do. [From a mechanistic point of view, it is still unclear how caffeine would increase strength training performance other than via psychological mechanisms](#) [2, 3], i.e. greater motivation and a higher pain threshold. In fact, research has found that [caffeine's ergogenic effect is not very replicable](#): even when testing the same individuals under the exact same circumstances, the effects of 3 mg/kg caffeine compared to placebo range from trivial to large. Moreover, [a 2021 meta-analysis found that caffeine has no significant effect on exercise performance in the heat](#). Psychological mechanisms would also explain why [caffeine affects speed-endurance and power sports more consistently](#): both are highly motivation-dependent activities compared to strength training.

[Caffeine also raises core body temperature](#), which may explain research findings that [caffeine is more effective in the morning in trained individuals, to combat the negative circadian rhythm effect of that time of day. In contrast, untrained individuals, who are likely less capable of pushing themselves, seem to benefit from caffeine at any time of day](#) [2]. In one study, [even 3 mg/kg caffeine did not consistently improve basketball performance in the evenings, only in the mornings](#). [A 2023 meta-analysis in women](#) found that the ergogenic effect of caffeine is twice as strong in the evenings as in the mornings (effect size 0.4 vs 0.2), although this difference was not statistically significant.

Other than its effect on core body temperature, caffeine's mechanism is thus likely in large part psychological, essentially the same as [watching violence or pornography: it gets you psychologically aroused and ready to go all-out in the gym](#), but it doesn't do much to physiologically increase muscular force production capacity.

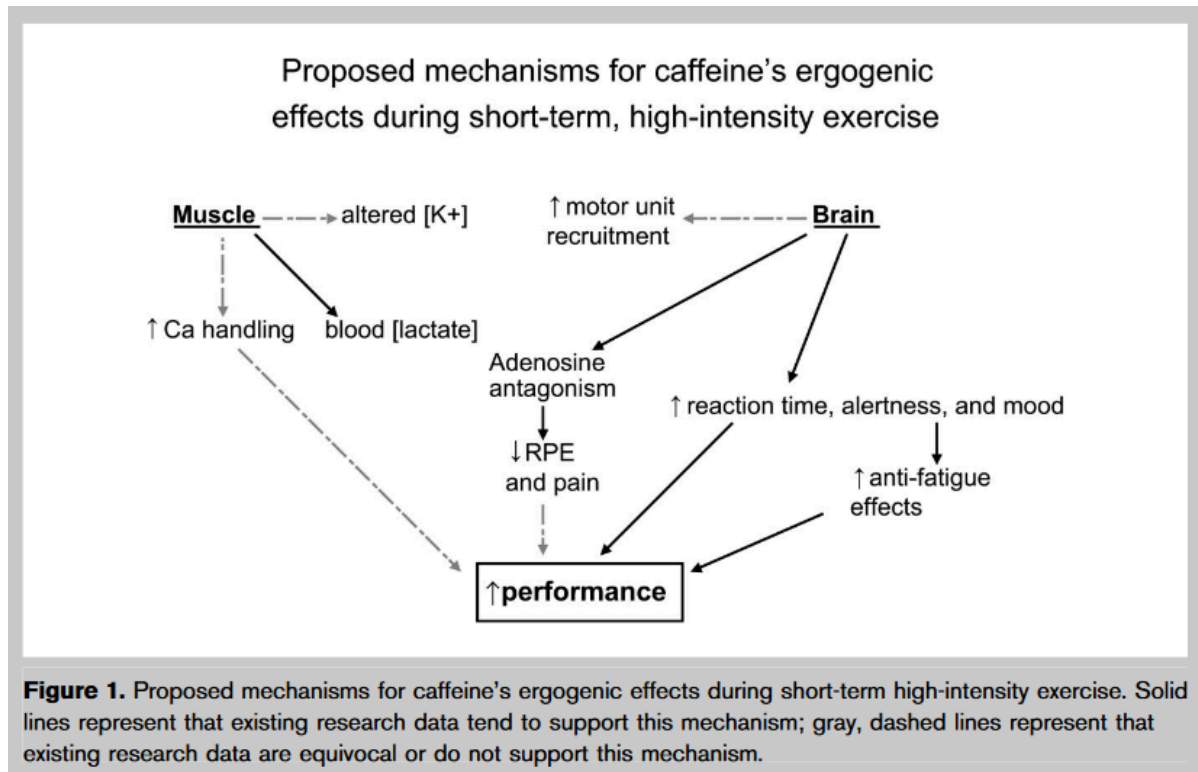
A primarily motivational effect of caffeine would also explain why [most research finds no consistent dose-response effect of caffeine on strength training performance](#) [2, 3, 4, 5, 6, 7, 8, 9, 10, 11]. [A 2022 meta-analysis](#) found caffeine supplementation's effect sizes on strength, endurance and power were similar at 0.9-2 mg/kg as previously reported for much higher dosages, often 6 mg/kg. [Another 2022 meta-analysis](#) also found no significant dose-response effect of caffeine intake on exercise performance of any kind up to 6 mg/kg and higher doses even had a *lower* effect on performance. In contrast, [some research](#), including [a 2022 meta-analysis of caffeinated chewing gum](#), suggest around 3 mg/kg is needed to reliably improve objective strength training performance compared to placebo. It's possible that 3 mg/kg is needed to make caffeine have a physiological effect on muscle strength, rather than just a motivational effect, but overall, the dosage of caffeine taken often does not influence the effect on exercise performance.

Since caffeine's main benefit is likely increased motivation, it's not surprising that people vary greatly in how well they respond to caffeine. [In some research, only 50% of people experience an increase in performance after consuming caffeine. Low responders may still respond to very high dosages](#), but [some research finds no effect of even a whopping 6 mg/kg caffeine on performance](#). Caffeine responsiveness may be related to someone's motivation level. Some people don't need caffeine to perform well, whereas others need external stimulation to go all-out.

[People also vary genetically in how fast they can metabolize caffeine, which may consequently affect how much a given dose of caffeine can improve your performance.](#)

How much effect we experience from caffeine is largely the result of our CYP1A2 genotype, which encodes the primary enzyme that metabolizes caffeine. [A 2023 meta-analysis](#) found that only people with the CYP1A2 genotype with A allele benefitted from caffeine supplementation before bicycling exercise.

The diagram below illustrates the proposed mechanisms via which caffeine may increase high-intensity exercise performance.



[Source](#)

Fat loss

What about caffeine's use as a fat burner? Most 'fat burners', including caffeine, don't directly make you lose body fat. They are just compounds that increase your energy expenditure and/or decrease your appetite, thereby facilitating negative energy balance. Unfortunately, caffeine's effect on your energy expenditure is just as overrated as its ergogenic effect. While [there appears to be a dose-response effect of caffeine intake on subsequent energy expenditure and metabolic rate](#), the effect is short-lived and small. Even repeated high dosages do not generally cause an increase in whole-day energy expenditure above 100 kcal. [Some research finds no effect of caffeine on energy expenditure at all](#) [2]. Moreover, in contrast to what you'd expect from a stimulant, [caffeine does not appear to reduce your appetite or there is only](#)

[acute appetite suppression that is compensated for later in the day so that you end up with the same total energy intake.](#)

Muscle growth & strength development

Overall, caffeine does not seem to have much use for your physique. Many studies found that long-term caffeine supplementation did not result in significant body recomposition.

- [Jung et al. \(2017\)](#) found that consuming 284 mg of caffeine in a pre-workout supplement cocktail every day did not increase strength development or body composition changes in strength trained men.
- [Tinsley et al. \(2017\)](#) found no fat loss or muscle growth from caffeine supplementation in strength trainees, even with l-carnitine and green tea extract added to the caffeine.
- The only study supporting caffeine is useful as a fat burner is [Ferreira et al. \(2019\)](#) and these were ideal circumstances with contradictory results: the duration of the study was short enough that tolerance didn't negate the long-term effects (2 weeks), the dosage was very high (5 mg/kg) and the subjects performed sprint interval training after caffeine ingestion, resulting in a significantly higher energy expenditure. Still, energy expenditure did not increase at rest, only after training, and the increase was only 18 kcal, not remotely enough to explain the greater fat loss in the caffeine group. Caffeine also didn't result in a significant decrease in energy intake. While the between-group difference in energy intake didn't achieve statistical significance, it's likely that the fat loss was largely the result of the caffeine group simply consuming less food than the other group and therefore lost more fat: all macronutrient intakes were lower in this group with a trend towards significance for protein intake. So even under ideal circumstances with a high dosage, it's questionable if it was the caffeine that contributed significantly to fat loss.

- [Giráldez-Costas et al. \(2021\)](#) found no effect of 4 weeks of supplementing 3 mg/kg caffeine pre-workout on 1RM bench press development or measures of power and explosiveness, although there were some trends for the caffeine to increase movement velocity across a wider range of training loads, compared to a placebo in strength-trained men.
- [Pakulak et al. \(2021\)](#) found 3 mg/kg caffeine was no more effective than placebo to induce muscle growth or strength development in trained men during a 6-week strength training program.
- [Tamilio et al. \(2021\)](#) found rugby players did not gain more strength when supplementing 3 mg/kg caffeine before their strength training sessions over the course of a 7-week strength training program, even though their total work volume and performance were acutely enhanced by the caffeine supplementation. The placebo group actually gained significantly *more* deadlift strength than the caffeine group. So even if you can get a sustainable ergogenic effect out of caffeine, it may not translate into greater training adaptations.
- [Siedler et al. \(2023\)](#) found no effect of a commercially available ‘fat burner’ supplement containing caffeine (OxyShred) on the body composition and resting energy expenditure of exercising individuals. (While the authors make it sound like there was an effect on REE, this effect was also present in the protein-supplemented control group without the fat burner, so it was the effect of the additional protein both groups consumed vs. the control group, not the fat burner.)

Safety & addiction

Caffeine supplementation is quite safe, but chronically using high doses poses some problems. For one, caffeine supplementation increases anxiety. [Just 150 mg caffeine can increase anxiety levels](#) and [raise increased cortisol production](#).

Second, some parts of your cognition deteriorate with chronic, high-dose caffeine use. It's tempting to conclude that caffeine just makes you smarter and improves everything you do. However, this is not true. Caffeine selectively improves certain aspects of cognitive functioning but deteriorates others, especially chronic, high-dose caffeine use. For example, [Lin et al. \(2023\)](#) found that using 450 mg caffeine per day (3×150 mg) impaired working memory performance and brain activity in the hippocampus. This impairment is not observed with single servings in short-term research, suggesting it's an adaptation to longer-term use.

Third, your sleep suffers. While it's common knowledge that caffeine is bad for your sleep, the magnitude of this negative effect is generally underappreciated, as discussed in the course's lifestyle module. [Even a single double espresso consumed 16 hours before going to bed can still impair sleep quality by reducing the time you spend in deep sleep stages](#). By that time saliva caffeine concentrations are already close to zero, since caffeine's half-life is ~5 hours, and you probably won't feel the effect anymore subjectively, so [caffeine's negative effect on your sleep is more prolonged than its subjective effects](#). [A 2023 meta-analysis of 24 studies](#) concluded: "To avoid reductions in total sleep time [and sleep quality], coffee (107 mg per 250 mL) should be consumed at least 9 h prior to bedtime and a standard serve of pre-workout supplement (218 mg) should be consumed at least 13 h prior to bedtime."

Problem 4: [Caffeine induces tolerance to its own effects and subsequent mental withdrawal symptoms when you stop using it \[2, 3\]](#), the 2 key components of addiction. [Repeated caffeine use upregulates the number of adenosine receptors](#), which caffeine blocks as its primary mechanism of action. The body essentially compensates for caffeine's blocking of the adenosine receptors by creating more of them. When you stop using caffeine but still have the increased number of adenosine receptors, this can make you tired.

In fact, [in many studies, it's unclear if caffeine is really ergogenic or if any 'positive' effects are merely a reduction in withdrawal symptoms](#) [2]. Researchers had long overestimated the positive impacts of caffeine because they didn't exclude chronic users. The participants then had to avoid caffeine for a few days before the study, which caused them to be in withdrawal and caffeine's 'positive' effects were actually merely withdrawal symptom reversal. They didn't really feel better on caffeine: they just felt worse without it.

Many people assume legal drugs are perfectly safe and only associate withdrawal with illegal drugs, but [objectively there is little relation between the toxicity and addictiveness of drugs and their legal status](#).

Tolerance and withdrawal build up much earlier than most people realize: [100 mg caffeine per day is enough to cause withdrawal after some people stop using it](#). That's only about one cup of coffee. The most common withdrawal symptoms are headaches, fatigue, depression, difficulty concentrating and irritability. If your training sessions are notably poorer without stimulants, you may very well be in withdrawal. Withdrawal can also cause muscle stiffness and weakness. [At about 750 mg per day, your tolerance to caffeine generally becomes complete](#). At this point, you cease to get any benefit from consuming caffeine. You may still feel like you do, but you're mostly just fighting withdrawal symptoms. In studies of long-term regular caffeine consumption, we see caffeine's ergogenic effect decreases with continued use.

- [Lara et al. \(2019\)](#) found the performance enhancing benefits of 3 mg/kg per day caffeine wore off progressively during the first 20 days of usage.
- [Beaumont et al. \(2017\)](#) found using 1.5-3 mg/kg per day resulted in complete tolerance to a dosage of 3 mg/kg within 4 weeks.

Some studies also find habitual caffeine users no longer respond well to acute caffeine supplementation.

- [Wilk et al. \(2019\)](#) found habitual users of 5 mg/kg per day caffeine did not experience an improvement in bench press power output when consuming 3, 6 or even 9 mg/kg caffeine, suggesting complete tolerance.
- [Evans et al. \(2018\)](#) found that consuming 200 mg caffeine pre-workout improved sprint performance in athletes habitually using under 40 mg per day but not in athletes consuming over 130 mg per day.
- [Bell & McLellan \(2002\)](#) found 5 mg/kg caffeine still improved endurance performance in habitual caffeine users, but the benefits were greater and longer-lasting in non-users.
- [Griest et al. \(2023\)](#) found habitual caffeine users (~400 mg per day) only experienced an improvement in cycling performance from 6 mg/kg caffeine compared to placebo after 24 h of caffeine abstinence, not after 8 h. Caffeine was no more effective than placebo when the cyclists had their regular amount of caffeine earlier in the day. This study design was akin to the typical coffee drinker that drinks coffee in the morning and then uses a pre-workout later in the day before going to the gym. Based on this study, the pre-workout won't do much anymore in this scenario.
- [Yildirim et al. \(2023\)](#) studied caffeine consumption in soccer players habituated to ~360 mg per day. They found no acute ergogenic effect of 100 or 200 mg caffeine consumption on the majority of soccer players' strength and power tests compared to placebo. The only exception was that 200 mg caffeine improved 1 out of the 6 test measures, suggesting a higher dose was perhaps necessary to still get any ergogenic effect.
- [Filip-Stachnik et al. \(2023\)](#) compared pre-workout caffeine vs. placebo. "The oral intake of 3 mg/kg of caffeine by resistance-trained men habituated to caffeine

[~2.2 mg/kg per day] did not enhance the number of repetitions during a medium load full-body resistance training session to failure.”

[Many other studies](#) [2, 3, 4, 5, 6, 7, 8, 9] found high-dose caffeine can still provide an acute, ergogenic (one-time positive) effect in habitual caffeine users. However, since these studies did not assess the long-term response to a given dose of caffeine, they may only show that habitual users can still get an effect out of caffeine if they use a higher dosage than they're used to taking in a single dose. More importantly, habitual caffeine users may be in a state of withdrawal when consuming a placebo, thus 'better than placebo' may actually just mean 'performing as normal, in contrast to the negative effects of withdrawal'. Then again, some [research finds caffeine has the same \(endurance\) performance enhancing effects during chronic use as after 2- or 4-day withdrawal periods](#) [2]. In contrast to the other long-term within-subject studies, [Tamilio et al. \(2021\)](#) found no significant decrease in the ergogenic effect of 3 mg/kg caffeine for 7 weeks, but the participants only used it 2 times per week, so the average daily intake was only 0.9 mg/kg per day. Based on this study and the other research, this is around the sustainable intake level to avoid tolerance, roughly equivalent to 100 mg caffeine, 1 Red Bull or 1 cup of coffee per day.

Many people are stuck in a negative spiral in which they are sleep deprived so they use caffeine to feel normal, resulting in worse sleep quality and progressively more caffeine consumption and further sleep debt accumulation. Over time, they end up completely reliant on caffeine to feel normal. The only way out of the spiral is to go through withdrawal and be more strategic with dosing.

On the bright side, caffeine's withdrawal symptoms appear to be just as psychological as its ergogenic effects: [cognitive ability isn't majorly affected during withdrawal, even though it feels like it is](#). The severity and duration of withdrawal is dose-dependent, but

you should have dealt with the worst of it after 3 days and pretty much all of it after 9 days. Afterwards, many people are pleasantly surprised by how good just 100 mg of caffeine taken on an empty stomach can make them feel.

How to take it

Taking 1 mg/kg or around 100 mg pre-workout can sustainably increase motivation in the gym and undo the negative circadian rhythm effect of training early in the day. If you notice absolutely nothing from those doses even after multiple days without caffeine, you can take more. However, since there is no consistent dose-response effect but there is potential for tolerance and withdrawal, higher doses are often inadvisable for chronic use. Dosages of 3 mg/kg can be taken occasionally to potentially boost performance for competitions or unplanned morning workouts.

You should consume the caffeine 30-60 minutes pre-workout, as [caffeine's peak ergogenic effect occurs about 1 hour after consumption](#).

In contrast to what you might expect, the form of caffeine does not considerably impact its absorption speed. [Coffee, tea, cola and caffeine capsules all have an average time to peak effect of about one hour in the literature](#). Different studies have found very different results, however, with capsules being absorbed significantly faster in some and significantly slower in other research. The reason for this variability is that people differ greatly in how fast they absorb caffeine, just as they differ in how long the caffeine stays in their body: the terminal half-life of caffeine, which is the time it takes for caffeine levels to drop by 50% in your body, ranges from 1.5 all the way up to 9.5 hours with an average of ~5 hours.

However, the form of caffeine does seem to matter. [Pure anhydrous caffeine powders \(or capsules\) are more ergogenic than coffee with the same amount of total caffeine](#),

probably due to interacting components in coffee that reduce caffeine's beneficial effects. While [one study found the opposite, namely that coffee was more effective than the same amount of pure caffeine](#), this was likely due to the greater placebo effect of noticing that they were drinking coffee. [A subsequent study found that supplementing caffeine along with decaffeinated coffee was more effective than both coffee and pure caffeine in the same amounts](#). The ergogenic effect was small in any case and often only relevant for low-intensity squats. Still, the research supports that anhydrous caffeine supplementation is more effective than drinking the same amount of caffeine in coffee.

Most energy drinks also don't seem to contain any active ingredients other than caffeine. [Double-blinded research consistently finds that the other ingredients in most energy drinks, including B-vitamins, taurine, tyrosine and carnitine, do not provide any isolated or additional benefit compared to pure caffeine consumption \[2, 3, 4, 5\] and decaffeinated energy drinks have no mental effects](#). Anecdotally though, many people subjectively report feeling more effect from energy drink than other sources of caffeine. This is likely a placebo effect. Intuitively, drinking *energy* drink must surely be good for your *energy* level. Energy drinks also commonly associate themselves with extreme sports, feeling good and being energetic with their advertising. That said, it's also possible that some energy drinks contain more caffeine than advertised. [Independent third-party lab testing has found that many energy drinks contain ~20% more caffeine than what's on the label](#).

Pre-workout supplements may even be *less* effective than pure caffeine. [A 2022 cross-over experiment by Kruszewski et al.](#) found that anhydrous caffeine supplementation before 5 sets of bench presses to failure in trained men resulted in slightly but significantly greater repetition performance than the same dosage of caffeine in a multi-ingredient pre-workout supplement. The pre-workout contained

approximately 5 g beta-alanine, 5 g l-citrulline malate, 2 g arginine alpha-ketoglutarate, 2 g l-tyrosine and 1.7 g l-tyrosine. Similarly, [Zart et al. \(2024\)](#) found that caffeine (5 mg/kg) but not a combination of caffeine and L-arginine (0.15 g/kg) improved maximum torque during leg extensions. [Moltavo-Alonso et al. \(2024\)](#) similarly found that caffeine but not caffeine together with sodium bicarbonate increased strength training performance. However, [other research](#) merely finds that other common pre-workout supplement ingredients, such as citrulline or beta-alanine, have no additive ergogenic effects: they don't reduce the performance enhancement of caffeine, but they don't increase it either.

In conclusion, anhydrous caffeine is the form of choice for ergogenic effects. It seems to be most physically effective, you can dose it most accurately and it's *by far* the cheapest as well.

To track your total caffeine consumption, you can use the following chart. Product labels are preferable, but it may be wise to add a 20% error margin to energy drinks. Note that the caffeine content of tea and coffee strongly depends on how strong you make them. For a detailed table of different types of coffee from different popular places, see [table 1 in this article](#). To remain maximally caffeine sensitive for your pre-workouts, it's ideal to simply avoid all caffeinated beverages. If you enjoy coffee, you can keep drinking as much decaffeinated coffee and tea, or herbal tea, as you want, as the caffeine content should be below the threshold of psychoactivity. Beware of cacao when tracking your caffeine intake. Cacao can have a very high concentration of caffeine, ranging from an average [0.21% in commercial cacao](#) to 0.6% for high-quality cacao [\[2, 3\]](#). That can amount to the equivalent of 6 cups of coffee in 100 g cacao(!)

If you protest you don't like the taste of decaf coffee, realize this may be a nocebo effect. [In double-blind research, the psychological effects of caffeinated and decaffeinated coffee are very similar with major expectation \(placebo\) effects \[2\]](#).

People that consumed decaf coffee under the illusion they were drinking caffeinated coffee responded the same way on cognitive and psychological tests as people drinking caffeinated coffee, indicating they couldn't tell the difference. The brand of coffee and the production method can have far larger effects on coffee's flavor than whether it's caffeinated. Moreover, if you've supplemented anhydrous caffeine in powder form, you'll know caffeine itself is absolutely disgusting. We're not talking acquired taste here. We're talking worse than chewing on paracetamol.

Product	Serving size (fl. oz)	Caffeine in one serving (mg)
<i>Coffee</i>		
Regular drip or percolated	8	95–330
Brewed or percolated, decaffeinated	8	3–12
Instant, prepared from powder	8	30–70
Espresso	1	50–150
<i>Tea</i>		
Black, regular, brewed or tea bag	8	40–74
Black, decaffeinated	8	2–5
Green, brewed or tea bag	8	25–50
Oolong, brewed or tea bag	8	21–64
White, brewed or tea bag	8	15
Instant, prepared from powder	6	33–64
Yerba mate, brewed or tea bag	8	65–130
Iced tea	12	27–42
<i>Beverages</i>		
Carbonated beverages with caffeine added	12	22–69
Alcoholic beverages with caffeine added	1	3–9
Energy drinks with caffeine added	8.2–23.5	33–400
Caffeinated waters	16.9–20.0	42–125
<i>Foods</i>		
Chocolates	8 oz	0–6
Sweets	Various	1–122
Snacks, from US Department of Agriculture database	1 oz or 1 bar	3–41
Snacks, gums, and mints	Various	20–400
Fast foods	Various	1–49

Adapted from the 2012 USFDA report on caffeinated food and CBs [Somogyi, L.P. (2012) *Caffeine Intake in the U.S. Population* (<http://www.fda.gov/downloads/AboutFDA/CentersOffices/OfficeofFoods/CFSAN/CFSANFOIAElectronicReadingRoom/UCM333191.pdf>)].

Interaction with creatine

A final consideration for the supplementation of caffeine is that [simultaneous creatine and caffeine consumption may negate part of the benefits of creatine supplementation](#). [Harris et al. \(2005\)](#) and [Vandenberghe et al. \(1996\)](#) found that consuming high-dose caffeine during creatine loading phases negated the positive effect of creatine on muscle strength. The absorption of both supplements is not impaired by simultaneous consumption, but multiple subjects in Harris et al.'s study complained of gastrointestinal (GI) distress. Creatine and caffeine also seem to have opposing effects on muscle relaxation times. [High-dose, short-term caffeine supplementation during creatine loading negates the shortening of muscle relaxation times by creatine, even after the caffeine is out of the blood](#). [Caffeine still provides acute net ergogenic effects after the loading phase in multiple studies, so the interaction seems to be most pronounced during creatine loading](#). [Koozehchian et al. \(2022\)](#) tried studying the interaction between creatine and caffeine, but with only 12 subjects and a 7-day study length, the study was underpowered to detect any effect of either supplement, let alone the interaction between them. The only good study we have on long-term concurrent caffeine and creatine supplementation is [Pakulak et al. \(2021\)](#). In this study, participants received either 0.1 g/kg per day creatine, 3 mg/kg per day caffeine, both or a placebo pre-workout for 6 weeks. There was a negative interaction effect of creatine and caffeine for leg extensor muscle thickness, with greater growth in the creatine-only group than the other groups. The interaction was not significant for 3 other measured muscle groups, 2 strength tests or total body fat-free mass; however, the total absolute gains in strength, fat-free mass and muscle thickness were the greatest in the creatine-only group. The study had less than 80% statistical power due to getting fewer than hoped for participants.

The seeming negative interaction between caffeine and creatine is another reason not to use too much caffeine. It's also safest not to use any caffeine while creatine loading.

After the loading phase, if you moderate your caffeine dosing, and you supplement caffeine pre-workout and creatine post-workout, the negative interaction is probably not a huge problem, but an argument could be made to avoid caffeine altogether if you already supplement creatine, which is far more beneficial.

Menno's verdict: Massively overrated and easy to abuse but beneficial for strength athletes when *strategically* used and good to enhance motivation for the many people that can use a kick in the butt to go all-out in the gym.

Betaine (Trimethylglycine (TMG))*

What is it?

Betaine is a derivative of the amino acid glycine. Higher amounts of betaine are found in [certain foods such as wheat bran, wheat germ, spinach, beets and wheat bread](#). The [average betaine intakes range from 100-400 mg per day](#).

What does it do?

Betaine works as a methyl donor. Naturally occurring betaines serve as osmolytes and help in the maintenance of cell volume and fluid balance, such as protection from dehydration. It is not clear how this would improve performance or body composition, though there are [speculations](#). One key purported mechanism is increased creatine synthesis, but [Del Favero et al. \(2012\)](#) found no increase in phosphorylcreatine content after 10 days of supplementing 2 g betaine. Any plausible mechanism of action related to cellular swelling or anti-dehydration should overlap with creatine, which means creatine supplementation might make betaine supplementation redundant.

[We've summarized the literature on betaine supplementation's effects on body recomposition and performance here](#). While several studies find positive effects of betaine supplementation, they all trace back to Danisco, a company that sells betaine supplements. In contrast, all but 1 of the studies without a conflict of interest find no benefits. [A 2021 meta-analysis concluded betaine supplementation does not significantly influence our body composition](#).

[Schwab et al. \(2002\)](#) found that 6 grams of betaine per day increased total and LDL-cholesterol levels, which is a risk factor for cardiovascular disease. It also decreased plasma homocysteine concentrations though, which is normally protective

against heart disease. There was no effect on systolic blood pressure. The overall safety of betaine is thus questionable.

How to take it

If you believe in the industry sponsored research, [the effective dosage range is 2.5 – 5 g per day, which may be divided into several doses spread across the day, to increase plasma betaine levels](#) [2].

Alternatively, [1 g of choline has been found to result in similar elevations in plasma betaine levels as betaine supplementation itself](#), so choline supplementation or a high intake of eggs should also make betaine supplementation redundant.

Betaine is also found in certain foods in possibly ergogenic amounts: see the table below.

Food	Betaine per 100 g
Wheat bran	1330 mg
Wheat germ	1241 mg
Spinach	600 mg
Beets	250 mg
Wheat bread	200 mg
Note: the exact amounts vary depending on the preparation method .	

Menno's verdict: Promising enough to keep an eye on, but I wouldn't bother with it until there's independent research finding benefits for long-term outcomes.

Guarana extract

What is it?

Guarana extract is an extract from a seed that contains a high amount of caffeine and other stimulatory compounds like tannins, procyanidins, theobromine and theophylline.

What does it do?

Mechanism: The exact mechanism isn't proven yet, but it has been suggested that guarana compounds are converted into amphetamine in the human body. However, some research contradicts this hypothesis.

Benefits: Guarana seeds have stimulatory properties. Caffeine containing guarana seeds can be consumed instead of pure caffeine at an equivalent dosage to get additional psychological effects.

How to take it

Dosage: 50-75 mg once per day or 100 mg divided into two doses with 50 mg each.

When to take it: Guarana should be taken before noon. If two doses are taken, then one should be taken in the morning after waking up and the second just after noon. It shouldn't be taken at night because of its stimulatory effect.

Versions to buy: Semi-purified extract seems to have a lower caffeine content than impurified guarana seed extract.

Menno's verdict: May be superior to caffeine at equivalent caffeine dosing, so worth trying for stimulant lovers.

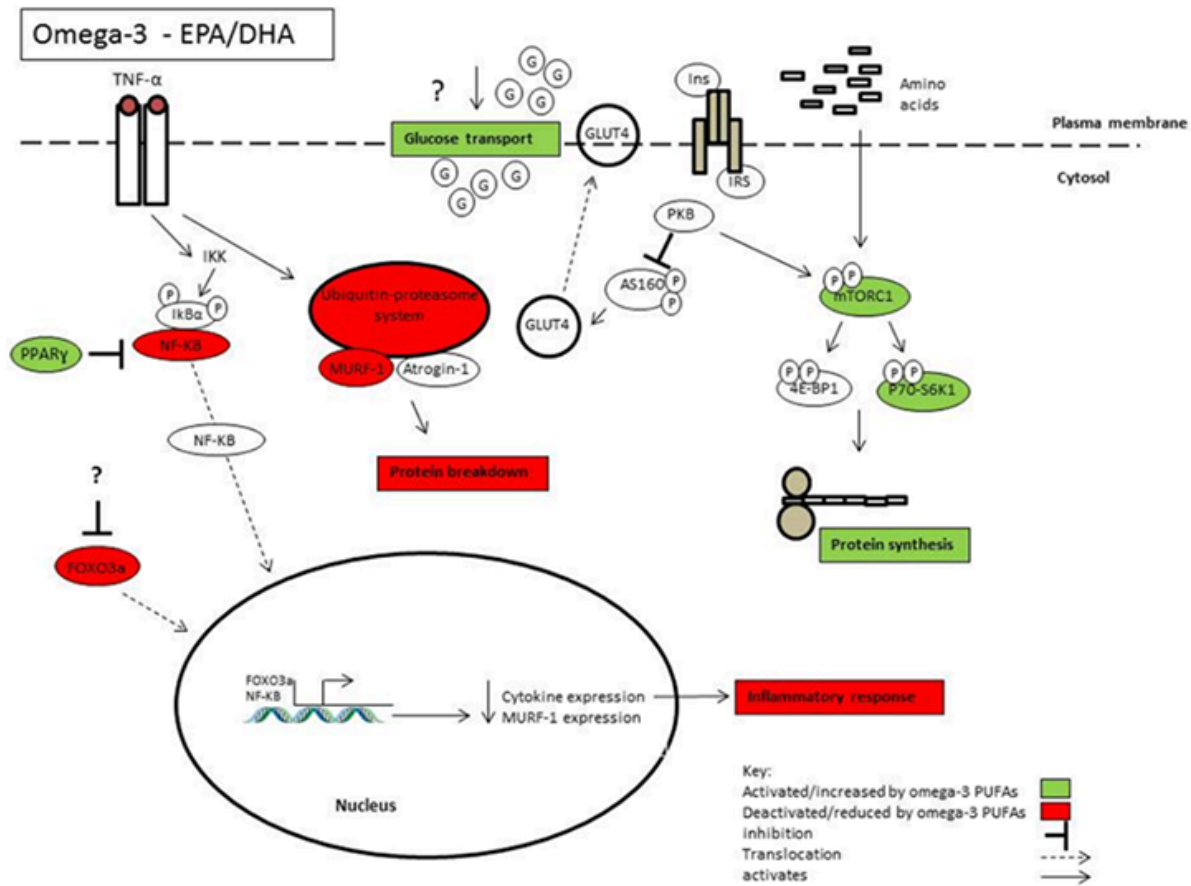
Fish oil*

What is it?

Fish oil is a supplement that contains omega-3 fatty acids, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Both are polyunsaturated fatty acids.

What does it do?

Omega-3 and omega-6 fatty acids are stored in our cells' membranes. During inflammatory or oxidative stress, these polyunsaturated fatty acids release from the membrane. Depending on the omega 3-to-6-ratio in the membrane, the dominant form is released. DHA, EPA and arachidonic acid (AA, omega-6 fatty acid) are used to produce different eicosanoids after their release from the membrane. Eicosanoids are signaling molecules with many functions in the body, especially for the immune system. Consequently, omega-3 fatty acids are a vital component of the diet. [Not only are omega-3s incredibly important for health, omega-3 fatty acids have also been shown to aid muscle growth and fat loss, in part by directly improving protein balance.](#) See the module on dietary fat for more information.



An overview of the effects of omega-3 fatty acids.

How to take it

Fish is the ideal source of omega-3s. Without fish in your diet, it's very difficult to consume the optimal amount of omega-3 (generally 2-3 g per day), especially since the fatty acid balance ratio in most foods has deteriorated since the agricultural revolution. Since not everyone likes eating fish regularly, omega-3 supplements have become a popular alternative. Fish oil capsules are the most popular option.

However, there are 2 problems with fish oil pill supplementation compared to consuming fish.

Oxidation and concentration

First, most fish oil supplements are of absolutely horrible quality. [Almost all commercial fish oil supplements are severely oxidized and/or only contain a part of the omega-3 on the label](#): “Only 3 of 32 fish oil supplements contained quantities of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) that were equal or higher than labelled content, with most products tested (69%) containing < 67%. The vast majority of supplements exceeded recommended levels of oxidation markers. 83% products exceeded the recommended PV levels, 25% exceeded AV thresholds and 50% exceeded recommended Totox levels. Only 8% met the international recommendations, not exceeding any of these indices.” Only 1 of the 32 supplements passed all tests.

In [a 2016 analysis of the top 3 US fish oil supplements](#), omega-3 levels varied from 33% to 79%, the oils were adulterated with a total of 30 different fatty acids comprising up to 36% saturated fatty acids and worst of all, the oils were severely oxidized to the point that the oxidation products exceeded the maximum safety levels. Unsurprisingly then, the fish oils were incapable of providing any antioxidant protection in vitro.

PUFAs are highly susceptible to peroxidation because of their multiple double bonds. When a free radical steals an electron from a PUFA, it can cause a chain reaction that makes the PUFA fall apart like a domino piece, forming various neurodegenerative compounds in the process, such as malondialdehyde (MDA). MDA can damage proteins and DNA. [Without anti-oxidants to protect them, omega-3 supplements can increase lipid peroxide and MDA levels in your body.](#)

Bioavailability

Second, fish oil supplements tend to have considerably lower omega-3 bioavailability than fish. [Visioli et al. \(2003\)](#) studied the increase in plasma omega-3, a measure of

bioavailability, after consuming various dosages of fish oil supplements in ethyl ester form compared to consuming smoked salmon for 6 weeks. The supplements were consumed with the main meal. They concluded that 2x more EPA and **9x** more DHA was needed in supplement form to obtain the same increase in plasma levels as with salmon. A similar 8-week study by [Elvevoll et al. \(2006\)](#) found that cooked salmon resulted in a 3x higher increase in serum EPA and a 4.5x higher increase in serum DHA than the equivalent dosage of cod liver oil. “Consumption of as little as 2 meals per week including salmon (a total of 1.2 g EPA + DHA on average per day) is almost as effective as intake of 15 mL cod liver oil per day (a total of 3.0 g EPA + DHA per day) in raising the serum concentrations of EPA and DHA.” In contrast to the above 2 studies, a small study by [Harris et al. \(2007\)](#) found no significant difference between the bioavailability of fatty fish vs. a fish oil supplement: “the consumption of equal amounts of EPA and DHA from oily fish on a weekly basis or from fish-oil capsules on a daily basis is equally effective at enriching blood lipids with n-3 FAs.” However, in absolute terms the fish group achieved a slightly greater increase in blood omega-3 levels and for EPA the rise was significantly greater during the first 4 weeks. Thus, the study may have been underpowered to detect the difference in bioavailability from the relatively low dosage of omega-3 in a small sample.

[Many studies](#) [2] have investigated how to make omega-3 supplements closer in bioavailability to fish. [Ethyl esters of omega-3 fatty acid supplements tend to perform the worst, as this form is particularly difficult for the body to digest](#) [2].

Triglyceride-bound forms generally perform better than ethyl esters. It's not clear if there are differences between natural triglyceride forms – essentially pure, natural fish oil – versus re-esterified triglyceride forms – chemically concentrated fish oil. A few studies found that free fatty acids and krill oil have higher bioavailability than triglyceride-bound fish omega-3s, although the results are not fully consistent. For example, [Beckermann et al. \(1990\)](#) compared the relative bioavailability of various fish

oil supplement forms. They concluded “the mean relative bioavailability of EPA/DHA compared to triglycerides was 186/136% from free fatty acids and 40/48% from ethyl esters. Maximal plasma levels were about 50% higher with free fatty acids and about 50% lower with ethyl esters as compared to triglycerides.” The free fatty acids resulted in significantly more fish burps though. In fish, most omega-3 fatty acids are free or bound to triglyceride, so it makes sense that those forms are highly bioavailable to humans.

Krill oil seems to have the highest bioavailability based on the research so far. For example, [Schuhardt et al. \(2011\)](#) compared the bioavailability of 1.7 g EPA + DHA consumed either re-esterified triglycerides, ethyl esters or krill oil. Ethyl esters again performed worst with 26% higher bioavailability of the re-esterified triglyceride bound form and 68% higher bioavailability of krill oil. [Krill oil supplements have considerably higher bioavailability than triglyceride-bound fish oil supplements according to multiple other studies](#) [2, 3, 4]. In krill, some omega-3 fatty acids are also bound to phospholipids, DAG and MAG, instead of almost exclusively triglyceride (TAG) and free fatty acids. However, krill meal does not appear to have higher bioavailability than fish oil though, so the phospholipid and other bound forms don't seem to be responsible for the greater bioavailability. Krill oil supplements are generally more expensive than fish oil supplements and despite their greater bioavailability, [a 2020 meta-analysis found krill oil supplements don't achieve a significantly greater effect on our blood lipids than regular fish oil supplements on a dose-equated basis](#). In contrast, [TAG-bound fish oil omega-3 has been found to reduce blood triglycerides more effectively than ethyl esters, in line with the difference in bioavailability](#). Whether krill oil is worth the extra money is thus questionable.

In fact, omega-3 supplementation as a whole may not be cost-effective compared to consuming a cheap fish, such as farmed, frozen or canned salmon. When you factor in

the major bioavailability difference of the omega-3s and the fact salmon also has many other nutrients, in particular high-quality protein, it can be cheaper than getting a high-quality omega-3 supplement.

To avoid paying for poison, it's crucial to only supplement independently validated omega-3 supplements. Overweight individuals and individuals with high chronic inflammation levels should be particularly wary of consuming untested omega-3 supplements. Combining poor quality fish oil supplements with inflammation can easily do more harm than good. We recommend only the following brands, which have been shown in independent lab work to be pure and non-oxidized.

- Jarrow Formulas EPA-DHA Balance or Krill Oil
- Athletic Greens Premium Omega-3
- Vital Choice Wild Salmon Oil
- Neptune Krill Oil
- Rosita Real Foods's Extra-Virgin Cod Liver Oil (limit to recommended serving size to avoid vitamin A overload)
- Source Naturals ArcticPure
- Enzymotec Omega PC
- Aker Biomarine Superba Krill Oil

[The best choice of supplementation for vegetarians is algae omega-3](#). There's not much research available on its bioavailability. [One study by Arterburn et al. \(2008\)](#) found algal omega-3 supplements have the same bioavailability as cooked salmon, but it was funded by the producer of the algal supplement.

ALA supplements are borderline useless, as the conversion to DHA is only a few percent, as discussed in the module on dietary fat.

To maximize the bioavailability of your omega-3 supplements, you should consume them with high-fat meals. [Lawson & Hughes \(1988\)](#) found that high-fat meals improved the bioavailability of omega-3s in ethyl ester fish oil by factor 3, but the total absorption was still only 60% then. The bioavailability of triglyceride fish oil was substantially greater regardless of meal co-ingestion and improved far less with a high-fat meal: only by 30% for EPA and not significantly for DHA. “Absorption of EPA, but not of DHA, from fish oil triacylglycerols was significantly improved from 69% to 90% by co-ingestion with the high-fat meal. Absorption of both EPA and DHA from fish oil ethyl esters was increased three-fold, to about 60%, by co-ingestion with the high-fat meal, indicating that absorption of fatty acid ethyl esters is highly dependent on the amount of co-ingested fat.” Note that most of the above research already supplemented the omega-3s with meals, so this strategy alone is not enough to make supplements as bioavailable as fish.

The dosage should be as needed to reach your ideal omega-3 intake, generally 0.5-3 g combined EPA and DHA: see the course module on dietary fat.

Menno’s verdict: Highly recommended for people that don’t consume enough fish in their diet. Stick to the few trustworthy brands!

Arachidonic acid

What is it?

Arachidonic acid is an omega-6 fatty acid with 20 carbon atoms (eicosanoid) that is the counterpart to the omega-3 fatty acids in the omega-3/omega-6 fatty acid ratio.

What does it do?

Mechanism: Upon stress, like resistance training for instance, eicosanoids are released from the membrane. Arachidonic acid is the precursor for other eicosanoids (PGF(2 α) and PGE2), which stimulate muscle protein synthesis.

Benefits & drawbacks: There is not enough evidence to support arachidonic acid's positive effect on adaptations to resistance training. Arachidonic acid is theoretically a proinflammatory fatty acid. For this reason, individuals who experience chronic inflammation (such as rheumatoid arthritis) are advised to limit their arachidonic acid intake.

How to take it

Dosage: Based on anecdotal evidence, it is used at the dosage of around 2,000 mg

When to take it: 45 minutes before a workout

Versions to buy: Arachidonic acid is available in capsule form.

Menno's verdict: Don't bother.

Beta-alanine*

What is it?

Beta alanine is a naturally occurring amino acid with an additional carbon atom compared to the amino acid alanine (used as building block for human proteins). Beta alanine is a building block of carnosine.

What does it do?

Mechanism: [Beta-alanine acts as a buffer against metabolic stress](#) by increasing carnosine storage in the body. As a buffering agent, it counteracts the pH drop, acidosis and neuromuscular fatigue that occur after heavy reliance on the glycolytic system during high-intensity exercise.

Benefits: Since beta-alanine only counteracts fatigue associated with the glycolytic system, [beta-alanine's endurance enhancing effect are generally only significant for activities lasting longer than a minute](#) [2] but not long enough to rely on the aerobic system. Since strength training sets typically last shorter than a minute, most studies, including [a 2022 meta-analysis](#), find [beta-alanine does not enhance improve strength development or muscle growth in strength trainees](#) [2]. [Even for athletes, beta-alanine supplementation generally does not result in significant between-group differences in training adaptations](#) [2, 3, 4], although some of the (industry sponsored) studies reported positive trends.

[Beta-alanine may be more effective in older people, due to lower carnosine levels, and women, due to their greater ability to buffer against metabolic stress.](#)

How to take it

Dosage: 5 g a day is commonly advised. Beta alanine supplementation can cause a tingling sensation in the lips and skin (paresthesia). Spreading the dosage across meals can prevent it.

When to take it: In combination with meals.

Versions to buy: Beta alanine can be obtained in the pure form. However, there are also time-release formulations available to reduce the tingling sensation if spreading the dosage across the meals isn't an option.

Menno's verdict: Possibly somewhat useful for CrossFitters and certain strength-endurance athletes but not for pure strength trainees.

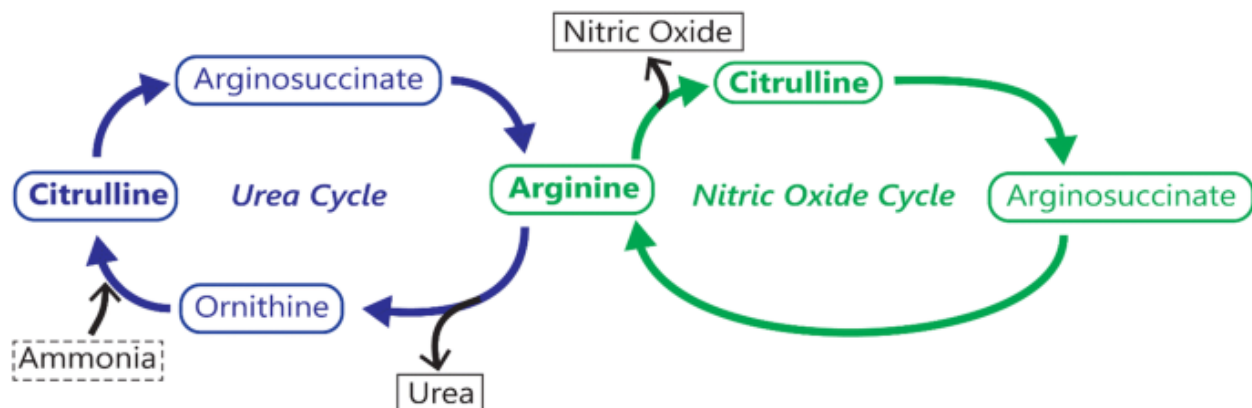
Citrulline (malate)*

What is it?

Citrulline is an amino acid, which is an important intermediate in the urea cycle. It isn't used for protein synthesis. Citrulline is essentially the 2.0 version of arginine, as it's absorbed more effectively and converted to arginine. Citrulline is widely regarded as the most promising of the many nitric oxide (NO) booster supplements available.

What does it do?

Citrulline belongs to the NO booster family of supplements, more formally known as nitric oxide precursors. Citrulline stimulates arginine production, which is converted to nitric oxide. NO's primary benefit is vasodilation, the widening of blood vessels, which can improve blood flow.



Citrulline stimulates the synthesis of arginine from glutamine in the gut. Arginine in turn is converted to nitric oxide (NO). It's more effective at raising arginine levels in the body than direct arginine supplementation, because arginine is broken down more rapidly by the liver. [Source](#)

[The resulting increase in work capacity is small](#), however, usually a single rep in the latter sets of multiple sets of high repetition work. [In multiple studies there is no](#)

[\(considerable\) increase in strength performance at all \[2, 3, 4, 5\]. A 2019 meta-analysis supports citrulline supplementation infers a small benefit to strength\(-endurance\) performance](#), but [a 2021 meta-analysis that specifically looked at maximal muscle strength found no significant effect](#). Citrulline mainly benefits activities that induce high metabolic stress, so it's more effective for strength-endurance training and less effective for strength training. Purely for the performance benefit, citrulline is thus of interest for athletes like rugby players and martial artists.

However, for strength trainees like bodybuilders and powerlifters, acute performance is irrelevant if it doesn't improve long-term gains in strength or size. It's questionable if reducing metabolic stress or improving blood flow is beneficial for muscle growth and strength development in the first place. Metabolic stress can increase muscle activity as a compensatory mechanism. As a result, blood flow restriction training can have positive effects on muscle growth and strength development (see advanced training techniques module). So, does citrulline supplementation increase strength or muscle development over time?

We have only 1 RCT on longitudinal citrulline supplementation in strength trainees. [Hwang et al. \(2018\)](#) had strength-trained men consume a pre-workout placebo or 2 g L-citrulline malate or 200 mg/day of glutathione + 2 g/day of L-citrulline. Neither citrulline group achieved a significantly higher training volume, increase in 1RM strength or lean mass growth than the placebo group after 8 weeks. Macronutrient intakes did not differ between groups. Statistical power was high for such a study with 75 participants. For those reading the full text, note that the paper reads as if citrulline did work, but this is probably the influence of the study's sponsor, a manufacturer of citrulline supplements.

An experiment by [Townsend et al. \(2022\)](#) also found no benefits of supplementing dietary nitrate, another NO booster with similar mechanisms of action as citrulline, on muscle growth and strength development. A group of strength training male Division I baseball athletes followed a concurrent exercise training program for 11 weeks with a placebo supplement or 180 mg per day of dietary nitrate from spinach extract, consumed pre-workout on training days. There were no significant differences between groups in macronutrient intakes during the programs. After the program, there were no significant differences between the groups in improvements in body composition, maximal strength or anaerobic cycling performance, nor changes in resting heart rate or blood pressure.

In contrast to the above 2 studies of either compound in isolation, [Roux-Mallouf et al. \(2020\)](#) found that supplementing the 2 NO boosters together could be beneficial for strength development, albeit again not muscle growth. However, this study was not representative of serious strength training and had major limitations. A group of untrained individuals supplemented either a placebo or a salad and drink with 520 mg nitrate and 6 g citrulline during an 8-week concurrent training program. The supplements had no effect on vascular function and muscle and cerebral oxygenation during exercise, although this was probably because they were consumed 4-6 hours pre-workout, which is probably too early. There was also no significant effect of the supplements on blood pressure levels. Despite the lack of a mechanistic effect, the NO booster group achieved a significantly greater increase in isometric knee extension strength, suggesting the NO boosters could improve strength development. However, there were multiple major limitations and null findings.

First, the placebo group, despite being previously untrained, managed to gain only 0.2 kg strength on this test. The training programs seemed to be mostly focused on endurance training. The researchers did not detail which strength training exercises

were performed other than “scapular and pelvic girdle muscle exercises” and leg extensions, nor how many sets were performed, but the rest intervals were reported to be only 20-30 seconds in between sets. Given the almost complete lack of strength development even in untrained individuals, this was evidently not a serious strength training program. It’s questionable if the same benefits would apply for serious strength training. In fact, the researchers did measure the bench press load progression of both groups and this did not differ between groups at any time point, as they only tangentially mention. Bench press progression is arguably a more relevant metric than isometric leg extension strength on a dynamometer.

Second, macronutrient intakes were supposedly recorded ‘in detail’ but were not reported in the paper, so it’s unclear if they were equal between groups. They mostly likely were not, because the placebo group lost a bit of fat, whereas the NO booster group gained some, with the difference trending towards statistical significance ($p = 0.07$). Changes in lean body mass did not significantly differ between groups, and were actually non-significantly more positive in the placebo group, suggesting the NO boosters did not increase muscle growth. In absolute terms, the body recomposition effects were thus overall actually better in the placebo group. Combined with the lack of difference in bench press progression, it’s hard to see this study as relevant evidence in favor of NO boosters.

[A 2022 meta-analysis on nitrate supplementation](#), which has a similar mechanism of action as citrulline, found that overall, nitrate supplementation can enhance strength training performance acutely, but none of the limited long-term studies found any effects on performance increases or muscle hypertrophy.

8 g Citrulline supplementation pre-workout may also increase muscle soreness, as found by [Chappell et al. \(2018\)](#), even though there was no increase in work capacity

during the German Volume Training they performed. [Other research finds no effect of citrulline supplementation on muscle swelling post-exercise.](#)

How to take it

The effective dosage, if there is such a thing, is 2-8 grams of L-citrulline malate consumed about 60 minutes pre-workout.

Menno's verdict: Probably useful for mixed athletes and one of the more promising supplements at the moment, but the current evidence does not show long-term benefits for strength trainees.

Creatine*

What is it?

Creatine is the most widely studied sports supplement by far and arguably the most effective one you can get over the counter. Creatine is a non-protein, nitrogen-containing organic molecule produced by the body from the precursor amino acids arginine, glycine and methionine. [Approximately 95% of creatine is stored in our muscles as an intermediate to produce energy, two-thirds of which in the form bound to phosphate, phosphorylcreatine \(PCr\), and one-third in free form.](#) Our brains also store some creatine. [Our bodies produce about a gram of creatine per day and we get another gram from our diet, but we can supplement another 2-5 grams on top of that to saturate creatine stores.](#)

What does it do?

Creatine helps recycle ATP, providing your muscles with a longer-lasting supply of rapidly available energy for muscle contractions. Muscle contraction requires energy, which comes from the hydrolysis of ATP, leaving ADP. The pure ATP content of muscle is very low, generally not enough for even a second of intensive exercise. To keep rapidly providing energy, the body uses phosphate to recycle the ADP back into the form of ATP so it can be hydrolyzed again for more energy. Phosphocreatine serves as the phosphate donor for the replenishment of ATP. The enzyme creatine kinase (CK) catalyzes the phosphate transfer from phosphocreatine to ADP. Thus, creatine storage provides a buffer against fatigue as follows: creatine consumption → more phosphocreatine storage in muscle → more phosphate available for ATP recycling → muscles can produce more energy.

The practical end result is that [creatine supplementation improves work capacity, strength development and muscle growth](#) [2, 3, 4]. Over the course of a training

program, creatine supplementation typically results in [4-11 kilograms extra strength development on the barbell lifts](#) and [1.1 kg \(2.4 lb\) extra lean body mass](#) [2]. [Creatine supplementation also tends to result in a very small decrease in body fat percentage](#) [2]. The lower body fat percentage is largely the result of the greater lean mass, but some fat loss may occur from the increased energy expenditure resulting from the lean mass and the higher training volumes.

[Creatine also has a paradoxical effect on muscle damage](#). Creatine supplementation tends to reduce muscle damage from single workouts, but this effect reverses over time so that people on creatine experience greater muscle damage from training. The greater muscle damage is likely the result of their greater repetition volumes.

Response continuum

Creatine's effectiveness depends on how well the person responds to it. [There is a continuum of creatine response](#) [2], depending primarily on much creatine the person naturally stores. Some people naturally have saturated creatine stores and consequently do not absorb any additional creatine into their muscles at all. Around [20-40%](#) of people are creatine non-responders, meaning creatine supplementation results in less than 10% or 10 mmol/kg of dry mass additional creatine storage in their muscles, which is less than half of what responders generally achieve. [Men also tend to gain more additional lean body mass and strength from creatine supplementation than women](#), likely in part due to their higher lean body mass and greater proportion of fast-twitch muscle mass [2]. Most creatine is stored in fast-twitch muscle fibers, so [people with more fast-twitch muscle fiber area tend to respond more favorably to creatine supplementation](#).

To test if you're a responder to creatine, you should compare your work capacity (see module on optimal program design) and bodyweight before vs after a loading phase. A

positive response on average entails gaining 1-2 kg of weight along with an increase of 1-2 reps in the later sets of your exercises. If you observe no effect of creatine loading on either metric, you may be a non-responder.

Water weight gain

Much of the initial increase in lean body mass is water drawn into your muscles by creatine. This can amount to up to 2 kg of extra body weight. Many people dismiss this extra hydration as being ‘just water’, but it’s still muscle mass: visually, it’s just as if you gained more muscle mass via strength training. Moreover, the cellular swelling might [directly activate anabolic signaling via insulin-like growth factor 1 \(IGF-1\)](#), which regulates satellite cell activation and proliferation, [as well as myogenic regulatory factors \(MRFs\)](#). Specifically, [downregulating myostatin via creatine supplementation may improve muscle growth, as myostatin inhibits satellite cell activation](#). [Creatine should not result in water storage in other body parts: all water retention is intracellular along with the creatine](#) [2, 3]. If extracellular water retention occurs, it’s typically due to not consuming enough fluids, resulting in dehydration and excess water retention in compensation, especially in the abdominal area (‘bloating’). Getting bloated from creatine is actually a good sign, as it suggests you’re absorbing a lot of creatine. Simply consuming more fluids should solve the problem. In some people creatine can cause digestive issues that also cause bloating though. This is typically remedied by improving its absorption: see the ‘how to take’ section.

Safety

[Creatine supplementation has somehow been found to increase dihydrotestosterone \(DHT\) levels in rugby players in one study](#). DHT is implicated in the development of male pattern baldness (see the skincare module), so a common concern of creatine supplementation is that it causes baldness, but this is highly speculative. No study has reported hair loss resulting from creatine and there’s no established mechanism how it

could. In the study, there was no effect on testosterone levels, in line with most [other research](#). Since the body uses free testosterone to produce DHT, it's mechanistically unclear how creatine could raise DHT levels. The reported DHT levels in this study were variable and not nearly outside the normal range. The supposed increase was 0.3 nmol/L and [DHT's reference range is 0.8-3.5 nmol/L in adult men](#), so the increase was only about 10% of the maximum physiological level.

[Creatine is widely considered safe \[2, 3\]. Creatine supplementation generally doesn't affect liver or kidney functioning \[2\]](#). In some individuals, an increase in urinary creatinine levels is observed. This is benign. It just shows the body's breaking down the creatine into creatinine.

In fact, creatine supplementation is associated with a wide range of tentative health benefits, including better cardiovascular health, in particular blood flow, better glucose control, [improved cognition](#), protection against concussions and [reduced depression](#). [Creatine supplementation seems to very slightly improve our intelligence and short-term memory \[2\]](#), especially [when the body is under high stress](#), [when you're very sleep-deprived](#) and [in elderly individuals](#). These effects seem to result from extra creatine storage in the brain and improved neuromuscular functioning. [All creatine's health benefits for already healthy, non-elderly individuals are unvalidated and likely marginal though](#). [A 2022 meta-analysis](#) found that creatine supplementation only improves memory functioning in people over 66 years old. The [lack of significant cognitive benefits in healthy young individuals was confirmed in a 2023 RCT](#).

How to take it

If you haven't supplemented creatine the month before, start with a 5-day loading phase with 20 g creatine per day for men or 15 g for women, spread across at least 3 meals. [Keep the dosage per serving to no more than 5 grams if your gut's sensitive to](#)

[creatine, as digestive problems can occur at higher dosages](#). After this, [5 g per day post-workout or with your first meal of the day is an almost universally effective maintenance dosage](#). Just [3 or even 2 grams per day or 0.03 g/kg per day provides most of the benefits already](#) [2] and 3 g is advisable for women, but [supplementing 5 grams may provide slightly greater benefits in some muscular men](#), so assuming cost and tolerance are not issues, large men should supplement 5 g per day [2].

Creatine loading is not necessary. [Creatine loading does not improve total cumulative uptake](#) and [does not significantly increase long-term strength development or muscle growth](#). However, a loading phase makes it much easier to see if you're a responder, because the weight gain and improvement in work capacity occur more quickly.

If you miss a dosage, you can double up the next dosage to make up for it.

[There is no need to cycle creatine](#). You can supplement it indefinitely.

[Creatine uptake is facilitated by insulin](#), so consuming creatine with [carbs](#) [2, 3] or presumably protein or insulin sensitizing substances can increase acute creatine uptake. However, the final saturation level may not increase. A study by [Pittas et al. \(2024\)](#) found that on average, even a hefty dose of 95 g carbs during the loading phase did not increase creatine uptake (+12% in both groups, in contrast to the authors' interpretation), nor did consuming the carbs increase the final muscle saturation level after a month. The final saturation level in our muscles is what determines our long-term gains, so most people probably don't need to bother with adding carbs to their creatine. However, if you're a non-responder or you get digestive issues from supplementing creatine, consuming the creatine after a high-carb meal may improve its uptake. Anecdotally, improved creatine absorption also tends to alleviate most side effects, like nausea and cramping.

If you experience cramping from creatine supplementation, you probably need to drink more water. It's also advisable to check for mineral deficiencies, in particular magnesium. In a way, cramping and water retention with weight gain are good signs, as they suggest your body is absorbing the creatine effectively – you're a responder – and it's now increasing demand for fluids.

Timing

[Some studies](#) find creatine supplementation is slightly more effective to enhance muscle growth when consumed post-workout than pre-workout [2, 3], an effect that could be due to the greater uptake post-workout when insulin sensitivity is very high. However, [other research](#) finds the timing of creatine supplementation does not matter [2]. It's plausible that creatine timing has only a minor effect, so it's hard to detect in small, short studies. To ensure maximum effectiveness of your creatine, it's safest to consume your creatine post-workout, but responders may be able to take it whenever they want.

Another reason to consume creatine post-workout is that some research shows consuming caffeine and creatine together blunts the effects of creatine: see the caffeine section for a research overview on this interaction effect. Given that creatine can induce far more robust ergogenic effects than routine caffeine use, it's advisable to avoid caffeine consumption altogether during the creatine loading phase.

Best form

Creatine monohydrate is the most validated form of creatine supplementation and it's the cheapest to boot. [Creatine monohydrate is already nearly 100% bioavailable](#), so there's no reason to buy the fancier versions that are advertised to have better absorption, such as creatine ethyl ester. [No version of creatine works better than creatine monohydrate](#) and other versions are typically much more expensive [2, 3].

You should dissolve creatine for maximum bioavailability: [creatine capsules have up to 35% lower bioavailability than dissolved creatine powder or meat](#). You can probably compensate for the lower bioavailability of capsules by supplementing a higher dosage, but that may cause digestive issues and it's more expensive, especially as capsules are generally more expensive per gram than powder to start with. After dissolving the creatine, it's best to consume it within 2 hours. [Dissolved creatine starts degrading into creatinine within hours, though it can take weeks before all creatine has degraded](#).

Some individuals get digestive issues from creatine monohydrate supplementation. If this is the case for you, a fancier form of creatine can, anecdotally, sometimes allow you to supplement creatine without these side-effects.

Menno's verdict: If you're not impressed by creatine, you won't be impressed by any other legal supplement (mostly because the rest is even worse, not because creatine is that magical). Creatine is as close to a must-have supplement as it gets for responders.

Glutamine

What is it?

Glutamine is a conditionally essential amino acid.

What does it do?

Mechanism: Glutamine was suggested to increase muscle protein synthesis; however, this effect was only observed *in vitro* or in isolated cells. These findings couldn't be confirmed in healthy individuals. A possible reason for this may be that glutamine is a preferable fuel source (over glucose) for intestinal cells, which might use up glutamine before it can act as muscle protein synthesis enhancing agent.

Benefits: There is some evidence that glutamine supplementation may reduce the drop in performance during long endurance events. However, there is no evidence that glutamine supplementation is beneficial for resistance trainees, although it may be beneficial for diseased individuals who suffer from conditions that induce muscle wasting. Glutamine supplementation may be beneficial for people who don't eat enough protein (like vegans on a low protein diet).

How to take it

Dosage: The standard supplementation dose is 5+ g, but this dose does not seem to encourage any muscle building effects. Higher doses may be beneficial for protein deficient individuals.

When to take it: These recommendations differ. The general guideline is to consume as much as possible, as often as possible (every 2-3 hours, i.e. upon waking up, when going to bed, before/during/after workouts, etc.). Considering the very limited evidence

that glutamine is beneficial for healthy resistance trainees, the best recommendation is likely not to consume it at all.

Versions to buy: Glutamine can be purchased as powder, capsules or tablets.

Menno's verdict: Useless outside of certain gut pathologies.

HMB

What is it?

β -Hydroxy β -Methylbutyrate (HMB) is a metabolite of leucine that's purported to prevent muscle breakdown.

What does it do?

HMB can initiate anabolic signaling by activating the mTOR pathway, similar to its parent leucine. Given the same mechanism, it's unclear how HMB would be beneficial for someone already consuming enough high-quality dietary protein, as leucine intake will already be optimized. Accordingly, most studies on young, trained individuals, including 2 [meta-analyses](#) [2], have found no positive effect of HMB supplementation on athletic performance or body composition, unless protein intake was suboptimal. Moreover, [the validity of the research that has found positive effects has officially been questioned](#) (read: suspected of fraud).

How to take it

1-3 g daily to reduce muscle wasting, if your protein/leucine intake is insufficient.

Menno's verdict: Useless on top of a sufficient dietary protein intake.

Ornithine

What is it?

L-ornithine is an amino acid but not a proteinogenic amino acid, i.e. it can't be used to build proteins. It plays an important role in the urea cycle.

What does it do?

Mechanism: Ornithine's function in the urea cycle is to bind an ammonia-containing molecule (carbamoyl phosphate) to form citrulline (which is another popular supplement).

Potential benefits & drawbacks: Ornithine is supplemented because of its theoretical ergogenic properties. The idea behind it is that ornithine should increase performance due to its ability to bind ammonia. Ammonia accumulation in skeletal muscle leads to fatigue and a drop in performance. However, there is very limited evidence that this hypothesis applies to real-life resistance trainee settings. Although [one study](#) has shown increased lean body mass and power gain in response to ornithine supplementation, this study was confounded through co-administration of arginine and did not control for protein intake.

If ornithine indeed has performance enhancing properties, they would be noticeable during long-lasting endurance events (over 2 hours) where ammonia accumulation may become a problem. In this case, ornithine isn't likely to increase physical performance directly but rather reduce the subjective feeling of fatigue.

How to take it

Dosage: A common dose is 2-6 g ornithine in hydrochloride form, daily.

When to take it: Before a long-duration aerobic exercise.

Versions to buy: Ornithine hydrochloride was used in multiple studies. L-ornithine L-Aspartate and L-Ornithine α -ketoglutarate seem to be other effective forms. However, because of the higher molecular weight of aspartate and α -ketoglutarate compared to hydrochloride, higher supplement doses have to be ingested to obtain the desired L-ornithine amount.

Menno's verdict: Most likely useless.

Phosphatidic acid

What is it?

Phosphatidic acid is a phospholipid that is one of the components of the cell membrane and an intermediate for the synthesis of other phospholipids.

What does it do?

Mechanism: Phosphatidic acid was suggested to activate the mTOR pathway.

Benefits & drawbacks: [One unpublished research study](#) suggested that phosphatidic acid increases strength and muscle gain as a response to resistance training, but it was sponsored by the supplement industry and the corresponding author, Jacob Wilson, has been [widely criticized](#) [2] for publishing incredulous data in favor of the supplement industry. [A much more credible study](#) did not find any beneficial effect of phosphatidic acid supplementation on strength and hypertrophy.

How to take it

Dosage: 750 mg per day.

When to take it: On training days, one half of the dose 30 min before and one half immediately after resistance training. On rest days, one half of the dose taken in with breakfast and the other half with dinner.

Versions to buy: Phosphatidic acid supplements are available as capsules. Some supplements combine phosphatidic acid with other substances, like leucine for example. Since leucine has been shown to activate the mTOR pathway, it is unclear if the potential beneficial effect from these supplements is based on leucine or

phosphatidic acid. If it is the former, then the combined phosphatidic acid supplements represent a very expensive way to sell leucine.

Menno's verdict: Most likely useless.

Smelling salts*

What is it?

Solution of ammonium carbonate.

What does it do?

Mechanism: When a person sniffs a solution of ammonium (carbonate), ammonia gas enters the nose. This irritates the nasal tract and the lungs, causing the sympathetic nervous system to acutely start working overtime. Heart rate increases and you feel as if you just woke up from the dead.

Benefits & drawbacks: If smelling salts help a person to push himself/herself to the limits, they're fine to use, but the effect is likely entirely psychological. While ammonia feels like a powerful stimulant, the effect only lasts a matter of seconds, generally less than a minute. [Inhaling ammonia does not increase muscle activity, rate of force development, maximal force production](#) [2, 3, 4, 5], [bench press or squat repetition performance](#), or [deadlift 1RM strength](#) in multiple studies, though [one study by Bartolomei et al. \(2018\)](#) found ammonia inhalation potentiated rate of force development with a trend for increased maximal strength as well. This positive finding may have been a fluke, given the substantial evidence failing to show any benefits. In general, anything that increases arousal, such as caffeine and music, is more likely to aid power and endurance performance than maximal strength, probably because without a reference weight or reps you have less performance feedback and there's more room to push harder simply by exerting more effort.

How to take it

Dosage: In contrast to what many people might expect, [smelling salts are generally safe](#). Ammonia is toxic to the nervous system, but one should inhale so little that it isn't a problem. It may irritate the nasal tract, but that's generally all the damage ammonia does.

When to take it: A few seconds before high intensity performance is required (e.g. 1RM test) or when one is about to pass out or needs to be woken up after passing out. Inhaling ammonia is a practice generally reserved for Strongmen, Powerlifters and other aggressive sports like boxing to revive unconscious boxers before they time out.

Versions to buy: Smelling salts are available as ampules, wipes or in liquid form.

Menno's verdict: Worth experimenting with for strength athletes.

Fat Loss

Many supplements purport to aid fat loss and some are known as ‘fat burners’. These compounds generally don’t directly make you lose but fat rather increase energy expenditure and/or decrease your appetite, making it easier to achieve an energy deficit and lose fat as a result of that. Here we’ll discuss the most relevant ones, but as a spoiler: [a 2021 systematic review and meta-analysis](#) concluded any fat burner’s effect on fat loss is trivial compared to the effects of your diet and exercise. Arguably the greatest benefit of some of these supplements is that they decrease your appetite, making cutting easier.

Albuterol

What is it?

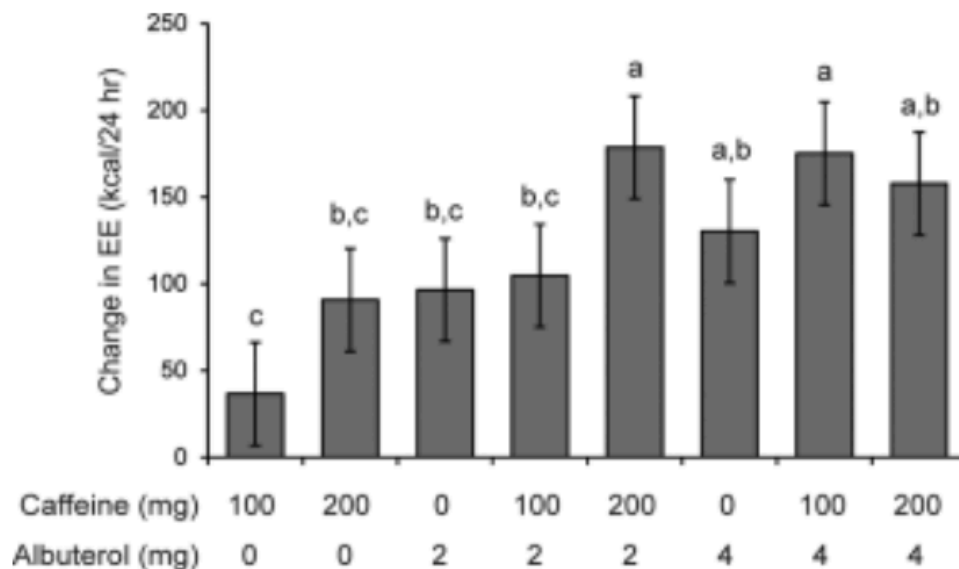
Albuterol, also known as salbutamol, is an organic molecule that is a β_2 adrenergic receptor agonist. Its effects are thereby very similar to epinephrine AKA adrenaline.

What does it do?

Albuterol’s main medical use is to treat asthma by relaxing airway smooth muscle, ‘opening the lungs’. More generally, albuterol has very similar effects to ephedrine, but it is much stronger on a mg per mg basis. Albuterol also seems to be a more potent anti-catabolic and may in fact be directly anabolic, because [albuterol has androgenic activity](#), like testosterone but weaker. As a result, [albuterol can increase strength development and muscle growth](#) [2, 3, 4, 5]. This is mostly a long term effect, since like ephedrine, [albuterol seems to have no major acutely ergogenic effect](#) [2, 3]: it does not directly improve strength training performance as a stimulant, only long term via improved training adaptations.

Albuterol is not very potent as a fat loss aid. [Some research finds no fat loss at all from albuterol use](#), even with *ad libitum* food intake. Albuterol is thus not great at suppressing appetite. Though [theoretically one would expect albuterol to suppress appetite](#) [2, 3], some people actually report increased hunger as a side-effect. This may simply be the result of weight loss instead of the albuterol itself though. [Research in rats suggests that albuterol's appetite suppressing effect is weaker in lean individuals](#).

Like most stimulants, [albuterol does increase metabolic rate in a roughly dose-response manner](#) [2, 3]: 1 mg albuterol is comparable to 100 mg caffeine.



[Source](#)

It is unclear if one becomes tolerant to albuterol's thermogenic effect [like one does to its bronchodilating effect](#). It is probably the case, since ephedrine is one of the few stimulants that does not evoke tolerance and it also doesn't evoke tolerance to its bronchodilating effect. However, the above studies show that there are still strength

and body composition effects with long term albuterol use, so tolerance is likely not complete.

It has been suggested that diphenhydramine, common brand name Benadryl, and [ketotifen can prevent albuterol tolerance by resensitizing beta-adrenoceptors \[2\]](#), but there is no direct research on how this affects energy expenditure. Moreover, given [ketotifen's relatively common side-effects of drowsiness and weight gain](#), it may somewhat defeat the purpose of taking a stimulant. In theory, it could be possible to mitigate the negative interaction by only taking the ketotifen before going to bed though. Hunger and drowsiness aren't a problem when a person is asleep, so the night may be used to resensitize adrenergic receptors.

How to take it

Dosage: Start with 2 mg up to 3 times a day with a gradual increase up to a maximum of 16 mg total per day.

When to take it: [Once a person develops tolerance to albuterol, simply increasing the dosage may not help](#), so it can be prudent to cycle albuterol's use over the course of weeks during long term use, even if only for economic cost-benefit.

2-Weeks-on-2-weeks-off is a popular dosing regimen.

Side note: Albuterol is on the World Anti-Doping Agency's list for prohibited substances.

Versions to buy: [Albuterol should be always supplemented orally \(in pill or liquid form\), as inhaling it at bodybuilding dosages can give a heart attack.](#)

Menno's verdict: Reasonably safe and effective to increase energy expenditure and improve your gains. Shame it's illegal in many countries.

5-HTP & tryptophan

What is it?

5-HTP (5-Hydroxytryptophan) is a metabolite of the amino acid tryptophan.

What does it do?

5-HTP is a precursor of the neurotransmitter serotonin (and melatonin in the evening).

Serotonin is the 'liking' neurotransmitter that makes you feel relaxed.



Curiously, 5-HTP supplementation appears to be more effective as an appetite suppressant than a mood enhancer, leading to significantly greater weight loss than placebo in overweight individuals in 3 studies [1, 2, 3]. Serotonin levels likely mediate the effect, leading specifically to a decrease in carbohydrate cravings in (pre)-diabetic individuals, who often have lower brain serotonin levels. However, nausea is a relatively common side-effect, which may explain the appetite suppressing effect of 5-HTP. Lean individuals using non-nauseating dosages are thus less likely to experience significant appetite suppression from 5-HTP supplementation.

Side note: 5-HTP shouldn't be combined with any neurological drug (e.g. antidepressants). Selective serotonin re-uptake inhibitors (SSRI) usage in combination with 5-HTP is potentially lethal.

How to take it

Dosage: 300-500 mg per day, taken once or divided into several doses. Lower doses may be effective when taken together with other substances. Beware with dosages above a gram a day, as 5-HTP circumvents your body's autoregulation of serotonin production, so more 5-HTP causes increased serotonin production with the potential for lethal serotonin toxicity.

When to take it: For its satiety increasing effect, 5-HTP should be taken with a meal.

Versions to buy: 5-HTP is available in capsule form. 5-HTP is preferred to tryptophan in a high protein diet, since tryptophan competes for absorption with other large neutral amino acids to cross the blood-brain barrier.

Menno's verdict: I haven't observed any fat loss benefits, so until there's research in lean strength trainees, I don't recommend it for anyone other than (pre)-diabetic individuals.

Fiber supplements*

A good diet supplies the body with plenty of fiber, both soluble and insoluble. [Fiber supplements cannot \(yet\) rival whole foods in terms of satiety](#) or health, since [the health effects of fiber are influenced by the plant's cell walls and many of its other nutrients and phytochemicals during digestion](#).

However, as is often the case with supplementation, a person is better off consuming enough fiber in the form of a supplement than not consuming enough in the first place from nothing but whole foods. [Soluble fiber supplements in particular can help improve fat loss](#) [2, 3] chiefly by reducing your appetite.

If supplementation is deemed to be the lesser evil, there are several fiber supplements of choice. Choosing the wrong fiber supplement can easily do more harm than good for digestive health and [not all types of supplemental fiber are equally satiating](#). There are many [studies in which fiber supplementation does not result in a significant reduction in energy intake](#) or fat loss.

Whichever fiber supplement is chosen, it's prudent to start with just a few grams of fiber per meal or even per day to avoid inducing a laxative effect or otherwise upsetting digestion. The digestive tract must adapt to large amounts of fiber and [digestive side-effects of fiber supplementation are common](#).

And again, fiber supplements are not a full replacement for whole foods. If a person needs fiber supplements to consume enough fiber without a very specific reason, their diet probably sucks and supplementation is a mere band-aid.

Below we'll cover the 3 most promising fiber supplements.

Menno's verdict: Fix your diet before even considering fiber supplementation.

Resistant starch

What is it?

[Resistant starch is a third type of fiber](#) and has been marketed heavily as a sort of super fiber.

What does it do?

[Resistant starch functions very much like soluble fiber and it does not seem uniquely potent at increasing satiety or improving health](#). In some research, [resistant starch consumption does not influence appetite at all \[2\]](#). While [resistant starch has zero net calories in rodents](#), humans can metabolize it relatively well: [resistant starch yields our bodies 3 kcal/g \[2\]](#). Overall, resistant starch seems to be much like any other fiber: healthy but not something you can't get from food.

How to take it

Dosage: Resistant starch is commonly supplemented in the form of potato starch, not to be confused with potato *flour*. One tablespoon contains about 8 grams of resistant starch.

For resistant starch supplements, it is advisable to start with small doses of ¼ teaspoon (added to ½-1 glass of water) and then increase the amount as the tolerance increases.

When to take it: To benefit from its blood sugar lowering properties, it is reasonable to take resistant starch with meals or after a meal.

Versions to buy: Resistance starch supplements can be bought online (e.g. on Amazon) in powder form. The same applies for raw potato starch, which is likely to be cheaper.

Psyllium husk

What is it?

Natural, soluble fiber that is well tolerated compared to other fiber supplements.

What does it do?

Mechanism: Psyllium husk increases fecal size by absorbing water and gas in the intestine. It also acts like a laxative.

Benefits: Psyllium husk is less likely to induce diarrhea or flatulence than other fiber supplements. As a bonus, psyllium husk can function as a binder and volumizer in meals like pancakes to create very low calorie recipes. [Psyllium husk can be counted as having 2 calories per gram](#). However, psyllium's scientific track record as an appetite suppressant is quite poor.

How to take it

Dosage: 15 g daily, divided into three doses of 5 g each.

When to take it: It is advisable to take it with meals. It is important to coingest psyllium husk with water (200 ml water + 5 g supplement).

Versions to buy: Psyllium husk is available in capsule form or as powder. It is reasonably cheap in powder form when bought from bulk protein suppliers.

Glucomannan

What is it?

Glucomannan is a natural, soluble fiber that is extracted from the konjac root.

What does it do?

Mechanism: Like other fibers, glucomannan is used against constipation. It decreases the transit time of the feces.

Benefits: It is extremely viscous and thus absorbs a ton of water, so much that it can hold a gelatinous texture after some processing. Shirataki noodles are a popular application of glucomannan's viscosity. Unsurprisingly, [glucomannan is thus particularly filling and effective as a weight loss supplement](#) [2, 3], although [not all research finds supplementation achieves significant fat loss](#). They may be called miracle noodles, but don't expect any fat loss miracles from them.

How to take it

Dosage: Since glucomannan swells up enormously, most people can only tolerate a few grams per day.

When to take it: For best effect glucomannan needs to be consumed before a meal with a large amount of water to bind to.

Versions to buy: Shirataki noodles (aka zero calorie noodles) or as a powder.

Alpha-Lipoic Acid (ALA)

What is it?

ALA is a fatty acid that also contains sulfur atoms and is present in mitochondria. Not to be confused with α -Linolenic acid, which is also abbreviated as ALA.

What does it do?

Mechanism of action: ALA is involved in energy metabolism and exhibits antioxidant properties.

Benefits: ALA has the potential to reduce appetite and potentially reduce nutrient uptake. However, the latter effect is likely not to be strong enough to be meaningful. ALA is likely to help obese or overweight individuals to reduce weight when following a calorie-restricted diet or no prescribed dietary intervention. However, [the average weight loss difference of 1.27 kg is not very impressive considering that the examined dieting period was between 2 months and a year in most research studies](#). It is unclear if the potential weight loss enhancing effect transfers to normal-weight individuals.

[ALA supplementation has been found to significantly reduce inflammation levels in individuals with high chronic inflammation](#), but there's no indication it has clinically meaningful effects in healthy individuals.

How to take it

Dose: The standard dose is 300-600 mg. However, [doses up to 1.800 mg](#) have been used with success in research.

When to take: The supplement can be taken fasted or divided into three doses, which are taken before meals.

Versions to buy: ALA is available in capsule form online (e.g. from bulk protein suppliers).

Menno's verdict: Possibly worth trying for obese individuals.

Apple Cider Vinegar

What is it?

The active compound in apple cider vinegar is acetic acid. Acetic acid, also called ethanoic acid, is a small organic molecule with a carboxylic acid group, which can be produced by bacteria through oxidation of alcohol (ethanol).

What does it do?

Mechanism of action: Acetic acid was proposed to upregulate the expression of genes for fatty acid oxidation enzymes in the liver to suppress body fat accumulation. Also, acetic acid seems to delay gastric emptying.

Benefits: Apple cider vinegar is very healthy and, more importantly for the physique, it functions as a mild appetite suppressant. [This may be because acetic acid is ketogenic in humans: we only know for sure it is in animals.](#)

To quote Kris Gunnars: “Apple cider vinegar is incredibly popular in the natural health community, and has been shown to have numerous benefits. It can significantly reduce the blood sugar response after a high-carb meal, and may have modest effects on the weight ([33](#), [34](#)). Studies have shown that taking vinegar with a high-carb meal can increase fullness so much that people eat 200-275 fewer calories for the rest of the day ([35](#), [36](#)). In one study, taking 15-30 mL (1-2 tablespoons) of vinegar per day caused weight loss of 2.6 – 3.7 pounds (1.2 – 1.7 kg) over a period of 12 weeks ([37](#)).”

Even though the effect on weight loss is not strong, it may be worth trying to supplement with apple cider vinegar, as it is reasonable cheap.

How to take it

Dose: 1-2 tablespoons diluted in at least a large glass of water to avoid the acid burning the throat.

When to take: After a meal.

Versions to buy: Less processed apple cider vinegar options (organic, unfiltered) should be preferred, as they are likely to contain more nutrients.

Some people like the taste. Most people don't. The taste can be masked to some extent with sweetener and diet soda (preferably one with an apple flavor).

Menno's verdict: Worth trying after meals during contest prep when hunger becomes a major problem.

CLA

What is it?

Conjugated Linoleic Acid (CLA) is a name for an entire group of fatty acids, all of which are 18 carbon atoms long and have two double bonds separated by one single bond. The two most researched representatives of this class are c9t11 (cis-9, trans-11) and t10c12 (trans-10, cis-12). These are the CLA isomers typically found in CLA supplements.

What does it do?

Mechanism: CLA interacts with a molecular signaling receptor family (PPAR) that is involved with fat burning, steroid signaling, inflammation, and glucose/lipid metabolism.

Potential benefits & drawbacks: CLA is a very potent fat burning agent in animals; however, it doesn't transfer to humans because of the big differences between species in this area. CLA's fat burning activity in humans is very poor, if present at all. Though some studies (but not the majority) have shown statistically significant fat loss in the CLA supplementation group, the magnitude of fat loss was very low (<1.13 kg in 4 months). Other supplements, like ephedrine, performed much better in comparable scenarios.

Similar findings apply to lean body mass (LBM) gain mediated by CLA supplementation. Although some studies detected increases in LBM, this finding isn't supported by the majority of evidence. There is limited and mixed evidence on the positive effect of CLA supplementation strength gains in trained individuals. Most importantly perhaps, almost all positive research is funded by the supplement industry.

How to take it

Dosage: The standard dose lies between 3.2 - 6.4 g, 70 weight-% of which should be attributed to c9t11 or t10c12.

When to take it: CLA is usually taken with meals.

Versions to buy: CLA mixtures containing either c9t11 or t10c12 in high amounts.

Menno's verdict: Useless.

Coleus forskohlii

What is it?

Coleus forskohlii is an herb that is used in Ayurvedic medicine.

What does it do?

Mechanism: Coleus forskohlii increases cyclic adenosine monophosphate (cAMP) concentrations in the body. High levels of cAMP (exceeding those obtained through Coleus forskohlii supplementation) increases lipolysis.

Benefits & drawbacks: Coleus forskohlii is used as testosterone booster and fat burning supplement. More research is needed to confirm these beneficial effects. Many research studies on coleus forskohlii were conducted *in vitro* (in reagent tubes) and not in the human body. Whether coleus forskohlii shows the same effects in a healthy human body is questionable.

How to take it

Dosage: The usually applied dose is 250 mg coleus forskohlii that contains 10% forskolin (the active compound in the leaves and stem) taken twice daily (total dose is 500 mg, which equals 50 mg forskolin). However, it isn't established yet if this dose is optimal.

When to take it: In theory, coleus forskohlii supplementation 15-20 min prior to a meal should reduce appetite and taking it prior to a workout should increase testosterone. However, the evidence to support this theory is missing.

Versions to buy: The supplement is available in capsule and powder form. It is important to pay attention to forskolin amount in the given supplement, as the quantities of the active compound differ depending on the brand.

Menno's verdict: Probably useless.

Ephedrine

What is it?

Ephedrine is an active compound of the herb Ephedra. It belongs to the class of alkaloids; organic, nitrogen-containing compounds that are found in plants and have a physiological effect in humans.

What does it do?

Mechanism: Ephedrine is a stimulant that functions comparably to caffeine. It increases the effects of norepinephrine, a hormone similar to adrenalin (= epinephrine).

Benefits: For bodybuilding purposes, ephedrine is like caffeine on steroids: unlike caffeine, [taking ephedrine generally significantly enhances weight loss without major adverse health effects](#). Still, most people greatly overestimate the effects of stimulants on actual weight loss. Even at very high and risky dosages, the increase in metabolic rate of ephedrine and caffeine combined is generally below 10% with 5% being more common. The main reason for supplementation and its success in weight loss diets is its appetite suppressant effect. In many studies ephedrine was paired with caffeine to enhance this effect.

Ephedrine is also a significant mental stimulant. It reduces feelings of fatigue and increases attentional control. However, it is generally less mentally noticeable than caffeine and is often said to 'work under the radar'.

[Ephedrine may also increase exercise strength-endurance, but just as with caffeine, it's questionable if these effects are physiological or if the stimulants just make people willing to train harder](#). For strength training, the ergogenic effect is likely marginal.

[Perhaps the most awesome aspect of ephedrine is that, unlike caffeine, one develops a tolerance to its side effects but not its positive effects.](#) This didn't stop people from abusing ephedrine, of course, which is why it's now banned in many countries.

Warning: Individuals prone to cardiac disorders, may not want to take ephedrine (for too long). Ephedrine significantly increases blood pressure while it's in effect. However, for lean, active and healthy individuals, this is normally not a major concern.

How to take it

Dosage: Start with a dosage as little as 4-10 mg and gradually building up the dosage each day by as little as 4-10 mg. The maximum dosage that appears to be safe for long term use is 60 mg, split into 3 dosages. This dosage has been used in several studies in overweight individuals for months without clinically relevant side effects in most people.

Side note: Ephedrine is on the World Anti-Doping Agency's list for prohibited substances. The athletes don't pass the doping test when ephedrine's concentration in urine is greater than 10 micrograms per milliliter.

When to take it: Just like caffeine, intake too close before bedtime should be avoided. It has a similar half-life (normally 6 hours).

Versions to buy: Ephedrine supplements or supplements that contain a combination of ephedrine and caffeine are not approved in the US. However, botanical supplements (herbs or tea) that contain ephedra (the plant from which ephedrine is extracted) are legal. Ephedrine HCL (hydrochloride) is sold in other countries like Canada as a medication for the relief of nasal congestion.

Medically, ephedrine is preferred over various similar supplements, such as clenbuterol. 'Clen' has a similar mechanism of action, but it also [has a ridiculously long half-life of 35 hours](#), which means it will always interfere with sleep quality. Moreover, there is an [almost complete lack of research establishing clen's safety in humans](#), though we do know it's probably more effective than ephedrine both for fat loss and muscle growth: [clenbuterol majorly increases resting energy expenditure and activates muscle anabolic signaling](#).

Ephedrine is also preferred over its weaker counterparts, pseudoephedrine and synephrine. Pseudoephedrine is very similar but far weaker: 240 mg per day is a commonly prescribed and safe dosage. Synephrine is essentially the same stuff but is also weaker and less researched. [Jung et al. \(2017\)](#) found that consuming 20 mg synephrine pre-workout did not affect strength development or body composition changes in strength trained men.

Menno's verdict: Shame it's illegal in many countries now, as it's basically a stronger, non-addictive caffeine. Arguably the best fat loss supplement there is.

Methylphenidate (e.g. Ritalin)

What is it?

Methylphenidate is an organic molecule with a structure similar to amphetamine (Speed/Adderall).

What does it do?

Mechanism: It primarily acts by increasing the activity of dopamine and norepinephrine, but unlike cocaine and amphetamines, it has a low affinity for the serotonin transporter. This creates a state of high arousal and heightened attentional focus without hyperactivity symptoms or euphoria.

Benefits: When it comes to body composition, methylphenidate acts like most other stimulants: it suppresses appetite and induces a mild increase in metabolic rate.

[Methylphenidate has an excellent safety profile with comparatively little development of addiction \(tolerance, dependence and withdrawal\)](#), at least at therapeutic dosages and in oral form. [However, methylphenidate addiction has been documented in animals and research in adults without ADHD is lacking](#). People habituated to high doses over the course of multiple months should gradually taper off their dosage to avoid potential withdrawal symptoms from abrupt cessation of the drug's use. Intravenous or nasal (snorting) consumption of methylphenidate have a considerably greater capacity for addiction, as is common for more rapid drug delivery to the brain and higher peak drug concentrations.

[Caffeine and methylphenidate induce cross-tolerance](#) [2], so beware of combining them. The effects can become very strong and the risk of addiction increases correspondingly.

How to take it

Dosage: The recommended dosage is generally 0.2-0.8 mg/kg (10-60 mg), spread across the day, as [methylphenidate's half-life is normally only 2 hours, although it varies across individuals up to 7 hours](#).

When to take it: Interestingly, [consuming methylphenidate with a meal speeds up its absorption](#), in contrast to food's regular effect of slowing down the absorption of drugs.

Versions to buy: Methylphenidate is not commonly available over the counter without a prescription.

Menno's verdict: Safe Speed. Illegal for recreational use basically everywhere unfortunately, otherwise it would be great to experiment with and see more research on individuals without ADHD.

Nicotine*

What is it?

Nicotine is an alkaloid: an organic, nitrogen-containing compound with physiological effect found in plants. Only the tobacco plant contains significant amounts of nicotine. Nicotine is the major addictive substance in cigarettes.

What does it do?

Nicotine mimics the neurotransmitter acetylcholine and can activate its receptors, which in turn increases dopamine and adrenaline levels. As a result, [nicotine is a good appetite suppressant](#) [2], mild stimulant and mild nootropic, specifically enhancing attentional control. The psychoactive effects are different from stimulants like caffeine and not everyone likes them.

Nicotine's psychoactive profile also makes it potentially addictive. However, the addiction risk of pure nicotine is not nearly comparable to that of smoking tobacco, as the speed of absorption and peak blood brain concentration are much lower with nicotine gum or patches than when you're inhaling it. Tobacco also has other psychoactive compounds that enhance the effect of nicotine. Nicotine addiction is a serious concern for people prone to tobacco addiction or addiction in general, but many other people have shown no symptoms of addiction when consuming up to 8 mg a day. [Women appear to be more prone to nicotine addiction than men](#) [2]. If a person has ever smoked tobacco and didn't like it much, the person is likely a non-responder to nicotine's addictive properties, at least psychologically. People prone to addiction tend to experience addictive symptoms after their first cigarette.

Despite functioning as a stimulant, [nicotine does not seem to have any performance enhancing effect on either endurance or strength](#).

[Nicotine also seems to function like an aromatase inhibitor](#), thus decreasing estrogen levels and increasing testosterone levels. These effects are minor, however, and the resulting increase in testosterone level is arguably trivial for muscle growth.

How to take it

Nicotine is the addictive component of cigarettes and comes with an obvious major warning not to take it if a person is prone to addiction. If you want to experiment with it, start with 1 mg gum and do not exceed 3 doses of 4 mg a day in total. You could start with patches instead of gum to be safe, but many people do not feel much effect from patches. [Gum chewing also inherently decreases stress and increases alertness](#).

Nicotine gum's bioavailability is strongly affected by the acidity (pH) of the mouth. [Beverages like cola and coffee greatly increase acidity of the saliva and thereby decrease the absorption of nicotine gum](#). As such, as a general guideline, it's best not to consume any food or beverages other than water within 30 minutes before or after nicotine gum consumption.

Menno's verdict: Looks good on paper for individuals not prone to addiction, but few people end up using it chronically because of the lack of pleasant psychological effects.

Spinach extract

What is it?

Spinach extract is isolated spinach leaf thylakoids. Thylakoids are structures that are found in chloroplasts of green plant cells and are responsible for photosynthesis.

What does it do?

Mechanism: Spinach extract delays fat digestion, but doesn't prevent it. It suppresses fat digesting enzyme (lipase), which results in the slowing of fat digestion. This in turn increases the levels of appetite-reducing hormones and reduces the level of the hunger hormone ghrelin.

Benefits: Spinach extract may cause reduced food intake due to its appetite suppressing properties. This may lead to weight loss over a prolonged period (several months).

Downsides: There is no convincing evidence that this is worth buying and certainly not in favor of just eating actual spinach until long term fat loss benefits in a somewhat relevant population have been shown by an independent lab.

How to take it

Dosage: 4-5 g spinach extract.

When to take it: in combination with a meal.

Versions to buy: Spinach extract is also known by a trademark name, *Appethyl*, which is owned by the Swedish company *Greenleaf Medical AB*.

Menno's verdict: Probably useless.

Yohimbine*

What is it?

Yohimbe is an alkaloid that can be found in the bark for the Pausinystalia Yohimbe tree.

What does it do?

In effect, yohimbine is similar to other stimulants like [caffeine](#) in that it activates the sympathetic ‘fight-or-flight’ nervous system and increases your energy expenditure, but yohimbine affects different receptors, which gives yohimbine a few unique properties, including the potential to increase libido. It’s an alpha-2-receptor antagonist (α_2 -blocker), which causes the body to increase noradrenaline production and makes yohimbine theoretically interesting to burn stubborn fat.

Fat cells have different receptors that control it, like buttons on your tv’s remote control, including the α_2 receptor. The α_2 receptor has the pesky property of functioning like a negative feedback loop for noradrenaline, which causes it to shut down fat burning (lipolysis). So fat with more α_2 receptors is normally harder to burn, hence the term stubborn fat. But since yohimbine blocks the α_2 receptor, this should *theoretically* make the fat lose its stubbornness and become easier to burn.

However, no study to date has found any effect of yohimbine supplementation on our fat distribution. [Sax \(1991\) performed a 6-month trial with an incremental dosage of yohimbine up to a hefty 43 mg a day. Not only was there no effect on the men’s body fat distribution as measured both by waist-to-hip ratio and by CT scan, there was no significant additional decrease in body fat percentage or blood lipids at all in the yohimbine group compared to the placebo group.](#)

While there’s no evidence that yohimbine helps with stubborn fat loss specifically, some other research does suggest it can help with overall fat loss. [The soccer player](#)

[study](#) is often heralded as the proof that yohimbine supplementation causes significant fat loss without any side-effects or loss of muscle mass or performance. However, this study has several major limitations.

1. There was no diet control during the actual study period, only before the tests, so the fat loss effect could be entirely explained by a reduced caloric intake as a result of yohimbine's appetite suppression. Then again, yohimbine's appetite suppression has never been documented in human research.
2. This study used a formula to estimate body fat percentage from skinfold measures that has been shown to underestimate body fat percentage in trained individuals with moderate reliability and its estimation of fat-free mass based on that figure has been shown to be *highly* unreliable. This unreliability is increased by the fact that [yohimbine is a diuretic and makes you urinate more](#), making it very unlikely that the formula accurately distinguished between lean body mass in the form of muscle tissue and lean body mass in the form of water. Since the subjects actually *gained* weight during the study, that makes the inference that they were losing fat very dubious.
3. A placebo control isn't very useful when yohimbine is so obviously felt. The soccer players may have thought they were given a performance enhancing drug, which could still have caused a placebo effect in comparison to the placebo group.
4. Finally, it's worth noting that the sole author from Serbia and Montenegro did not disclose his affiliations or funding source other than that the supplement was provided by Lama Inc.

More support for the idea that yohimbine causes water but not fat loss is provided by [other research showing that 15 mg yohimbine a day increases *weight* loss but *fat* burning \(lipolysis\) is unaffected](#). This study did find that the yohimbine group had a lesser decrease in resting energy expenditure of 6% vs. 10% (and 7% vs. 13% during

exercise), but the difference was not statistically significant. If we tentatively extrapolate these – once again not significant – findings to an individual with a resting energy expenditure of 2500 calories, it would mean that yohimbine increased energy expenditure by 100 calories a day. This person would burn 31 more calories during a training session that initially burned 500 calories.

Even if we assume that the lack of statistical significance was caused by insufficient statistical power, the study was still biased. The group receiving yohimbine was 8.2 kg (18 lb) heavier than the control group. This could result in higher relative retention of muscle mass during the diet and therefore a higher maintenance of metabolic rate.

[An older Polish study found that 15 mg yohimbine *did* significantly increase acute resting energy expenditure and exercise-induced energy expenditure by 8% in both lean and obese women.](#) The yohimbine also increased the release of glycerol and free fatty acids, i.e. fat burning, and over the 4-week cross-over study period this led to a whopping 0.7 kg / 1.5 lb greater average weekly weight loss rate. However, this was mostly the result of week 3's majorly outlying data in the yohimbine group with an increase in weight loss up to 2.8 kg, in contrast to the general trend of weight loss slowing down over the study period: see the table below.

Table 5 Effect of yohimbine on the weight reducing treatment.

Weeks	Weekly weight loss in kg			Mean ± SEM
	2	3	4	
Placebo	2.1	1.8	1.5	1.77 ±0.22
Yohimbine	2.3	2.8	1.8	2.43 ±0.2
P < 0.05				

Since the modest increase in energy expenditure doesn't match up with the measured weight loss, it's likely that either diet adherence was an issue, the data is just a fluke skewed by that one week, or the weight loss was again mostly water weight.

[A French study found no effect on 18 mg yohimbine per day during an aggressive weight loss diet on either weight loss or fat burning.](#)

How do we reconcile all the above seemingly contradictory findings? The disparity between short and long-term findings is likely the result of tolerance. Tolerance to yohimbine quickly develops: [the stimulation of noradrenaline is lost in just 15 days](#) of using just 12 mg a day, though yohimbine still modulates the activity of noradrenaline after that time.

Second, [yohimbine's fat burning effect is mainly noticeable during exercise and it is completely suppressed by the consumption of food](#). In practice this means yohimbine is likely only considerably effective when combined with intermittent fasting.

These small and transient increases in energy expenditure may not be worth it, because yohimbine supplementation comes with notable cardiovascular risks, including elevated heart rate and blood pressure, especially when combined with other stimulants. [Dosages upwards of 200 mg, around 10 times as much as used in research, can result in a coma, psychosis, retrograde amnesia, seizures and tachycardia.](#) More sensible dosages are generally free from clinical side effects, but increased blood pressure and anxiety are often reported anecdotally and in studies. Overall, it's clear that [yohimbine is a high-risk, low-benefit supplement.](#)

How to take it

Dosage: It is advisable to start with as little as 2.5 mg to assess how your body responds before gradually building up the dosage up to 0.2 mg/kg bodyweight in cycles of 2-4 weeks to avoid tolerance.

When to take it: [Yohimbine basically only works in the fasted state](#), so it needs to be combined with intermittent fasting to be potentially worth it. Most of the effects disappear quickly, within 4 hours, but [there is great individual variability of yohimbine's exact half-life ranging from less than an hour up to several hours](#).

Versions to buy: As with most commercial stimulants, [most yohimbine products only contain a fraction of the yohimbine that's on the label](#). So if using it, buying pure, standardized bark extract is advisable.



This is yohimbine extract, but good luck convincing the immigration officer.

Menno's verdict: Possibly worth trying for stimulant junkies on an intermittent fasting diet, especially during contest prep when every extra calorie burned helps and cardiovascular risk is low.