Examine®

Bone Health Supplement Guide

Table of Contents

Introduction

Your bones are more complex than is commonly assumed. They are composed of minerals (mainly calcium, magnesium, and phosphorus) attached to a structural matrix made of proteins (collagen and glycoproteins) and function as an endocrine organ (i.e., they produce hormones, osteocalcin).[1] Unlike your visible hair and nails, they are alive; they are continuously being broken down and built back up in a process called remodeling (or bone turnover), for maintenance and for repair after injury and daily wear. This is how bones adapt to stressors, which explains why exercise, especially resistance training, can increase *bone mineral density* (BMD)[2][3][4][5].

If your BMD is low, you suffer from osteo*penia* (literally, "*poor* bone"). If your osteopenia worsens to the point that your bones become brittle, it becomes an illness, called osteo*porosis* (literally, "*porous* bone"). Osteoporosis is more common in (postmenopausal) females than in males, but the latter are not immune.

The risk of osteoporosis varies by location; in general, in the northern hemisphere, the further north you go, the higher the risk.[6] The incidence of fractures varies greatly by country, but on average, some 50% of females aged 50 and older are at risk of fractures.[6] In 2010, it was estimated that 53.2% of females and 20.7% of males aged 50 and older in the UK would sustain a fracture before the end of their lives.[7] In 2010, an estimated 43.4 million adults aged 50 and older in the US suffered from osteopenia and 10.2 from osteoporosis (at the femoral neck or lumbar spine).[8]

Rate of osteoporosis of the femoral neck or lumbar spine in the US in 2010 (%)

AGE	50s	60s	70s	80s
FEMALES	6.8	12.3	25.7	34.9
MALES	3.4	3.3	5	10.9

Reference: Wright et al. *J Bone Miner Res.* 2014.[8]

Osteo*b*lasts and osteo*c*lasts are large cells on the bone surface. *Osteoblasts* synthesize and mineralize bone, whereas *osteoclasts* break down bone, causing minerals to be reabsorbed into the bloodstream.

If osteoclasts are too active or numerous, BMD decreases, leading to osteoporosis. Conversely, if osteoclasts are *not* numerous or active enough, BMD increases, leading to the rare, inherited condition called osteo*petrosis* (literally, "*stone* bone"). You might think that osteopetrosis makes bone more resilient, but no: osteoporosis[6] and osteopetrosis[9] both increase the risk of fractures.[10][11]

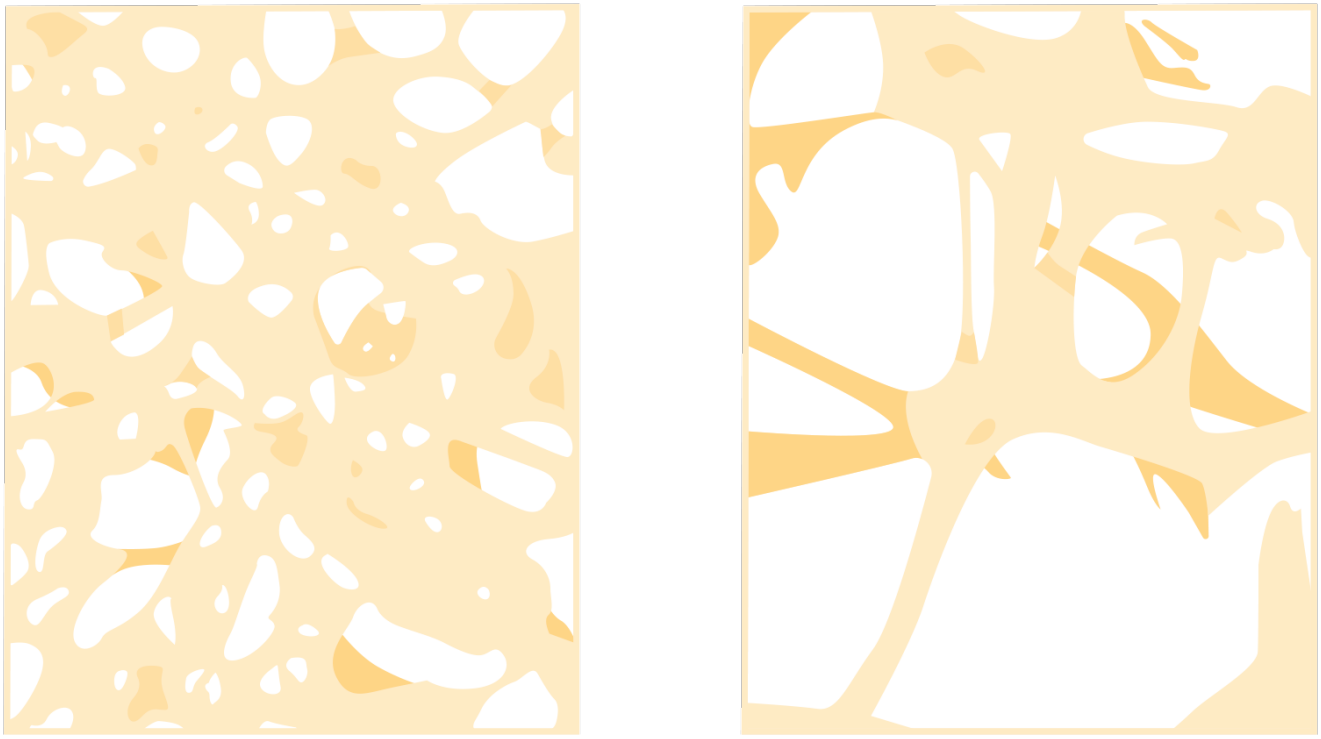
Interestingly, osteoclast activity is increased by inflammatory signaling. This may be why smoking, heavy alcohol consumption, and inflammation-linked diseases (such as diabetes and rheumatoid arthritis) are risk factors for osteoporosis, especially in older people.[12][13][14][15]

Conversely, estrogen decreases osteoclast activity while increasing the number and activity of osteoblasts. This explains why, after menopause, when estrogen levels decline significantly, the rate of osteoporosis becomes so much worse in females than males.[16]

The interrelation of genetics, age, sex, exercise, nutrition, supplementation, and other factors (some of which are still unknown to us) makes bone health a complex topic. On the bright side, it also makes supplement synergy possible, as some supplements can serve as building blocks (protein, calcium, magnesium) and some play supporting roles: vitamin D helps your intestines absorb calcium, whereas vitamin K helps shuttle calcium from the bloodstream to the bones, thus improving bone health as well as

cardiovascular health.

Architecture of normal vs osteoporotic bone



Normal bone

Osteoporotic bone

How is bone health measured?

Fractures

The main aspect of healthy bones is that they don't easily break. To measure bone health, the gold standard in research is to measure the number and severity of fractures.

This method, however, requires following a lot of people for a fairly long time — until enough fractures have happened and we have good reason to suspect that the differences between groups aren't due to random chance. For that reason, in bone-health research, measuring fractures is nowhere near as common as measuring BMD, and some studies that measure fractures aren't very accurate.

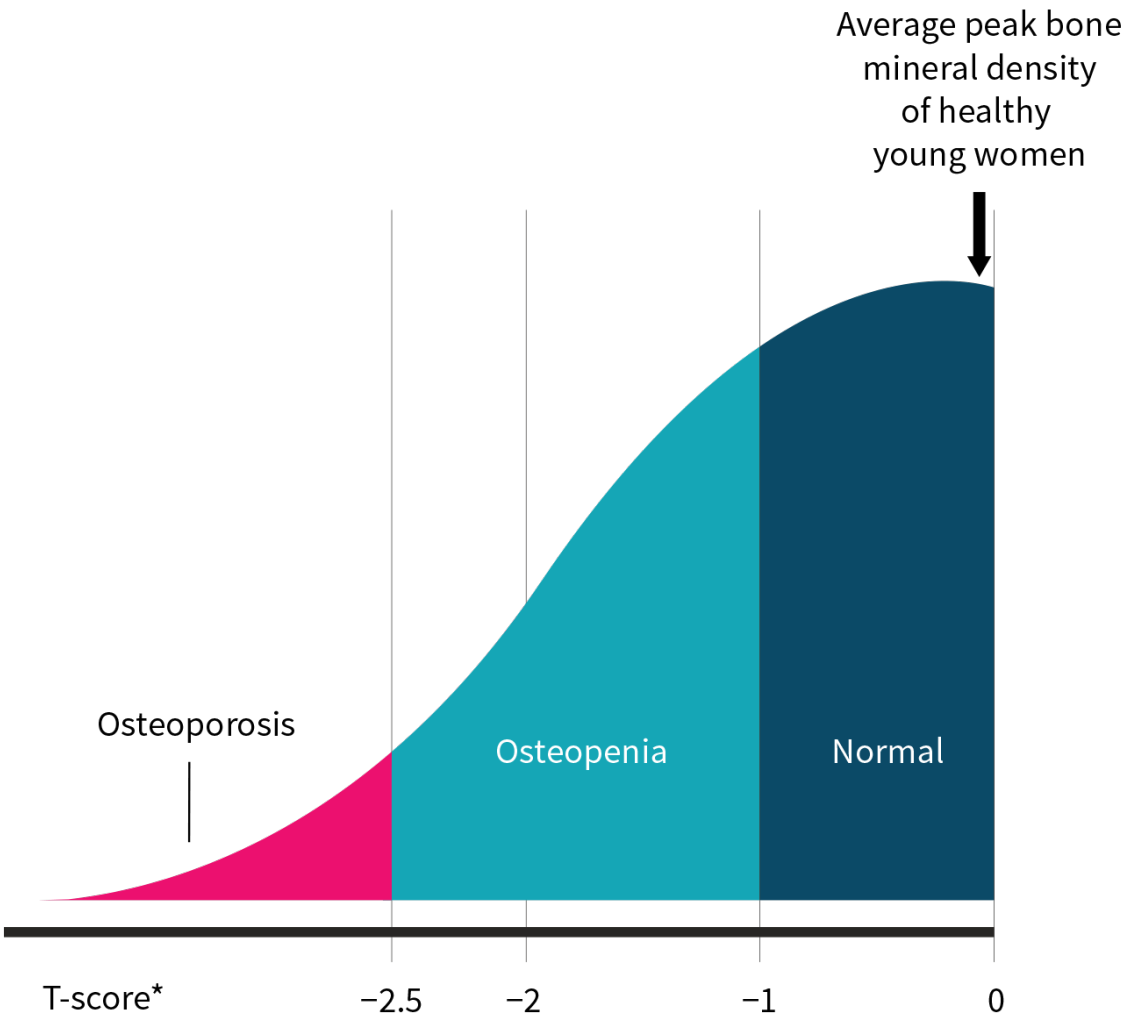
In people with osteoporosis, fractures are most common in hip bones (particularly the femoral neck), followed by the spine, wrists, and pelvis.[17]

Bone mineral density (BMD)

The most common way of measuring bone health is to measure BMD, using *dual-energy X-ray absorptiometry* (DXA or DEXA). During a DXA scan, you lie down on a bed while a robotic arm moves up and down the length of your body, emitting very low-level X-rays and measuring how many get absorbed. You then get a T-score, which is the number of standard deviations your BMD is from the peak BMD of healthy young people.[18]

- If your T-score is at least −1.0, your BMD is normal.
- If your T-score is under −1.0 but above −2.5, you have osteopenia.
- If your T-score is under −2.5, you have osteoporosis.

Osteoporosis and osteopenia (based on T-score)

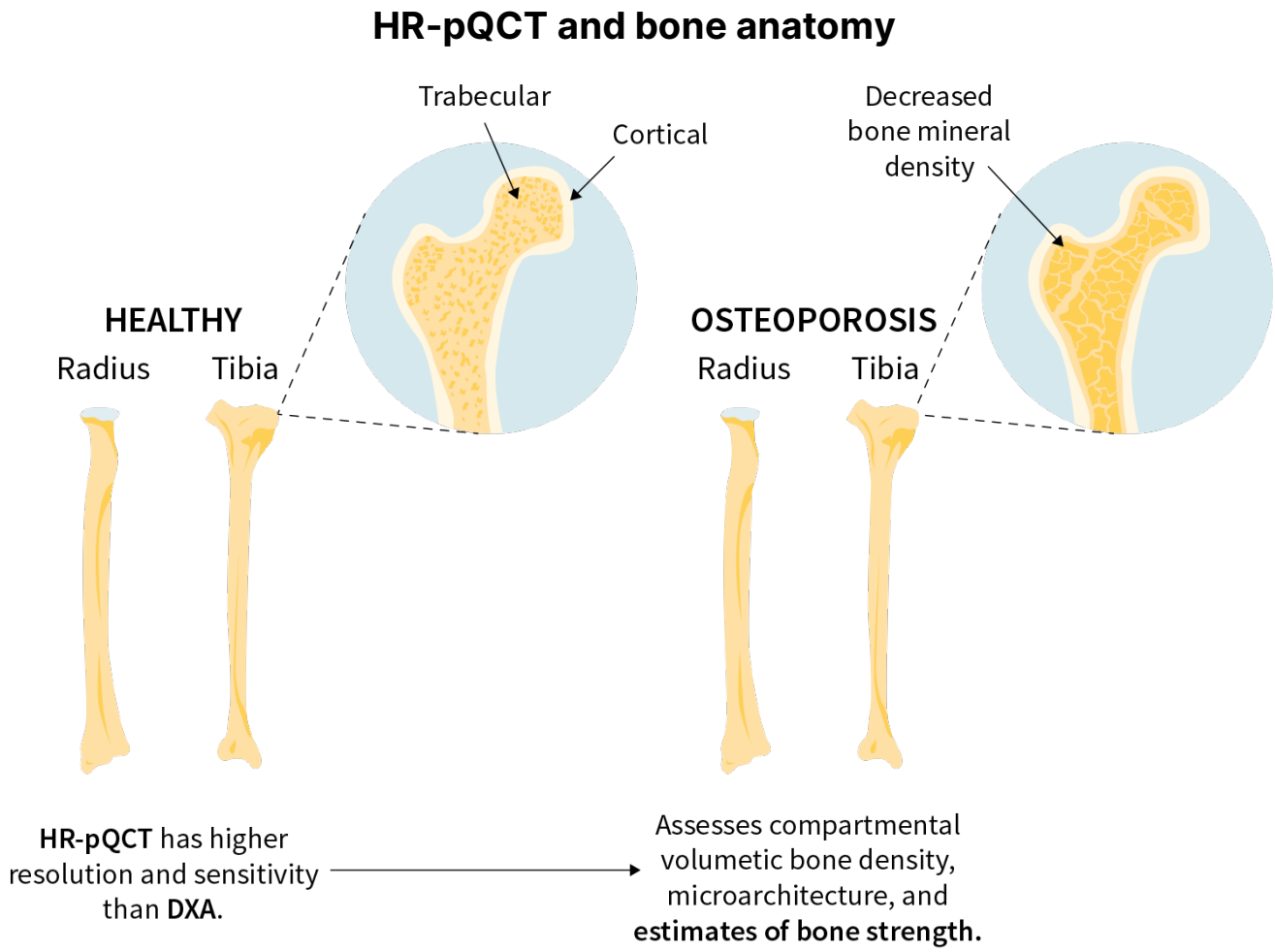


** Your T-score is the number of standard deviations your BMD is from the peak BMD of healthy young people.*

Except in people with osteopetrosis, BMD is inversely associated with fractures.[19] T-scores are oftentimes combined with known risk factors to predict fracture risk.[20]

Microarchitecture

As we said, bones are more complex than is commonly assumed, and BMD is only part of the "bone health" picture. A new technology called *high-resolution peripheral quantitative computed tomography* (HR-pQCT) can provide information not just about the amount of mineral in a bone but also about the morphology, architecture, and overall strength of the bone.[21][22]



Being much newer than DXA, HR-pQCT isn't anywhere as common in research, but its use is increasing.

Biomarkers of bone turnover

Since abnormalities in remodeling (aka bone turnover: the breaking down and building up of bone) are the cause of osteoporosis, it makes sense that measuring this process could provide insights into the risk of osteoporosis and fractures. And indeed, many biomarkers can be measured and interpreted as good or bad signs for remodeling and bone health — but this method isn't yet mature,[23] and mistakes have been made.

For instance, calcium in the urine is a biomarker of bone loss, and because more protein in the diet was linked to more calcium in the urine, higher protein intakes were hypothesized to increase bone loss. We now know, however, that this hypothesis was wrong.

Should you get tested?

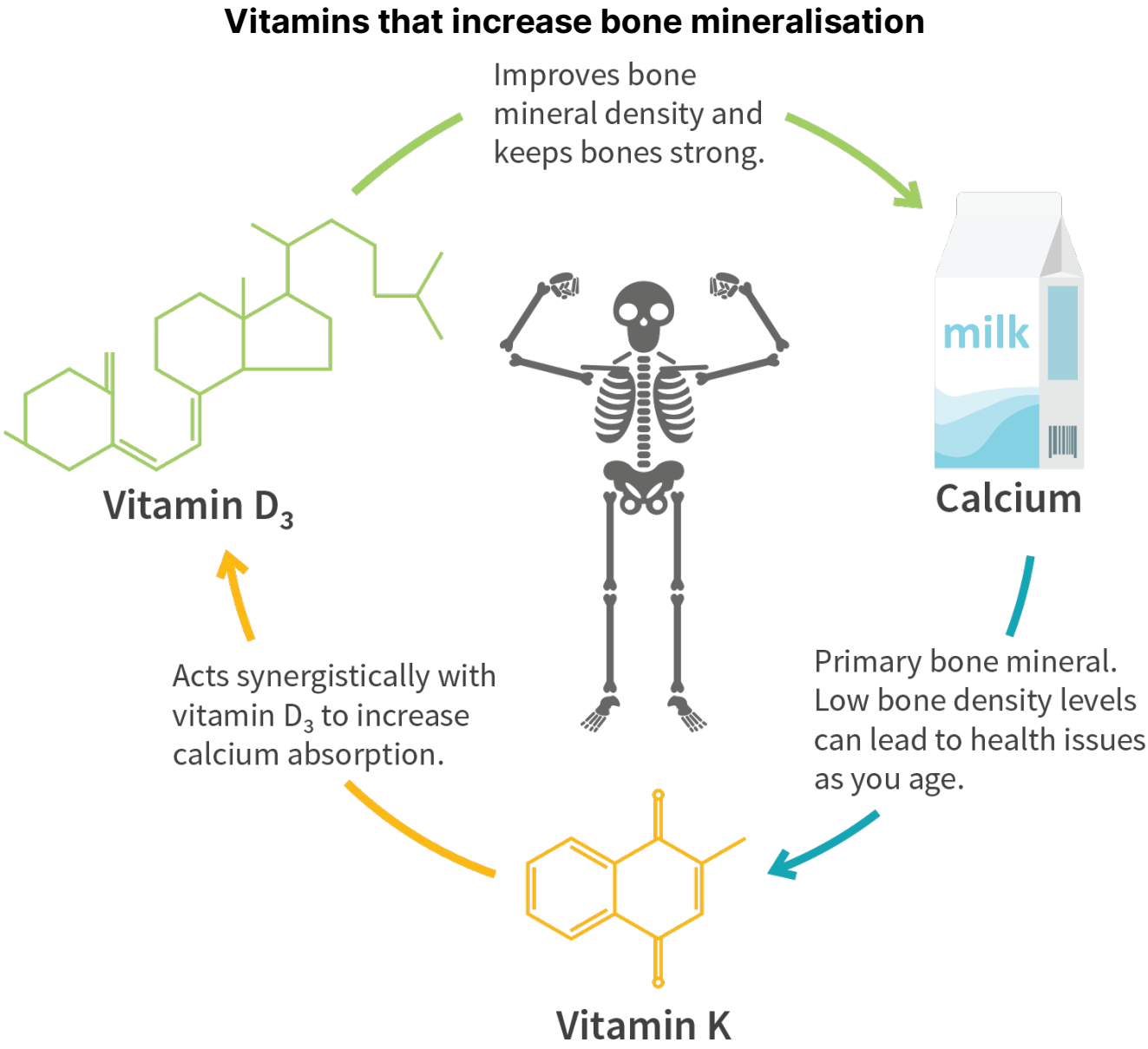
It may be a good idea to undergo a DXA scan early — for females, at least before menopause — to get a baseline measurement of your BMD. Usually, doctors prescribe a DXA scan only to older people or people they otherwise suspect of bone loss, but then the measurement can only show if you have osteopenia or osteoporosis, by comparison with the peak BMD of an *average* healthy young person; it cannot show how much bone you have lost since *you* were young. Be sure to discuss testing as well strategies for preserving bone mass with your physician.

Wyatt Brown, researcher

Combos

Core Combo

With a meal containing fat, take vitamin K (45,000 mcg of MK-4 and/or 200 mcg of MK-7). Make sure you consume at least 1.4 g of protein per kilogram of body weight per day (0.64 g/lb/day) or at least 90 g/day, whichever is higher.



If your vitamin D levels (25(OH)D) are adequate or you do not know your levels, 400 IU (10 mcg) of vitamin D_3 per day may help maintain levels in the adequate range. If your 25(OH)D levels are low, 800–2,000 IU (20–50 mcg) of D_3 per day is likely to raise them to an adequate level, at which point 400–1,000 IU (20–25 mcg) per day should suffice for maintenance. In case of full-blown deficiency, a medically supervised intervention will be needed.

💡 ***Tip:*** **Try one combo alone for a few weeks**

Taking too many supplements at once may prevent you from determining which ones are truly working. Start with just one of the combos suggested here for a couple of weeks before you consider making any modification, such as adding another supplement, altering a supplements dosage, or incorporating the supplements from an additional combo.

When adding another supplement to your regimen, be methodical. For example, you may wish to take all the supplements from two combos. Select the combo that you wish to try first and take this for a couple of weeks. Then, add one supplement from the second combo and wait another week to see how it affects you. Continue this process until you've added all the supplements you wish to.

If a supplement appears in two combos you wish to combine, don't stack the doses; instead, combine the ranges. For instance, if the range is 2–4 mg in one combo and 3–6 mg in the other, your new range becomes 2–6 mg. Always start with the lower end of the range — especially in this case, since the reason why one of the ranges has a lower ceiling in one combo may be due to a synergy with another supplement in the same combo. Reading through the full supplement entry may help you decide which dose to aim for, but if you're not sure, lower is usually safer.

Specialized Combos

For people suffering from a mineral deficiency

Before you consider adding calcium or magnesium (200–350 mg) to the core supplements, track what you eat for a week. If, on average, you are getting less than 80% of your Recommended Dietary Allowance (RDA) for either mineral, supplementation becomes an option, though first you should try eating more calcium-rich and/or magnesium-rich foods.

Primary Supplements

Protein

What makes *protein* a core supplement

Calcium is the main *mineral* but not the main *component* of your bones; by volume, your bones are about 50% protein. Unsurprisingly, the effect of dietary protein on bone health has been the subject of many randomized controlled trials and prospective cohort studies.

The consensus is that higher protein intakes can help maintain bone mineral density, or at least slow its decrease, especially in the presence of enough calcium. Luckily, higher protein intakes also enhance calcium absorption in the intestines (as does vitamin D). At *worst*, the effect of high protein intakes appears to be neutral.

Can higher protein intakes *increase* bone mineral density (BMD)? In that respect, the evidence is less clear. There are plausible mechanisms through which this might occur, but running trials long enough to gather robust data will be difficult and expensive.

Any protein found in food or supplements is called dietary protein. Overall, whole foods are the healthier choice, but if your food intake does not cover your daily protein needs, you could add a supplement (preferably a powder, since the protein-to-calorie ratio of powders tends to be higher than that of other protein supplements, such as protein bars).

Whey protein and casein protein powders are both derived from milk protein (which is 20% whey and 80% casein). If you are neither lactose intolerant nor vegan, look for a whey protein concentrate that is at least 80% protein. Whey protein is cheap and very anabolic (good for building muscle). Micellar casein is more expensive but more anti-catabolic (good for preserving muscle). Since micellar casein digests slowly, it is often seen as the ideal protein to consume before sleep, though some evidence suggests that bedtime protein may not provide any additional benefit if enough protein is consumed during the day.[24]

But what if you *are* lactose intolerant or vegan? Fortunately, you can still supplement protein powders. Whey protein isolates contain very little lactose. For vegans, two popular options are soy protein, a complete protein, and a 70:30 pea:rice protein blend, which is seen as the vegan alternative to whey protein due to their similar amino acid profiles.

How to take *protein*

In the United States, the Recommended Dietary Allowance (RDA) of 0.8 grams per kilogram of body weight (0.36 g/lb) is considered the minimum amount of protein a healthy adult must consume daily to prevent muscle wasting when total caloric intake is sufficient.[25]

The current evidence suggests, however, that this amount has been underestimated. Recent studies point to 1.0–1.2 g/kg as the minimum daily intake before the body starts downregulating important non-essential processes, from immune function to muscle protein synthesis.[26][27][28] Even a reanalysis of the data used to

establish the above RDA suggests the minimum daily intake should be at least 1.0 g/kg.[29]

Most studies that observed a positive effect on bone mineral density used 1.4 g/kg/day (0.64 g/lb/day) with a minimum of 90 g/day. It is unclear if higher doses are more effective, but they are unlikely to cause harm to your bones.

Daily protein intake for bone health

BODY WEIGHT	BODY WEIGHT	0.36	0.45	0.54	0.64	0.77	0.91	1.00	g/lb
LB	KG	0.8	1.0	1.2	1.4	1.7	2.0	2.2	g/kg
100	45	36	45	54	63	77	91	100	g
125	57	45	57	68	80	96	113	125	g
150	68	54	68	82	95	116	136	150	g
175	79	64	79	95	111	135	159	175	g
200	91	73	91	109	127	154	181	200	g
225	102	82	102	122	153	173	204	225	g
250	113	91	113	136	158	193	227	250	g
275	125	100	125	150	175	212	249	275	g

Green = Meets or exceeds the 90 g/day and 1.4 g/kg/day protein intake threshold.

Yellow = Meets 90 g/day but not 1.4 g/kg/day protein intake threshold.

Red = Does not meet 90 g/day and/or 1.4 g/kg/day protein intake threshold.

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

> 💡 ***Tip:*** **Use our Protein Intake Calculator**
>
> Your protein needs hinge on many factors — notably your weight, health goals, and level of physical activity. Based on our research and the data you input, we can calculate your optimal daily protein intake. Click on the image below to get started!
>
> **YOUR OPTIMAL PROTEIN INTAKE: ???**

Spreading your protein intake over a few meals will generally result in greater lean mass and strength. Moreover, higher doses will not be wasted and are probably necessary when eating mixed meals that contain a variety of protein sources. You may have heard that if you eat more than 30 grams of protein in one sitting, the “excess” will pass undigested, but that’s just a myth.

After exercising, when your muscles are more sensitive to the anabolic effect of protein, take a dose in the

range of your "desirable minimal protein intake per meal" (as shown in the table above). If you've been exercising on an empty stomach, you'll be in negative protein balance, so take this dose as soon as possible. Otherwise, try to take it within a couple of hours — the exact size of your "window of opportunity" depends on how much protein you're still digesting.[31]

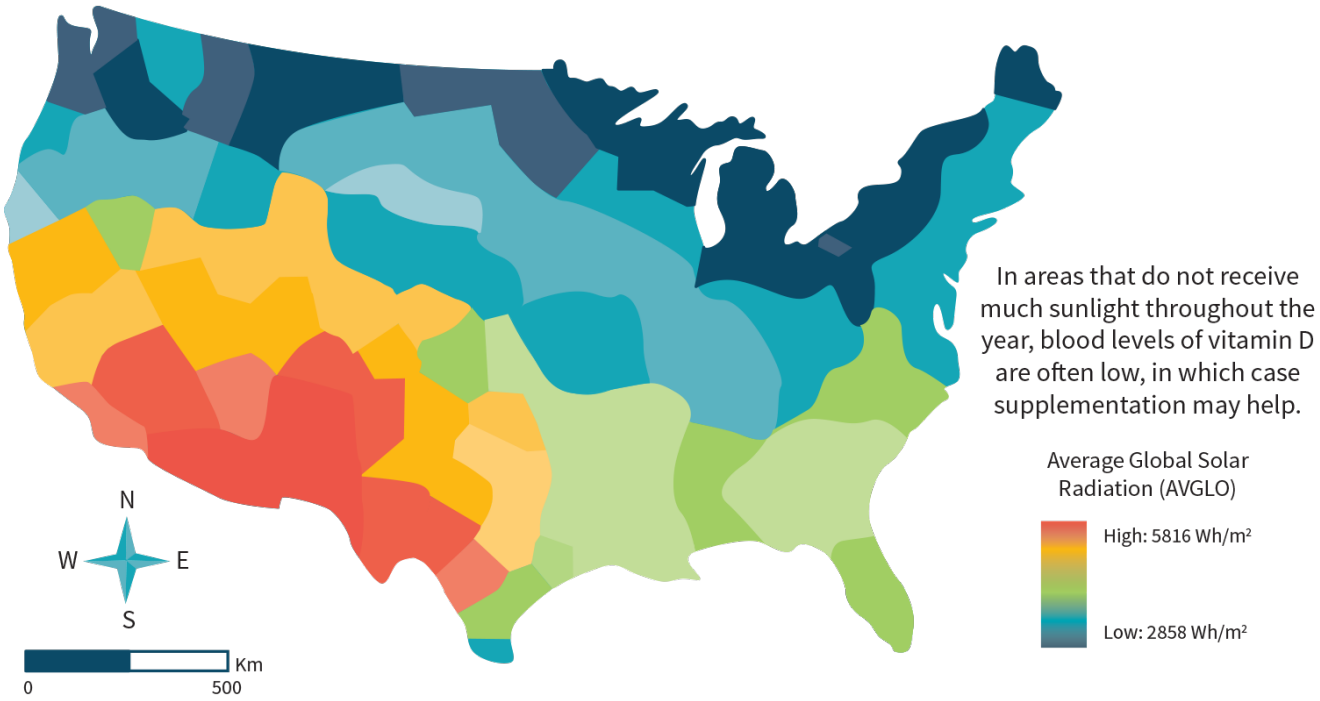
> 💡 ***Tip:*** **Why don't you recommend brands or specific products?**
>
> For two reasons:
>
> - We don't test physical products. What our researchers do — all day, every day — is analyze peer-reviewed studies on supplements and nutrition.
> - We go to great lengths to protect our integrity. As you've probably noticed, we don't sell supplements, or even show ads from supplement companies, even though either option would generate a lot more money than our Supplement Guides ever will — and for a lot less work, too.
>
> If we recommended any brands or specific products, our integrity would be called into question, so … we can't do it. That being said, in the interest of keeping you safe, we drew a short list of steps you should take if a product has caught your interest.

Vitamin D

What makes *vitamin D* a core supplement

Suboptimal levels of vitamin D are common, especially in people whose skin exposure to sunlight (meaning without protection from clothes or sunscreen) is limited. Moreover, the darker your skin, the longer you need to expose yourself to sunlight to synthesize enough vitamin D, which is why people with darker skin are at an increased risk of suboptimal vitamin D levels.[32]

Average yearly sunlight exposure in the US

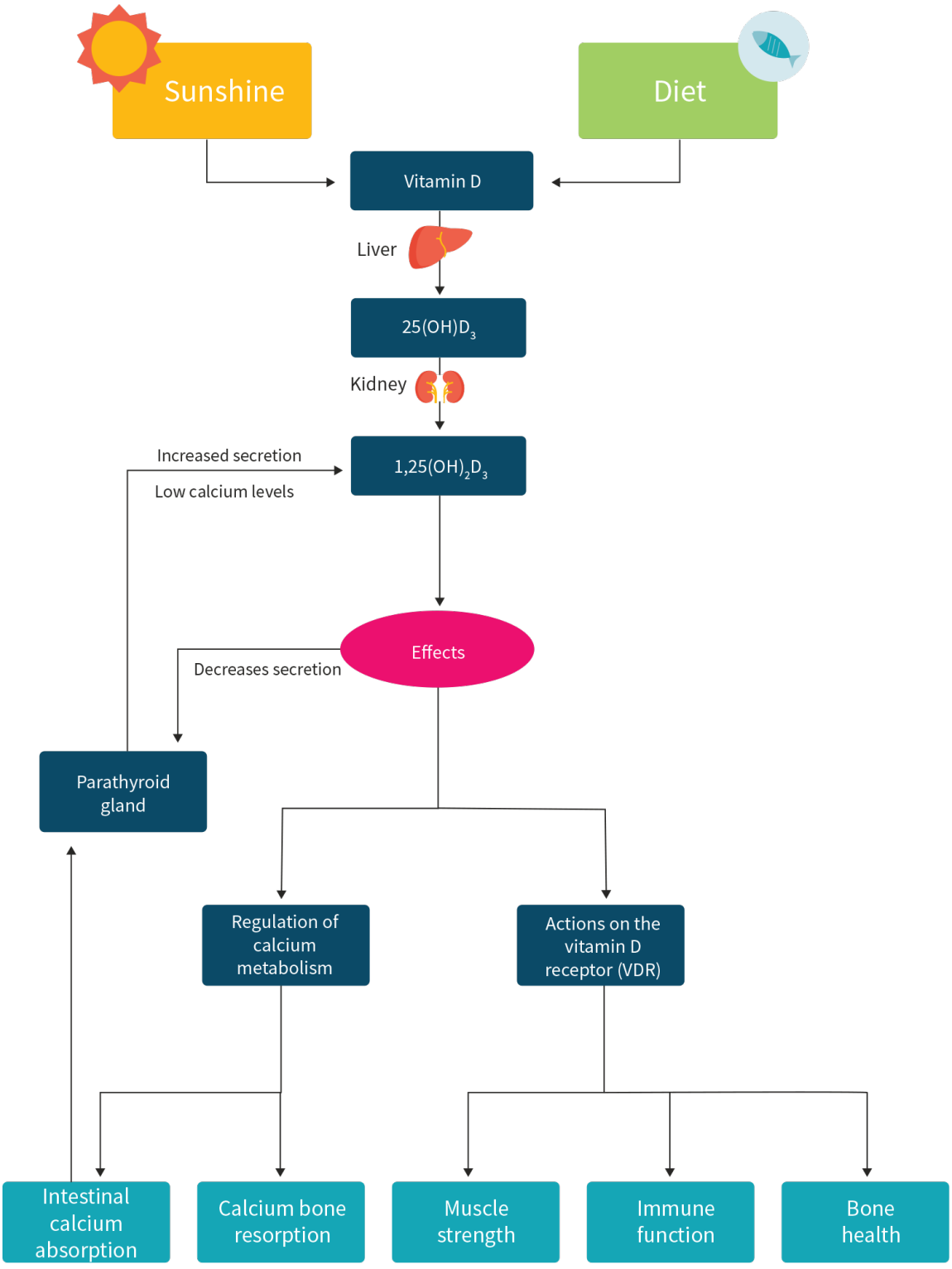


Adapted from Tatalovich et al. *CaGIS*. 2006. DOI:10.1559/152304006779077318

The situation doesn't improve as you age. The older you get, the less efficient your body becomes at synthesizing vitamin D, the less time you're likely to spend outside, the less vitamin D you're likely to get through food, and the more likely you become to carry extra fat (belly fat has been linked to vitamin D deficiency).[33][34]

By helping your intestines absorb calcium, vitamin D can strengthen your bones; it can also, alas, facilitate the calcification of your arteries, but this effect can be counteracted by vitamin K. Vitamins D and K can increase synergistically the rate at which minerals (notably calcium and magnesium) accumulate in bones, which is another reason to take them together.

Role of vitamin D in bone health



Adapted from Laird et al. *Nutrients*. 2010.[35]

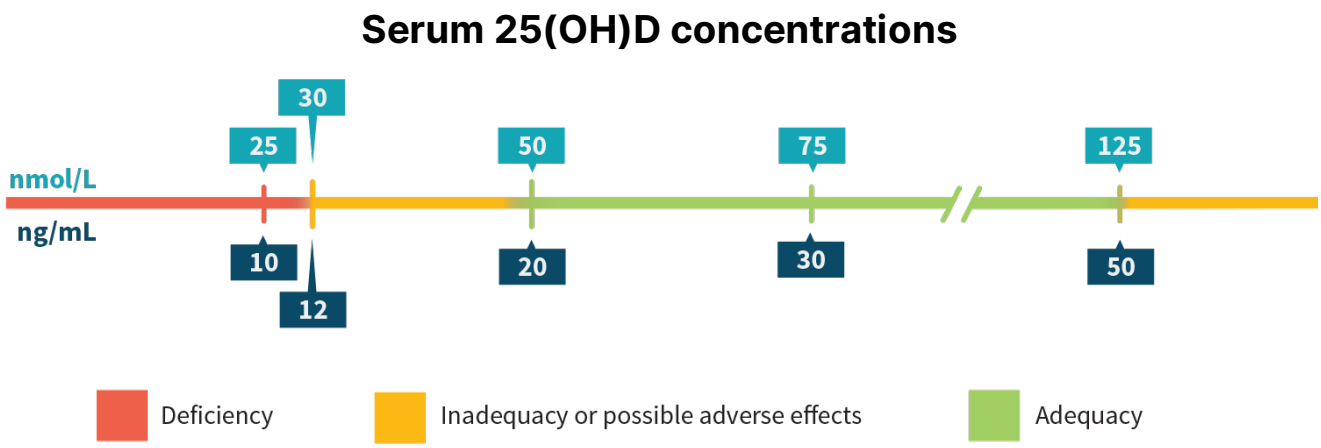
Vitamin D is commonly available in two forms. *Ergo*calciferol (D_2) is available in a handful of plants and fungi, whose D_2 content can be increased dramatically when exposed to *ultraviolet B* (UVB) radiation,[36][37] whereas *chole*calciferol (D_3) is synthesized from the cholesterol in your skin when exposed to the sun's UVB rays.[38][39][40]

D_3 is both more stable and more bioavailable than vitamin D_2. As a supplement, it is usually derived from lanolin, a waxy substance secreted by the skin glands of woolly animals, but a vegan-friendly option (a lichen extract) is also available.

Before turning to supplementation, you should try incorporating some foods rich in vitamin D into your diet. Very few foods, alas, contain appreciable amounts of naturally occurring vitamin D, with fatty fish being a notable exception (cod liver oil, in particular). For that reason, milk is commonly fortified with either D_2 or, more recently, D_3. Why milk? Because milk is rich in calcium, which vitamin D helps your intestines absorb. For the same reason, yogurt, cheese, and breakfast cereal are also commonly fortified with D_2 or D_3. Other commonly fortified foods include bread, margarine, and fruit juice (orange juice, in particular). As usual, which foods get fortified, if any, vary by country, based on local laws and policies.

How to take *vitamin D*

First, you should determine if you really need to supplement vitamin D by checking your current vitamin D levels (i.e., your blood levels of 25(OH)D).



Reference: Institute of Medicine. Overview of Vitamin D (chapter 3 in *Dietary Reference Intakes for Calcium and Vitamin D*. The National Academies Press. 2011. DOI:10.17226/13050)

In case of *deficiency*, a medically supervised intervention can be needed. *Do not begin any intervention without discussing it with your physician.* Common medical interventions include taking 50,000 IU (1,250 mcg) of D_2 or D_3 at least three times a week for six to eight weeks, though people with a borderline deficiency may not need as high a dose. At the end of this intervention, if vitamin D levels are above 30 nmol/L (12 ng/mL), a daily dose of 400–1,000 IU (20–25 mcg) is commonly used for maintenance.

In case of *inadequacy*, 800–2,000 IU (20–50 mcg) of D_3 per day is likely to raise vitamin D levels to an adequate level, at which point 400–1,000 IU (20–25 mcg) per day should suffice for maintenance.

In case of *adequate* vitamin D levels, a vitamin D supplement may not be necessary, especially if you spend a lot of time outside and live near the equator. However, taking 400–600 IU (10–15 mcg) of D_3 per day may help maintain vitamin D levels in the adequate range, particularly during the colder, darker months, when you are least likely to synthesize enough vitamin D from sun exposure.

In case of *high* vitamin D levels (which can cause adverse effects), seek the help of a medical professional. Of course, stop taking any supplement containing vitamin D, unless otherwise instructed by a medical professional.

If you do not know your vitamin D levels and cannot get them tested but are still intent on taking a vitamin D supplement, it would be prudent to limit yourself to a maintenance dose of 400 IU (10 mcg) of D_3 per day. Alternatively, you could track your food intake for a week to determine your average vitamin D intake, then select a complementary dose to reach your RDA.

Recommended Dietary Allowance (RDAs) for vitamin D (IU*)

AGE	MALE	FEMALE	PREGNANT	LACTATING
0–12 months	400**	400**	—	—
1–13 years	600	600	—	—
14–18 years	600	600	600	600
19–50 years	600	600	600	600
51–70 years	600	600	—	—
>70 years	800	800	—	—

* 40 IU = 1 mcg | ** Adequate intake (AI)

Reference: Institute of Medicine. Dietary Reference Intakes for Adequacy: Calcium and Vitamin D (chapter 5 in *Dietary Reference Intakes for Calcium and Vitamin D*. The National Academies Press. 2011. DOI:10.17226/13050)

If the maintenance doses in the paragraphs above prove insufficient, as could be the case notably if your BMI is over 30[41] or if you suffer from poor vitamin D absorption or processing (due to a problem with your kidneys, liver, or gastrointestinal tract), you could switch to 1,000–2,000 IU (25–50 mcg) of D_3 per day.

Vitamin D being fat-soluble, it is better absorbed when taken with a fat-containing food or supplement (e.g., fish oil).

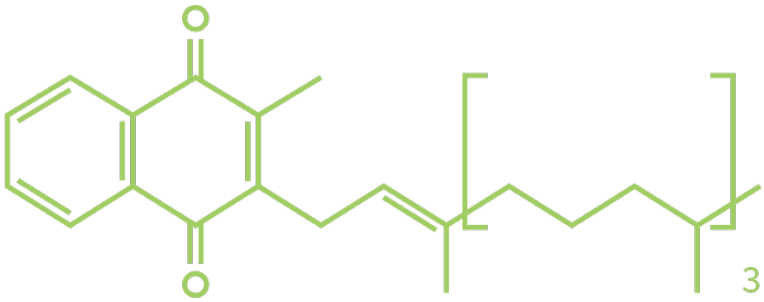
Vitamin K

What makes *vitamin K* a core supplement

Vitamin K is an umbrella term for a variety of molecules with similar but distinct structures.

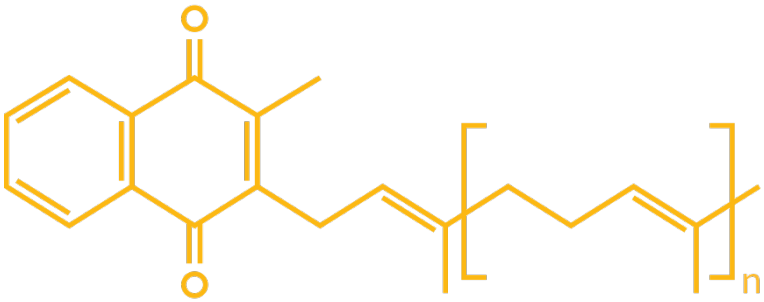
- K_1 (phylloquinone) is a molecule found in plants.
- K_2 (menaquinone) is a group of molecules.
    - K_2 MK-4 is mostly found in animal products.
    - K_2 MK-7 is mostly found in fermented foods.

The K vitamins

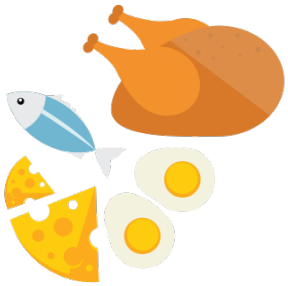


Phylloquinone (Vitamin K_1)

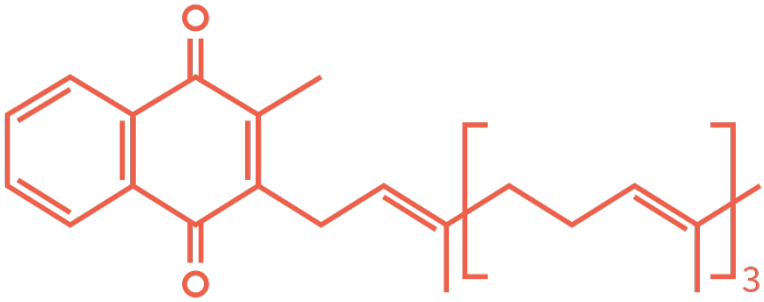
Found in plants



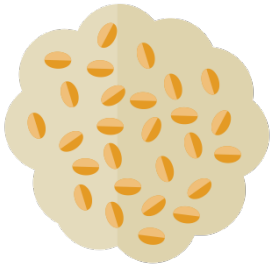
Menaquinone-4 (Vitamin K_2 MK-4)



Found in animal products



Menaquinone-7 (Vitamin K_2 MK-7)



Found in fermented foods

The accumulation of calcium in body tissues, notably bone, is called calcification. For bones, calcification is a good thing, but it can harden soft tissues, such as blood vessels — including coronary arteries, which supply oxygenated blood to the heart.

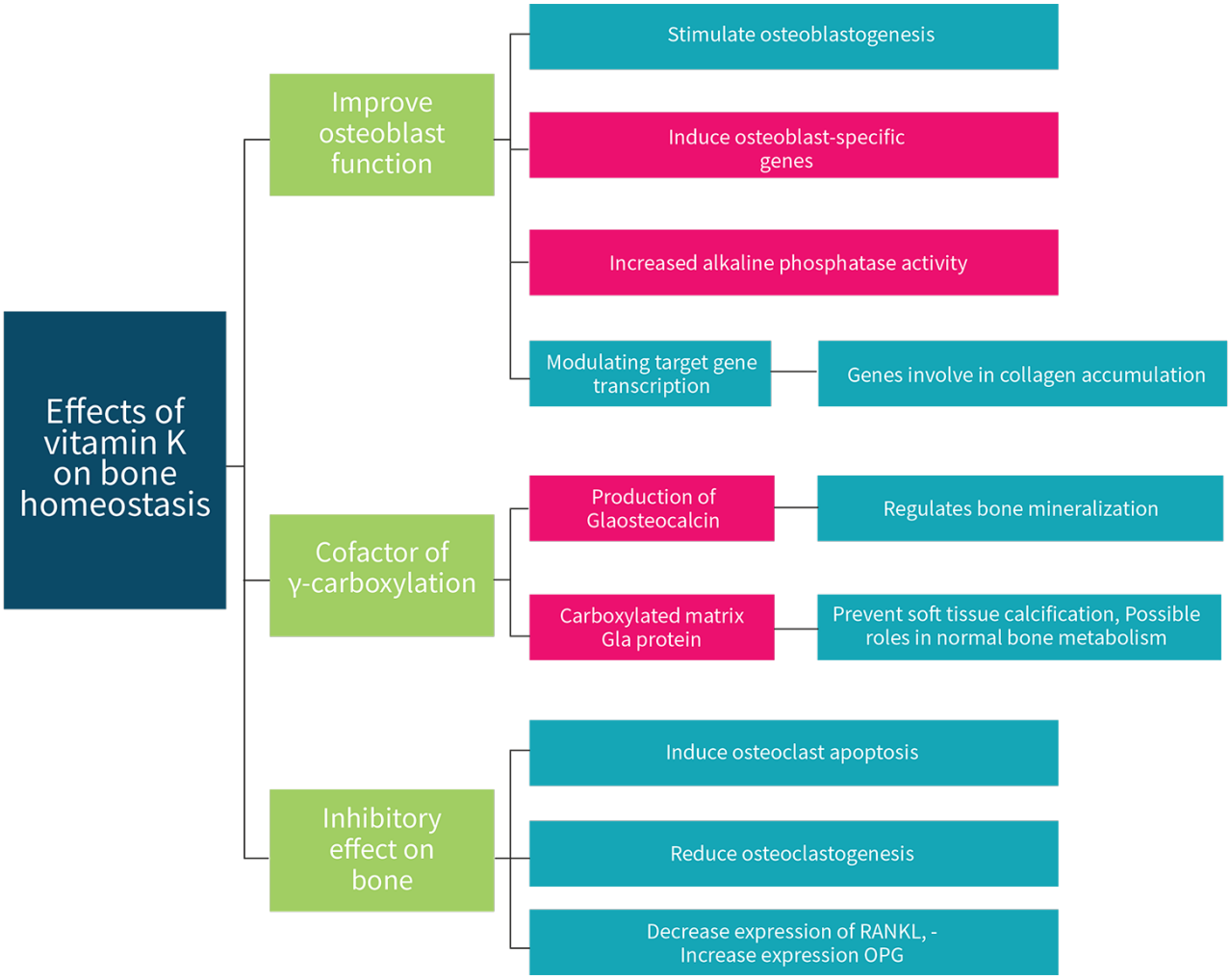
In all its forms, vitamin K is fat-soluble and supports blood clotting and calcium regulation; it helps ensure that more calcium gets deposited in bone and less in soft tissues. Hence, vitamin K can both strengthen bones and reduce cardiovascular disease risk. However, there are notable differences between the different forms.

After being absorbed by your intestines, K_1 is taken up by your liver (where vitamin K is used to make clotting proteins, which are then released into your blood) at a higher rate than MK-4, whereas MK-4 is taken up by soft tissues at a higher rate than K_1. This should make K_1 better at supporting coagulation (i.e., blood clotting), and MK-4 better at preventing calcium from being deposited in the arteries. Some K_1 converts indirectly to MK-4, but how much is unknown.

When it comes to bones, a few MK-4 trials looked at fracture risk and reported a decrease. One K_1 trial looked at fracture risk and reported a decrease, but without a concomitant increase in bone mineral

density, so more research is needed to clarify the issue. Some MK-7 trials found an improvement in bone mineral density, but none have looked at fracture risk.

Role of vitamin K in bone health



The vitamins K and D increase separately and synergistically the rate at which minerals (notably calcium and magnesium) accumulate in bones. MK-4 and MK-7 appear to do so more reliably than K_1.

Vitamin K is usually safe. Supplementation might cause some nausea or stomach upset, but those effects are uncommon.

K_1 is present mostly in leafy green vegetables, many of which are cruciferous. If you plan to increase your K_1 intake through plant foods, be aware that cruciferous vegetables contain goitrogens and thus can reduce thyroid hormone production. If you tend to eat a lot of cruciferous vegetables, such as kale, make sure to also get enough iodine — through iodine-rich foods (such as cod, shrimp, milk, yogurt, or cottage cheese), iodine-fortified foods (such as iodized salt), or supplements (75–150 mcg/day).

Micrograms of vitamin K per 100 grams of food

FOODS	K~1~	K~2~ MK-4	K~2~ MK-7
Collards	440	0	0
Spinach	360–380	0	0
Broccoli	113–180	0	0
Cabbage	98–145	0	0

FOODS	K~1~	K~2~ MK-4	K~2~ MK-7
Natto	Not measured	0	939–998
Chicken	0–4.5	8.5–60	0
Pork	0–3.4	2.1–6	0.5–0.12
Beef	0.7–2.4	1.1–15	0–0.12
Beef liver	2.7	0.82	18.2
Egg	0.3–12	7–9	Not measured
Egg yolk	Not measured	15.5–64	0
Butter	7	15–21	0
Blue cheese	Not measured	Not measured	2.5–22
Cheddar	2.1	10.2	0–2.3

References: Fu et al. *J Agric Food Chem*. 2016.[42] ● Manoury et al. *J Dairy Sci*. 2013.[43] ● Booth. *Food Nutr Res*. 2012.[44] ● Kamao et al. *J Nutr Sci Vitaminol (Tokyo)*. 2007.[45] ● Elder et al. *J Agric Food Chem*. 2006.[46] ● Schurgers and Vermeer. *Haemostasis*. 2000.[47] ● Booth et al. *J Am Diet Assoc*. 1996.[48] ● Shimogawara and Muto. *Arch Biochem Biophys*. 1992.[49] ● Hirauchi et al. *J Chromatogr*. 1989.[50]

How to take *vitamin K*

The doses below reflect the doses used in studies; they are much higher than the minimum amount of vitamin K you need to avoid deficiency-related issues:

Adequate Intake (AI) for vitamin K (mcg)

AGE	MALE	FEMALE	PREGNANT	LACTATING
0–6 months	2.0	2.0	—	—
7–12 months	2.5	2.5	—	—
1–3 years	30	30	—	—
4–8 years	55	55	—	—
9–13 years	60	60	—	—
14–18 years	75	75	75	75
>18 years	120	90	90	90

Reference: Institute of Medicine. Vitamin K (chapter 5 in _Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. _The National Academies Press. 2001. DOI:10.17226/10026)

As we saw, different forms of vitamin K have different metabolisms and distributions within the body, so taking more than one form may be beneficial.

Take 200 mcg (0.2 mg) of *MK-7* and/or 45,000 mcg (45 mg) of *MK-4*. MK-4 is the form best supported by the evidence, but more studies are needed to determine if smaller doses are also beneficial.

Vitamin K being fat soluble, it is better absorbed when taken with a fat-containing food or supplement (e.g.,

fish oil)

Do not supplement with vitamin K if you have been prescribed blood thinners (i.e., anticoagulants) that work by hindering vitamin K's blood-clotting properties, such as warfarin (Coumadin) or acenocoumarol (Sintrom). If you have been prescribed a diet low in vitamin K, you may need to strictly track your vitamin K intake to ensure it stays consistent.

Secondary Supplements

Calcium

What makes *calcium* a primary option

Like magnesium, calcium is one of the major mineral components of bone. A deficiency can lead to osteopenia and osteoporosis, two diseases characterized by dangerously low bone density.

Getting more than your *Recommended Dietary Allowance* (RDA) is not necessarily beneficial, however, and getting more than your *Tolerable Upper Intake Level* (UL) can be downright *dangerous* since it can lead to hypercalcemia (especially in people with cancer, hypothyroidism, or impaired kidney function). This disease, characterized by overly high calcium levels in the blood, can manifest as all kinds of health issues, from coronary artery calcification to mood disorders.

Recommended Dietary Allowance (RDAs) for calcium

AGE	MALE	FEMALE	PREGNANT	LACTATING
0–6 months	200*	200*	—	—
7–12 months	260*	260*	—	—
1–3 years	700	700	—	—
4–8 years	1,000	1,000	—	—
9–13 years	1,300	1,300	—	—
14–18 years	1,300	1,300	1,300	1,300
19–30 years	1,000	1,000	1,000	1,000
31–50 years	1,000	1,000	1,000	1,000
51–70 years	1,000	1,200	—	—
>70 years	1,200	1,200	—	—

* Adequate intake (AI)

Reference: Institute of Medicine. Dietary Reference Intakes for Adequacy: Calcium and Vitamin D (chapter 5 in *Dietary Reference Intakes for Calcium and Vitamin D*. The National Academies Press. 2011. DOI:10.17226/13050)

Hypercalcemia is more often caused by supplements than by a calcium-rich diet. If your diet is poor in calcium, look into dark leafy greens (also rich in vitamin K_1) or dairies. Milk-based protein powders (whey protein or casein protein) contain calcium, too, though less than milk itself — which often has the added advantage of being fortified with vitamin D to enhance calcium absorption. There's about 470 mg of calcium per 100 g of whey protein concentrate and about 880 mg per 100 g of micellar casein, compared to about 910 mg per 100 g of whole-milk powder.

Calcium may interact with several pharmaceuticals, notably diuretics (which increase calcium levels). It may increase the effects of digoxin. It may impair the absorption of bisphosphonates, levothyroxine, and calcium channel blockers. If you take any medication, talk to your doctor before you consider

supplementing calcium.

Finally, the size of many calcium pills is also a potential issue. With iron and potassium, calcium is one of three micronutrients responsible for almost a third of supplement-related emergency-room visits of adults aged 65 or more, and in the case of calcium, swallowing issues (choking or pill-induced globus or dysphagia) are most often to blame.

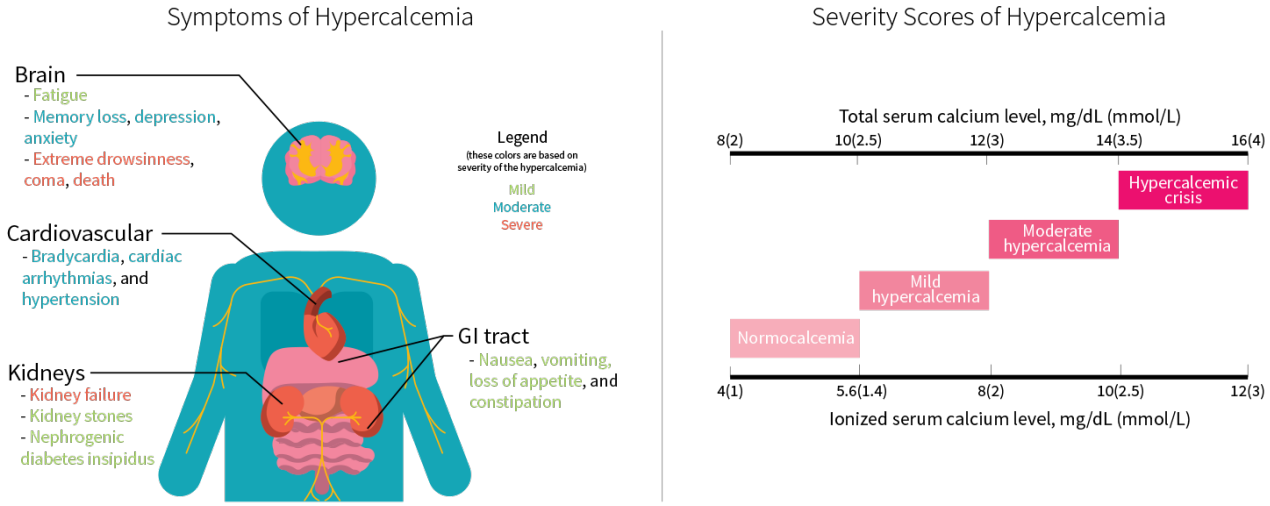
How to take *calcium*

To fight bone loss, the first supplements to consider are the vitamins D and K, which increase separately and synergistically the rate at which minerals accumulate in bones. *Supplementing with calcium should only be considered after a dietary evaluation.* Track what you eat for a week and compare the calcium content of your diet with the RDA for your gender and age. If, on average, you are getting less than 80% of your RDA, supplementation becomes a possibility, but you should first consider tweaking your diet.

Avoid taking calcium, iron, magnesium, and zinc at the same time in combinations of 800+ mg, since high amounts of these minerals will compete for absorption. Calcium may also impair the absorption of antibiotics, notably those in the tetracycline class (e.g., doxycycline) and quinolone class (e.g., ciprofloxacin), so take calcium and antibiotics at least six hours apart.

Excess calcium may cause constipation. Should it happen, lower your dose and/or take it with vitamin K (which can also reduce the risk of artery calcification) and/or vitamin D.

Symptoms and severity scores of hypercalcemia



Magnesium

What makes *magnesium* a primary option

Like calcium, magnesium is one of the major mineral components of bone. Hypomagnesemia (subnormal magnesium levels in the blood) are associated with bone loss; conversely, high levels are associated with greater bone mass in old age.

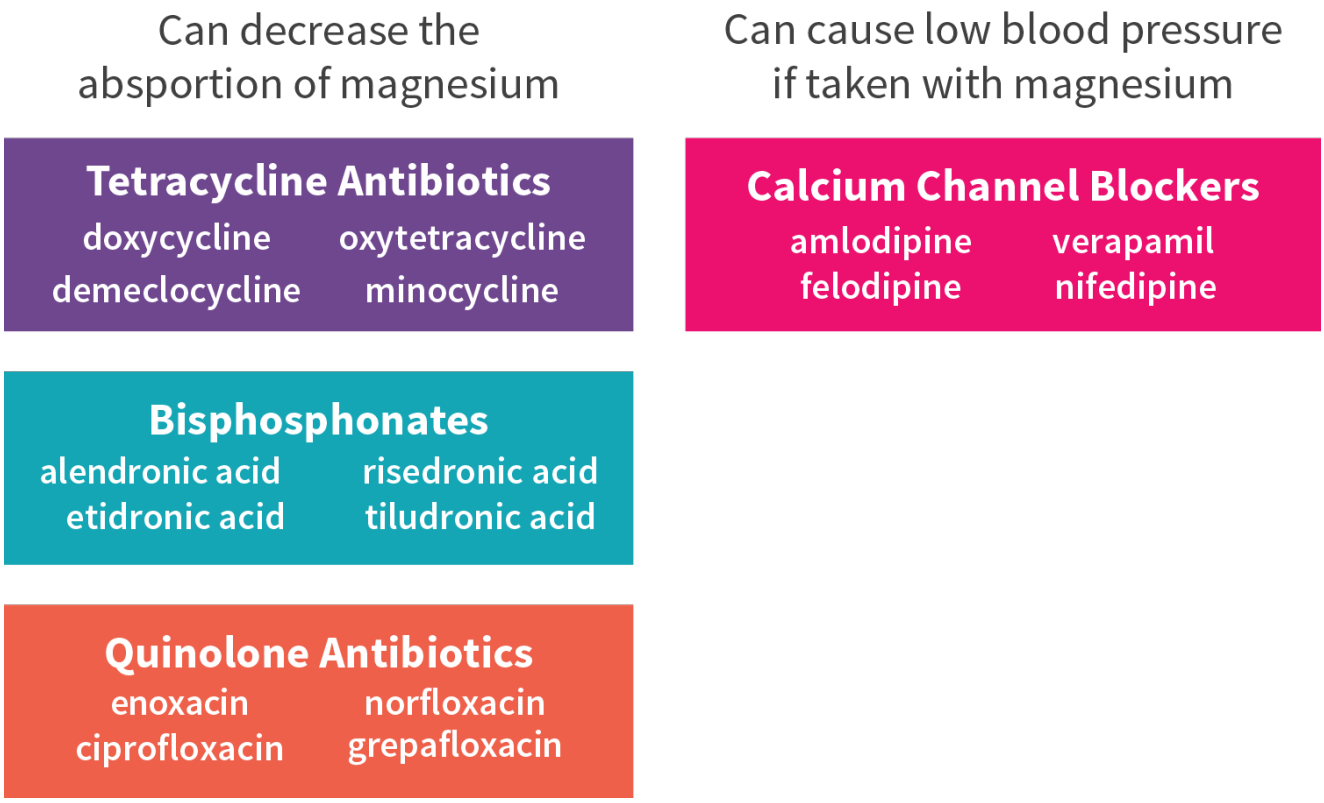
Who is more likely to have low magnesium levels?

- *Older people*, because they tend to have relatively low magnesium intakes[51] and may absorb less during digestion.[52]
- *People who sweat a lot*, because magnesium is lost through sweat. Athletes participating in sports requiring weight control may be especially vulnerable.
- *Type 2 diabetics.* It has been estimated that, over all adult ages in developed countries, hypomagnesemia affects less than 15% of healthy people but up to 50% of people with type 2 diabetes.[53]

In addition, certain diuretics, proton pump inhibitors, and the antifungal medication amphotericin B can cause significant magnesium loss.[54][55][56] However, potassium-sparing diuretics (e.g., amiloride, eplerenone/Inspra, spironolactone/Aldactone, triamterene/Dyrenium) may not.[54]

High doses of supplemental magnesium can cause diarrhea and general intestinal discomfort;[57] fortunately, magnesium obtained via food has not been seen to cause such problems.[57]

Drug interactions with magnesium



How to take *magnesium*

There is no single agreed-on, satisfactory method for assessing magnesium status.[58] To get a better sense of your typical magnesium intake, you should track what you eat for a week. If, on average, you are getting less than 80% of your RDA, supplementation becomes a possibility, but you should first consider tweaking your diet.

Recommended Dietary Allowance (RDA) for magnesium (mg)

AGE	MALE	FEMALE	PREGNANT	LACTATING
0–6 months	30*	30*	—	—
7–12 months	75*	75*	—	—
1–3 years	80	80	—	—
4–8 years	130	130	—	—

AGE	MALE	FEMALE	PREGNANT	LACTATING
9–13 years	240	240	—	—
14–18 years	410	360	400	360
19–30 years	400	310	350	310
31–50 years	420	320	360	320
>50 years	420	320	—	—

* Adequate intake (AI)

Reference: Institute of Medicine. Magnesium (chapter 6 of *Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride*. The National Academies Press. 1997. DOI:10.17226/5776)

A diet comprising magnesium-rich foods (such as those seen in the figure above) renders supplementation unnecessary, at least for the purpose of preventing anxiety. In case of magnesium deficiency, adding or increasing dietary sources of magnesium should be the first option, but in the absence of practical ways of doing so, supplementation can be used.

If you cannot get enough magnesium through foods, start supplementing with *200 mg* of magnesium once a day. Capsules with 400 mg are common, but keep in mind that the Tolerable Upper Intake Level (UL) for supplemental magnesium for adults is 350 mg. The higher the dose, the higher the risk of gastrointestinal issues.

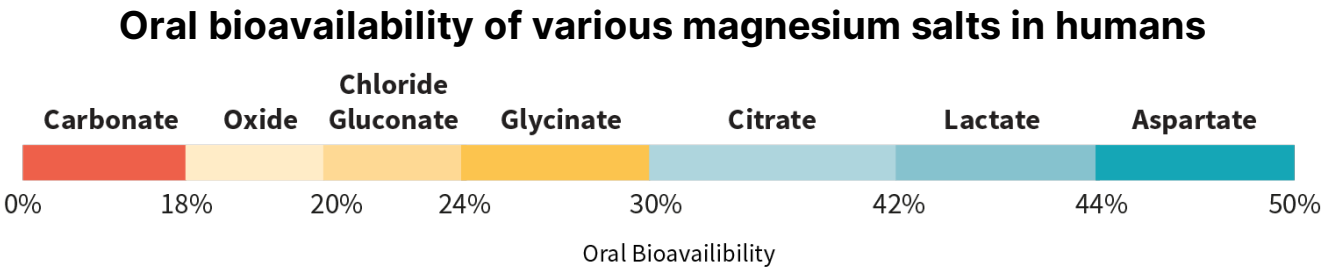
If your magnesium intake is very low, take up to *350 mg* of magnesium once a day.

Tolerable Upper Intake Level (UL) for supplemental magnesium (mg)

AGE	MALE	FEMALE	PREGNANT	LACTATING
0–12 months	—	—	—	—
1–3 years	65	65	—	—
4–8 years	110	110	—	—
>8 years	350	350	350	350

Reference: Institute of Medicine. Magnesium (chapter 6 in *Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride*. The National Academies Press. 1997. DOI:10.17226/5776)

Commonly supplemented forms include citrate, gluconate, and glycinate. To increase absorption, magnesium gluconate should be taken with food; other forms can be taken on an empty stomach. *Avoid magnesium oxide.* It has poor bioavailability (rats absorbed only 15% in one study;[59] humans, only 4% in another[60]) and is especially liable to cause intestinal discomfort and diarrhea.[60][61][62]



Reference: Ranade et al. *Am J Ther*. 2001.[63]

Since calcium, iron, magnesium, and zinc compete for absorption, it is better to take them at least one hour apart from each other. Magnesium may impair the absorption of other pharmaceuticals, notably bisphosphonates and antibiotics, especially those in the tetracycline class (e.g., doxycycline) or quinolone class (e.g., ciprofloxacin).[64] Take magnesium at least 6 hours apart from bisphosphonates or antibiotics.

Because magnesium might have a sedative effect and improve sleep quality, it is best to take it before bed.

Promising Supplements

Of the supplements we have reviewed, none currently fit the above description.

Unproven Supplements

Cissus Quadrangularis

What makes *Cissus quadrangularis* an unproven supplement

In Ayurvedic medicine, *Cissus quadrangularis* is used to relieve joint pain and promote bone healing. It has modest anti-inflammatory properties and may induce growth factors in connective tissues, including bone, but this latter effect is supported mostly by animal and *in vitro* evidence; convincing human evidence is still lacking.

Inadvisable Supplements

Coral Calcium

What makes *coral calcium* an inadvisable supplement

Aside from calcium carbonate, coral calcium contains magnesium and other trace minerals, but only in very small amounts. Coral calcium is more expensive than calcium carbonate on its own, yet it has not proven to be more effective, and contamination by lead and mercury is a concern.

Coral calcium is sourced from fossilized coral, but living corals can also be damaged during the dredging and mining of coral reefs. For your health as well as the planet's, you would do well to shun coral calcium supplements.

FAQ

Q. What about the supplements not covered in this guide?

Our guides are regularly updated, often with new supplements. We prioritize assessing (and reassessing) the most popular of them and those most likely to work. However, should there be a specific supplement you'd like to see covered in a future update, please let us know by filling out this survey.

Q. Can I add a supplement not covered in this guide to my combo?

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

Q. Can I modify the recommended doses?

If a supplement has a recommended dose range, stay within that range. If a supplement has a precise recommended dose, stay within 10% of that dose. Taking more than recommended could be counterproductive or even dangerous. Taking less could render the supplement ineffective, yet starting with half the regular dose could be prudent — especially if you know you tend to react strongly to supplements or pharmaceuticals.

Q. At what time should I take my supplements?

The answer is provided in the "How to take" section of a supplement entry whenever the evidence permits. Too often, however, the evidence is either mixed or absent. Starting with half the regular dose can help minimize the harm a supplement may cause when taken during the day (e.g., fatigue) or in the evening (e.g., insomnia).

Q. Should I take my supplements with or without food?

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

Q. What are DRI, RDA, AI, and UL?

The Dietary Reference Intakes (DRIs) is a system of nutrition recommendations designed by the Institute of Medicine (a US institution now known as the Health and Medicine Division). RDA, AI, and UL are part of this system.

- Contrary to what the name suggests, a *Recommended Dietary Allowance* (RDA) doesn't represent an *ideal* amount; it represents the *minimum* you need in order to avoid deficiency-related health issues. More precisely, it represents an amount just large enough to meet the minimum requirements of 97.5% of healthy males and females over all ages — which implies that the RDA is too low for 2.5% of healthy people.
- The *Adequate Intake* (AI) is like the RDA, except that the number is more uncertain.
- The *Tolerable Upper Intake Level* (UL) is the maximum safe amount. More precisely, it is the maximum daily amount deemed to be safe for 97.5% of healthy males and females over all ages — which implies that the UL is too high for 2.5% of healthy people.

As a general rule, a healthy diet should include at least the RDA of each nutrient — but less than this nutrient's UL. This rule has many exceptions, though. For instance, people who sweat more need more salt (i.e., sodium), whereas people who take metformin (a diabetes medicine) need more vitamin B12.

Moreover, the DRIs are based on the median weight of adults and children in the United States. Everything else being equal (notably age, sex, and percentage of body fat), you likely need a lesser amount of nutrients if you weigh less, and vice versa if you weigh more. The numbers, however, are not proportional — if only because the brains of two people of very different weights have very similar needs. So you can't just double your RDIs for each nutrient if you weigh twice as much as the median adult of your age and sex (even if we overlook that people weighing the same can differ in many respects, notably body fat).

Q. Why don't you mention vitamin K_3?

K_1 and K_2 are the only natural forms of are the only natural forms of vitamin K, but there exist several synthetic forms, the best known of which is K_3. However, whereas the natural forms of vitamin K are safe, even in high doses, K_3 can interfere with glutathione, your body's main antioxidant.

K_3 was once used to treat vitamin K deficiency in infants, but it caused liver toxicity, jaundice, and hemolytic anemia. Nowadays, it is used only in animal feed, in small doses. In the animals, vitamin K_3 gets converted into K_2 MK-4, which you can consume safely.

Q. What's the difference between elemental calcium/magnesium and other kinds of calcium/magnesium?

"Elemental" refers to the weight of the mineral by itself, separately from the compound bound to it. For instance, ingesting 100 mg of calcium citrate means ingesting 21 mg of elemental calcium, whereas ingesting 500 mg of magnesium gluconate means ingesting 27 mg of elemental magnesium.

Product labels display the elemental dosage. On a label, "210 mg of calcium (as calcium citrate)" means 210 mg of elemental calcium (and 790 mg of citric acid), whereas "27 mg of magnesium (as magnesium gluconate)" means 27 mg of elemental magnesium (and 473 mg of gluconic acid).

Q. Isn't soy protein *bad* for males?

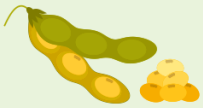
Phytoestrogens are plant compounds structurally similar to estradiol, the main estrogen in males and premenopausal females. Because soy contains isoflavones, a type of phytoestrogen, concern has been raised about soy affecting male health.

To this day, two case reports have documented adverse effects (gynecomastia, hypogonadism, reduced libido, and erectile dysfunction) from an estimated 360 mg of soy isoflavones per day for 6–12 months. However, a meta-analysis of 15 *randomized controlled trials* (RCTs, a much higher level of evidence than case reports) found that males' levels of total and free testosterone were not notably affected by either 60–240 mg of isoflavones or 10–70 grams of soy protein per day.

Accordingly, a couple of scoops of soy protein powder are unlikely to have estrogenic effects in males. If you'd like to take more, however, look for a soy protein concentrate or isolate produced through the alcohol-wash method, which dramatically lowers the isoflavone content.[65]

Keep in mind that the isoflavone content of different soy products can vary depending on several factors, such as the variety of soybeans used, differences in growing and storage conditions, and differential food processing techniques employed.[66] You can see how it varies below.

Isoflavone content of common soy foods

Food category	Food	Milligrams of isoflavones per 100 g of food		
		Average	Minimum	Maximum
 Traditional unfermented soy foods	Edamame	18	14	19
	Soybeans (boiled)	65	23	128
	Soybeans (raw)	155	10	440
	Soybean sprouts	34	0	107
	Soy milk (unsweetened)	11	1	31
	Soy nuts	148	2	202
	Tofu	30	3	142
 Traditional fermented soy foods	Miso	41	3	100
	Miso soup	1.5	1.5	1.5
	Miso soup mix (powder)	70	54	126
	Natto	82	46	124
	Soy sauce	1	0	3
	Tempeh	61	7	179
 Second-generation soy foods	Soy-based veggie “meats”	9	0	23
	Soy cheeses	26	3	59
	Soy yogurt	33	10	70
 Soy flours and protein powders	Soy flour (defatted)	151	74	324
	Soy flour (full-fat)	165	130	260
	Soy infant formula (powder)	28	21	31
	Soy protein concentrate (alcohol wash)	12	2	32
	Soy protein concentrate (water wash)	95	61	167
	Soy protein isolate	91	46	200

Reference: USDA FoodData Central Databases. Accessed Jan 18, 2019.

Q. Which dietary protein is best for bone health?

Most studies used dairy protein, yet the protein in our bones is mostly type 1 collagen. It follows that supplemental type 1 collagen should be optimal for bone health — and indeed, animal models appear to support this notion.

The few relevant human studies to date, however, had mixed results. Not only that, but they cumulated

factors (they gave collagen with calcium, vitamin D, dietary changes ...), making it impossible to determine which factor did what and to what extent. Until better human studies come along, collagen's superiority over other proteins (for bone health) will stay hypothetical.

Q. Don't dietary proteins *reduce* bone density?

More protein in the diet has been linked to more calcium in the urine. Two reasons have been suggested to explain this phenomenon:

- Your body draws from its calcium stores (in bones) to buffer the acid load caused by dietary protein. This has led researchers to suggest that higher protein intake could increase bone loss.[67]
- Most studies that looked at protein intake and calcium excretion list dairy products as a protein source,[68] so higher urinary calcium could simply be the result of higher calcium intake (i.e., more calcium in, more calcium out).

Therefore, looking only at calcium _excretion _wasn't enough. Subsequent studies showed that dietary protein promotes dietary-calcium absorption[69] and that high protein intake "promotes bone growth and retards bone loss whereas low-protein diet is associated with higher risk of hip fractures."[70] High-protein diets have also been shown to modestly suppress the decrease in bone mineral density caused by weight loss.[71]

What happens is that when you ingest more protein, you absorb more of the calcium in your food, so less calcium ends up in your feces. Later, your body gets rid of the calcium it doesn't need, so more calcium ends up in your urine, but not as much as would have otherwise ended in your feces.[72] Therefore, an increase in protein intake leads to an overall decrease in calcium excretion, which points to an increase in calcium retention. High-protein diets also raise your *insulin-like growth factor-1* (IGF-1),[73] which promotes notably bone growth.[74]

All in all, current evidence suggests that *protein's effect on bones is either neutral or beneficial*.[72][75]

Q. What causes bone loss during weight loss?

Bone mass is, for the most part, regulated by the activity of two specialized cell types. Osteoblasts are tasked with adding bone mass, while osteoclasts actively digest it and cause bone resorption. In the context of diseases like osteoporosis, increasing osteoblast number or activity shifts the balance toward bone resorption, causing a progressive loss of bone density over time.[76] Bone is capable of sensing mechanical stress, which lessens in response to weight loss. This shifts the balance of bone remodeling cells.

Calorie restriction also alters a number of hormones that play a role in the regulation of bone mass. Reductions in body fat have been linked to reduced levels of estrogen and other sex hormones,[77] and increased sex hormone binding globulin (SHBG), a protein that binds to and sequesters hormones, blocking their function.

Although shifts in overall hormone levels during calorie restriction and weight loss can be subtle, small changes in hormone levels (particularly estrogens, and IGF-1)[78][79][80] can work through both direct and

indirect mechanisms to alter the balance of osteoblast vs. osteoclasts activity to promote bone resorption and decreased bone density.

Q. Is exercise a contributing factor for bone mass retention on weight loss diets?

Weight training in particular increases mechanical loading, which is a stimulus for increasing bone mass.[81][82] While weight training can provide a benefit, the overall effect appears to be small during periods of weight loss.[71]

Q. How does obesity affect bone mass retention during weight loss?

Higher adiposity in obesity is associated with a lower rate of bone formation, so people with obesity that go on a reduced calorie diet may be more inclined to lose bone mass relative to non-obese counterparts.[83] Whether this is of clinical significance remains to be determined. Possibly in the context of obesity, decreased bone mass could be more detrimental, especially for older individuals with compromised bone quality and increased fracture risk (or trending in that direction). More research is needed to determine whether this may be the case.

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