

Bone Building Basics

Surprising New Research About the Foundations of Bone Health

In this special issue of *Advances*, we've heralded the coming of Strontium, a revolutionary new supplement which has only recently stepped out of the research clinic and into the hands of people wanting to take good care of their bones. But in our excitement over this vanguard bone-health nutrients, we should also remember that bone health is a total lifestyle commitment. While most people know the importance of "the basics" (like calcium, magnesium, and vitamin D), there are controversies that need to be addressed even surrounding the right dose and form of even these well-known nutrients. The facts about these and other lifestyle choices may surprise you.

**1300-1600 milligrams of
calcium is more effective for
lowering fracture risk.**

- **Get Enough Calcium.** Current "official" recommendations suggest an intake of 1000 milligrams of calcium for younger adults, and 1200 milligrams for people over the age of 50. Some evidence suggests that a still higher intake (1300-1600 milligrams) of calcium is more effective for lowering fracture risk in the elderly.¹ But these numbers are your total calcium need. The more calcium you get in your diet, the less you need from supplements. There is little evidence that ever-higher intake of calcium does your bones any additional good, and indeed taking too much calcium can inhibit the absorption and utilization of other important bone nutrients, such as zinc and copper.²

The best food sources of calcium are skim milk and many other low-fat dairy products. Contrary to what you may have heard, the balance of the evidence overwhelmingly favors the conclusion that milk is good for your bones.³

- **Get the Right Kind of Calcium.** Too many health-conscious people believe that conventional calcium supplements (or conventional calcium plus vitamin D) can put an end to bone loss. They can't. As multiple studies have documented, conventional calcium supplements – such as calcium gluconate, calcium citrate, calcium carbonate, and even calcium citrate-malate – slow, but do not halt or reverse, menopausal bone loss, whether taken alone or with vitamin D.⁴⁻¹⁸ Even a total daily calcium intake of 3000 milligrams of calcium from conventional sources isn't enough to stop bone loss, let alone turn the decline around.¹² You simply can't force the bones to take in more calcium, and build more bone, by taking more and more calcium: the mineral itself can only support your existing bone mass, or the building of bone induced by the other factors in your skeletal health program.^{1,22}

But there is one seeming exception. Ossein microcrystalline hydroxyapatite complex (MCHC) consistently halts, or even reverses, bone loss in controlled human trials.¹⁴⁻²¹ When put head-to-head against other calcium supplemental forms, MCHC consistently trumps the conventional calcium supplement.^{14-18,21,23-26} But actually, this is the exception that proves the rule, because MCHC's bone-building powers do not lie in the calcium itself.

True MCHC is not just a form of calcium, but is a calcium-based crystalline nutrient complex, which is how the mineral is actually stored in your bones. Supplements do exist which contain "calcium hydroxyapatite" which lack this crucial nutrient matrix, either because the "calcium hydroxyapatite" is not derived from bone but from chemical synthesis (this is also known "calcium orthophosphate"), or because it uses bone meal, which is heat-treated ("ashed"), breaking down the MCHC crystalline structure and destroying the non-mineral components of the complex. But these supplements, even though they contain the same chemical form of calcium, fail to reproduce the unique effects of MCHC on parameters of bone health.^{17,24-26}

Thus, the unique support for bone health provided by MCHC is probably due to a combination of its intact crystalline structure, and the vibrant blend of peptides, mucopolysaccharides, and growth factors which accompany the calcium in true MCHC supplements^{27,28} – factors which are not present in conventional calcium supplements, in bone meal, or in synthetic hydroxyapatite. The bottom line is that the effects of MCHC derive from the whole supplement, and not just from its calcium content.

Unfortunately, of course, vegetarians cannot consume MCHC because it is an animal product (although premium MCHC supplements use free-range, pasture-fed livestock from countries like New Zealand or Australia as sources for the raw materials). For vegetarians, the best calcium source is calcium citrate-malate.

Ossein microcrystalline hydroxyapatite complex (MCHC) consistently halts, or even reverses, bone loss in controlled, scientific studies.

Calcium citrate-malate is not the same thing as calcium citrate, or as a simple admixture of calcium citrate and calcium malate. Calcium citrate-malate is prepared in such a way that a significant number of its calcium atoms are bound to both citrate and malate molecules at once. This unique structure makes calcium citrate-malate six²⁹ to nine³⁰ times more easily dissolved in the stomach than plain calcium citrate.

This superior solubility may be at least part of the reason for the fact that calcium citrate-malate is considerably better-absorbed than calcium citrate. In fact, despite what is often said, nearly all studies have reported that plain calcium citrate is actually no better absorbed than calcium carbonate when taken with food.³⁰⁻³⁶ Most studies find that about 22 to 26% of calcium from calcium carbonate or citrate is absorbed, whereas calcium citrate-malate absorption is consistently found to be around 36 to 37% in capsules and tablets,^{29,36-38} and can be as high as 42% when dissolved in orange juice.³⁹

Calcium citrate-malate has been used successfully in many controlled trials to support bone mass and/or to lower fracture risk.^{5,7,8,11,13,43-48} Some of these trials have involved a direct face-off between calcium citrate-malate and other forms of calcium. Such trials demonstrate that, as might be expected from its greater bioavailability, calcium citrate-malate gives better protection to the bones than other vegetarian calcium sources – although its effects are still not as impressive as those of MCHC.



How Rumors Get Started

The widespread myth of calcium citrate's superior absorption is in part the result of poorly-designed studies, which used calcium excretion as a measure of absorption. The reasoning for using this method is based on the fact that, once your body has used all of the calcium which it can at the time that a dose of calcium is taken in, any extra calcium initially absorbed will then be passed out in the urine. Thus, by giving a dose of calcium so high that the body can't use it all, and then measuring how much calcium passes out through the urine, the comparative bioavailability of two calcium forms can in theory be gauged by seeing how much calcium excretion they cause.

That's a sensible-sounding and inexpensive testing method, and in many cases it probably gives a good picture of calcium absorption. But it falls down in comparing calcium citrate with the carbonate salt. First, the alkalizing effect of the carbonate reduces the amount of calcium excreted through the urine, making its absorption look lower; and then, some studies suggest, the citric acid in calcium citrate increases the body's excretion of calcium, making its absorption look higher!^{32,40,41}

Faith in calcium citrate's higher bioavailability was also shored up by a recent "meta-analysis" paper.⁴² Meta-analysis is done by combining the results of several separate studies into one monoreport, which gives a clearer picture of the overall results of the available scientific evidence. But the authors of this meta-analysis made one critical mistake: in combining studies, they assumed that calcium citrate was basically the same as calcium citrate-malate, and lumped the results for the two forms together. In fact, of course, the two forms are considerably different. By combining studies on calcium citrate with studies on the much more bioavailable citrate-malate form, the citrate salt acquired an undeserved glitter, reflected from citrate-malate's radiance.

On the other hand, the hype surrounding so-called "ionic coral calcium" is not the result of understandable errors in otherwise solid science, but of a lack of even the most elementary scientific credibility. Not one clinical trial has ever been performed using this calcium source to show that it is better absorbed or better utilized than other conventional calcium sources. Instead, astoundingly, the claims of high bioavailability for "coral calcium" are not based on controlled studies in humans, but on the stuff's ability to dissolve in water; and as has been shown, such a silly test bears little relationship to the ability of a living body to absorb calcium.³⁶ Indeed, this kitchen-counter method of testing absorption leads to ridiculous exaggerations of calcium absorption, such as 50% absorption for calcium citrate, or 95% absorption for "coral calcium" itself. In the real world, no calcium source has such a high bioavailability.

In one such trial,¹³ a subgroup of women in late menopause and a low dietary intake of calcium took 500 milligrams of calcium (either calcium citrate-malate or calcium carbonate) or a dummy pill for two years. By the end of the trial, all of the women in the study had lost some bone mineral density: again, conventional calcium supplements can slow, but cannot reverse, the loss of BMD over the body as a whole that accompanies menopause. The women receiving the placebo were in the worst shape, having lost 2.27% on the BMD in their spines. Women given calcium carbonate did get some benefits – they endured 15% less loss of BMD than the women receiving the fake pills – but women taking calcium citrate-malate fared much better than women receiving the more common calcium supplement, having escaped 60% of the loss of spinal bone mineral density suffered by the placebo group in the same period.¹³



Both calcium supplements were more protective at the hip. While women receiving only a dummy pill lost 2.11% of their hip BMD, women taking calcium carbonate held their hip BMD steady as a group (with most women ranging from a gain of 1.16% to a loss of 0.90%). But again, calcium citrate-malate demonstrated its superiority, with women taking this form of calcium actually experiencing a gain in hip BMD (on average, 0.87%, although the typical change in these women ranged from a gain of 1.88% to a loss of 0.14%). Similar results were seen in the lower arm bone.¹³

Bottom line: take your calcium in the form of MCHC if you are comfortable with animal products; choose calcium citrate-malate if you're not.

- **Rock Around the Clock.** Several recent studies have suggested that when you take your calcium can make a big difference in terms of both the amount of calcium you'll absorb, and the effects of that calcium on your bones.

For starters, take your calcium with food, as doing so will increase absorption.^{36,37} It's also important to spread your calcium supplements over the course of the day. Taking a smaller dose of calcium at each meal has several advantages over taking it all at once. For one thing, it will increase your total absorption of calcium (by as much as 80-100%).⁴⁹ And by keeping calcium levels in your serum high throughout the day and night, a multi-dose approach keeps parathyroid hormone (PTH) under control throughout the day, whereas a one-shot dose of your entire day's calcium supplementation causes only a temporary lowering of this hormone.^{50,51} (Keeping PTH under control is important: the hormone is released in response to low serum calcium, triggering your body to rob the bones of this mineral to meet needs elsewhere in the body). And to get the best possible results, take the largest single dose of calcium later in the day, at dinner or with a late-night snack. Studies show that this last daily calcium dose does a better job of reducing markers of bone teardown,^{52,53} perhaps by keeping PTH low while you're sleeping (and thus not taking any calcium).

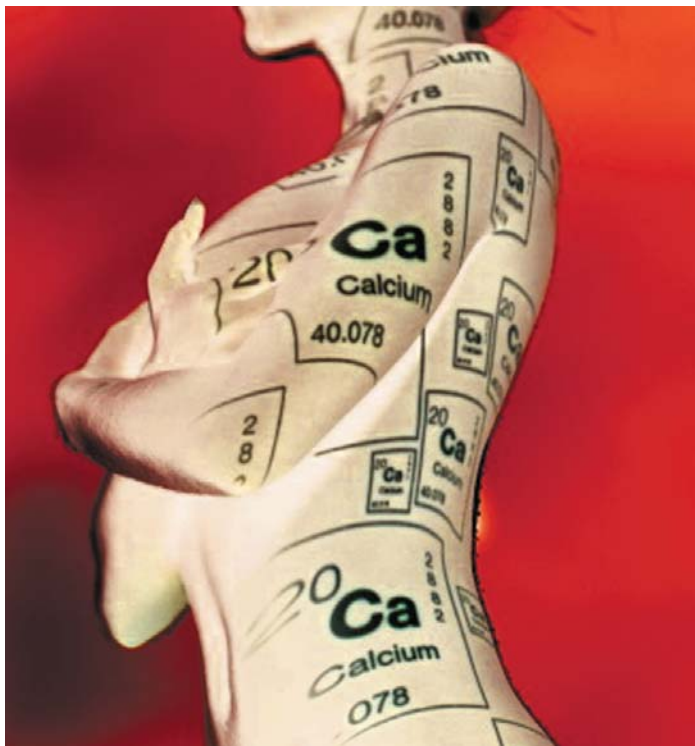
So, for instance, if you were taking a total of six calcium capsules a day, you might take one with breakfast, one with lunch, and three with dinner – or you might take two with each meal, and then go to bed with a nice glass of warm milk to help you sleep (and yes, Mom was right: a late-night glass of milk leads to sounder sleep,⁵⁴ probably thanks to its content of the amino acid tryptophan which (along with its calcium and magnesium content) increases levels of the sleep hormone melatonin).

- **Almost Everyone has Vitamin D Insufficiency!** Aside from improving calcium absorption, vitamin D is needed for proper muscle function, which may play a role in protecting against fractures by reducing falls.⁵⁵ So getting enough vitamin D is important. And you simply can't rely on the sun to meet your requirements, especially in Northern climates. Flat-out vitamin D deficiency is found in one third of otherwise-healthy Canadians at least once over the course of the year.⁵⁶ Indeed, the whole reason that our milk is now fortified with vitamin D is that rickets (bone disease caused by vitamin D deficiency) was epidemic in children in the Northern United States at the turn of the twentieth century – when kids spent a lot more time out-of-doors than do today's adults. There's a good reason for this: studies in human skin show that the amount of ultraviolet light that reaches the skin in Boston or Edmonton on cloudless winter days is not enough to make the body produce the vitamin.⁵⁷ But even in sunny Spain, researchers have found that 80% of children have inadequate vitamin D levels in March and October,⁵⁸ and the situation is much the same throughout central and western Europe,^{59,60} including France, Italy, and Greece.⁶⁰ Even in sunny Santiago, Chile, about one third of older men with normal sun exposure are suffering from frank vitamin D deficiency.^{60a}

From what we now know, the old RDA of 400 IU will not protect you from vitamin D insufficiency except in the sunniest of climates. A controlled trial in teen and preteen girls in Finland showed that a 400 IU vitamin D supplement was not enough to keep serum levels of the active vitamin above the cutoff for insufficiency,⁶¹ and studies in the health of large populations confirm the finding in Canadian⁶² and Danish⁶³ women lead to the same conclusion. More importantly, the use of standard 400 IU supplements have not been shown to reduce fracture rates,^{64,65} and neither 300⁶⁶ nor even 600 IU has detectable effect on BMD.⁵

It's clear that the caution surrounding vitamin D toxicity has been overblown.^{67,70} Indeed, the "lowest observed adverse effects level" (LOAEL) recognized by the RDA committees (2000 IU) was based on a single report in which a person taking this dose exhibited unusually high calcium levels in the blood – with no actual negative clinical effects. Indeed, doses as high as 4000⁶⁸ to 50 000 IU per day⁶⁹ have been used for months with apparent short-term safety

Vitamin D, together with calcium, helps to reduce the risk of fracture at a dose of 800 IU per day.



So how much vitamin D do you need? For optimal bone health – as opposed to simply avoiding a case of obvious rickets – scientists are now suggesting that the proper test is to see how much of the vitamin it takes to minimize the elevation of parathyroid hormone,⁷⁰ which as we've noted leeches calcium from the bones when serum calcium levels are low. To reliably reach this target, authorities are now recommending that people take vitamin D₃ supplements of 800 to 1000 IU^{67,71-73} – even in pregnant and lactating women.⁷⁴ Controlled studies show that vitamin D₃, alone or

together with calcium, increases BMD,⁷⁵ reduces the risk of falling,^{75,76} and most importantly lowers the risk of fracture^{10,77-79} at a dose of 800 to 1000 IU per day. And a body of evidence is emerging that there are an astounding range of other benefits to ensuring a high intake of vitamin D, including reduced risk of breast and prostate cancers, type 1 diabetes, heart disease, rheumatoid arthritis, and multiple sclerosis.^{60,67}

It's also important to know that vitamin D₂ (ergocalciferol) is significantly less effective than vitamin D₃ (cholecalciferol) at improving real vitamin D activity in the body.^{80,81} Unfortunately, many vegetarians feel ethically bound to refuse the use of D₃ supplements, because they are produced using lanolin, which comes from sheep's wool – an animal product. So while D₃ may be the preferable form, it will not be acceptable to all.

- Are You Absorbing that Magnesium? Magnesium is central to various aspects of bone metabolism, and borderline magnesium deficiency is surprisingly common. Unfortunately, far too many bone health formulas rely on magnesium oxide as the source of this mineral, for the simple reason that it takes up less room in a capsule, and therefore requires fewer capsules to be taken to reach the daily dose. But compared to other sources of the mineral, magnesium oxide has "extremely low" bioavailability (22.8%).⁸² Additionally, magnesium oxide is an antacid, which can impair digestion and nutrient absorption. This is an especial concern in many older people, whose low stomach acid may even trigger pernicious anemia (flat-out B₁₂ deficiency).

Magnesium citrate is certainly somewhat better, at 29.64% absorption,⁸² but much of the supposed "magnesium citrate" on health-food store shelves is not true, fully-reacted magnesium citrate, but a mixture of magnesium oxide and magnesium citrate. And indeed, much better absorption is available from other forms of magnesium. Among the available options, fully-reacted magnesium monoaspartate stands out as the best, with a remarkable 41.7% bioavailability.⁸²

- "Vitamin K" is Not All The Same! The importance of vitamin K to bone health is one of the more recent nutritional discoveries, but many bone health supplements do now contain some form of the nutrient. Unfortunately, nearly all are using phylloquinone (Vitamin K₁), the form of the nutrient produced in plants. By contrast, a large body of research has now clearly identified Menatetrenone (MK-4 – a form of vitamin K₂), the metabolite of K₁ produced in mammals for their specific use, as having unique bone health properties not shared by phylloquinone.⁸³ (The role of other forms of vitamin K₂, such as the bacterial menaquinones (most prominently MK-7), remains unclear).

Protein – makes a positive contribution to bone health.

The current Dietary Reference Intake (DRI) for vitamin K, established jointly by the Institute of Medicine in the United States and scientists from Health Canada, is 120 micrograms – but epidemiological and other evidence suggests a much higher intake is appropriate to maintain bone health in healthy people (in the range of 200 to 500 micrograms).^{83,84} At least 22 clinical trials have also documented that Menatetrenone supports bone structure and slashes the risk of a fracture at true “megadose” levels: 45 milligrams (45 000 micrograms) a day in women whose bone health has already suffered significant decay.

MK-4 has recently been made available in the United States at these doses – but buyer beware, because many companies are also trading off of the confusion between Menatetrenone and the other, bacterial “vitamin K₂” forms to pawn cheap bacterial menaquinones off as equivalent to genuine MK-4 – despite the fact that all of the clinical trials use the latter. In the mean time, Health Canada continues to deny access to this crucial bone health supplement to Canadians, limiting supplemental dosages of all forms of vitamin K to just 120 micrograms – which does not even meet the DRI established by their own expert panel!



- Remember the Neglected Nutrients. Calcium, magnesium, and vitamin D are very well-known as nutrients with an important place in bone health. By contrast, you may never have heard of the powerful support that Menatetrenone and Strontium can lend your bones before reading about them in Advances. But there are a host of nutrients important to bone health that are too often neglected in putting together a total lifestyle program. These would most prominently include manganese, zinc, and copper,^{2,46,85-87} and would extend to other, even more commonly-neglected nutrients such as silicon,^{88,88a} boron,⁸⁹ and vitamin C.⁸³ Methylating nutrients such as vitamin B₁₂ and folic acid are also emerging as important bone health supplements: low

levels of these vitamins are associated with poor bone health,^{90-94a} as are high levels of the toxic amino acid homocysteine (levels of which climb when B₁₂, folic acid, or TMG levels are low).^{94a-96} This may be because homocysteine itself exerts toxic effects of on the protein fibers in bone,^{97,98} or it may be because B₁₂ is needed for the normal functioning of bone-building osteoblasts.⁹⁹

- The Phosphorus Paradox. It's widely believed that Western diets are too rich in this mineral, and that excess phosphorus is bad for bone health. But phosphorus is an essential mineral, which makes up more than half of the mineral content of bone and which is needed for osteoblast function. And nearly a third of older Americans don't get the DRI of this essential mineral.

“just” 5000 or 6600 IU of preformed vitamin A is enough to roughly double your risk of a fracture

The concerns with phosphorus stem from theoretical speculations related to its effects on parathyroid hormone, and the belief that phosphorus causes you to lose calcium in

Table 1. “Alkaline-Ash” and “Acid-Ash” Foods. Average values for a class of food are given after the class name, which is given in full capitals; exceptional specific foods are also listed beneath the category name. Foods assigned more “negative” values are more alkaline; those with higher “positive” values are more acidic. Values are per 100g of food. Data taken from (132).

FATS AND OILS:	0	MEATS:	+9.5
FISH:	+7.91	Corned beef:	+13.2
Brown trout:	+10.8	Lean pork:	7.9
FRUITS:	-3.1	MILK AND DAIRY:	+8.7
Raisins	-21	Buttermilk:	+0.5
Currants	-6.5	Cheddar Cheese:	+26.4
NUTS:	+4.1	Cottage Cheese:	+8.7
Peanuts	+8.3	Soft Cheese:	+4.3
Hazelnuts	-2.8	Whole Milk:	+0.7
Walnuts	+6.8	Parmesan:	+34.2
GRAINS:	+5.7	Yogurt:	+1.5
Bread:	+3.5	Ice Cream:	0.6
Rye bread:	+4	Skim Milk:	+1.2
Whole wheat:	1.8	VEGETABLES:	-2.8
Flour:	+7.0	Spinach:	-14
Spagetti:	+6.7	Zucchini:	-4.6
White rice:	+1.7	Cauliflower:	-4.0
Brown Rice:	+12.5	Carrots:	-4.9
Oats	+10.7	Asparagus:	-0.4
LEGUMES:	+0.53	Cucumbers:	-0.8
French Beans:	-3.1		
Lentils:	+3.5		
Peas:	+1.2		

your urine. But studies show that it's the form of phosphorus that counts: phosphoric acid (the acidic phosphorus compound in some sodas) may cause increased calcium excretion because of its acidifying effect, but neutral phosphorus forms do not;¹⁰⁰ and indeed, one study¹⁰¹ found that even when sodas contain phosphoric acid, they don't increase calcium excretion unless they also contain caffeine.

In fact, a recent study¹⁰² has raised concerns that, with so many people taking calcium as supplements instead of drinking milk (in which calcium and phosphorus come together as a bone-building team), folks who don't get plenty of phosphorus in their diets (such as persons on low-protein diets and many of the elderly) may actually become phosphorus deficient, because calcium supplements can reduce phosphorus absorption. Several recent reviews in the scientific literature have emphasized the importance of getting enough of this "black sheep" in the bone-health nutritional family.^{83,85,103}

- **Eat an "Alkaline-Ash" diet.** When the body metabolizes minerals bound to certain organic ligands, alkaline ions are produced. These alkaline ions help to keep the body's acid-base load in balance. When the body becomes too acidic, calcium phosphate is leached from the bones in order to bring the balance back, contributing to the destruction of your bones.¹⁰⁴ Foods rich in such minerals are called "alkaline-ash." The most important "alkaline" foods are vegetables and fruits (see Table 1). As you can see from the Table, the widespread belief that whole grains and fish are "alkaline-ash" foods is a myth: in fact, these foods are "acid-ash" – that is, they contain moieties which, when metabolized, tend to acidify the body. Many grains are as acidic as beef and other meats, whose acidifying properties are more widely known. The more "acid-ash" foods you consume, the more important it is to get plenty of "alkaline-ash" fruits and vegetables to balance them. The "alkalinity" of these foods is probably a big part of the reason why people eating diets rich in fruits and vegetables have better bone health and metabolism.^{102,105-107}
- **Get Enough Protein.** Like phosphorus, protein has a bad rep' in many health-conscious circles because of its "acid-ash" properties. Surprisingly, however, the latest and best research consistently reports that protein – including animal protein – makes a positive contribution to bone health, especially when protein intake is somewhat higher than the RDA.^{43,108-111} The authors of studies which have commonly been presented as "proof" that animal protein is bad for bone health^{112,113} have come forward to state that their results have been misrepresented.^{114,115}

In fact, higher protein intake increases the bone-health benefits of taking calcium supplements.⁴³ Furthermore, research clearly shows that low protein intake results in impaired bone metabolism, reduced calcium absorption,

and bone-draining elevations in parathyroid hormone.^{116,117} And, importantly, the RDA does not provide enough protein to prevent impaired calcium metabolism.^{118,119}

So despite its "acidifying" influence – which can be countered with a rich intake of fruits and vegetables – the overall effect of protein on bone health is favorable. The optimal intake of protein to support a healthy skeletal system appears to be in the range of 1.0 to 1.5 grams per kilogram of body mass, or 0.45 to 0.68 grams of protein for each pound that you weigh.⁸³ This is an intake significantly higher than the RDA for protein, which is set at 0.8 grams of protein per kilogram of body mass.



- **Avoid Vitamin A Toxicity.** Ultra-conservative medical "authorities" have cried wolf on the dangers of nutritional supplements so often that many health-conscious people simply tune out when they raise an alarm. But recently, one example of a genuinely crippling result of long-term, chronic supplement overdose has emerged: the association between excessive preformed vitamin A (retinol/retinyl esters) and the loss of bone health. It's long been known, from animal studies, that getting too much vitamin A is bad for the skeletal system. In recent years, these findings have been confirmed in humans. Several large, well-designed population studies (and a few smaller and less rigorous ones) have now reported that men and women with the highest intake^{120,121} or serum levels^{122,123} of retinol are at the greatest risk of suffering a fracture; taking in the most retinol also associates with having the lowest bone mineral density (BMD).^{118,124-126} (It's important to understand that this refers to preformed vitamin A: beta-carotene and other 'provitamin A' carotenoids have not been associated with loss of bone health).

Frighteningly, the amount of retinol which these studies have found to put consumers at risk of broken bones is right in the ballpark found in many – and perhaps most – multivitamins: "just" 5 000¹¹⁸ or 6 600¹¹⁹ IU of preformed vitamin A is

enough to roughly double your risk of a fracture. It's extremely unlikely that you'd get dosages like these from food – you'd have to spend all day gorging on liver, eggs, and fortified milk – but it's all too easy to exceed the safety limit if you're taking the kind of multivitamin designed around an unthinking 'more is better' paradigm. And indeed, nearly no one in these studies would have reached the extreme levels of intake associated with increased fracture risk if it were not for the badly thought-out supplements they were letting into their systems.

But this doesn't mean that you should avoid all intake of retinol, or depend entirely on carotenoids to get your vitamin A. The rate of conversion of "provitamin A" carotenoids into retinol varies nearly ninefold from person to person,¹²⁷ and can be altered by age, genes, body weight, and alpha-tocopherol intake. Remember that retinol is an absolutely essential nutrient – and in fact, one of its most important functions in the body is in normal skeletal metabolism! Indeed, some of the same studies that reported the impairment of bone health caused by years of retinol overdose have found that people with the lowest vitamin A levels¹²¹ or intake¹²² also suffer an elevated fracture risk¹²¹ and lower BMD.¹²² It appears that the ideal retinol intake for bone health – from diet and supplements combined – is in the ballpark of 2000 IU.

But remember that, because of government-mandated fortification, a single serving of low-fat milk or yogurt contains between about 500 and 750 IU of vitamin A, and a standard 85g (3 oz) slice of liver contains an astounding 22 000 IU! So it's very easy to overshoot your safe vitamin A intake if your supplement contains more than 1000 IU of retinol. The goal of supplementation should be to put you into that happy medium where bone health is optimized, supporting the balance of the diet instead of overbalancing it with levels you'd never get from well-chosen foods.

- **Keep Active.** Exercise clearly helps build bone mass in young people. And it also improves balance, muscle mass, and strength, which reduces your chances of taking a fall by about 25%. Despite these facts, it isn't totally clear whether exercise actually increases bone mass, or protects against fracture risk, when people don't get started until their middle years or beyond.^{127,128} Despite this uncertainty, getting active is clearly a good idea, if only for the many other ways that it will improve your life, from energy levels to heart health to looking good. The kinds of exercise most likely to specifically support bone health are weight-bearing and/or high-impact activities, such as weightlifting and jogging.¹²⁶
- **Maintain a Healthy Weight.** While there are all kinds of good reasons to avoid the overweight that's creeping its way across every sector of our society, it's also important not to lose too much weight – or to lose weight too quickly. Low body weight, and quick weight loss, are associated with thinner bones, and higher fracture risk.¹²⁷

- **Quit Smoking.** Smokers are between half-again and twice as likely to suffer a fracture as nonsmokers,⁸³ apparently because the toxins in cigarette smoke interfere with normal estrogen metabolism and calcium absorption, and brings on early menopause.¹²⁹ For help quitting – especially if you've tried to quit before and have not yet escaped the addiction – see the resources at: <http://www.hc-sc.gc.ca/hccs-sesc/tobacco/quitting/index.html>, or talk to your doctor.

- **If you Drink, do so in Moderation.** Heavy drinking (more than two drinks a day) definitely puts you at risk for bone loss.⁸³ But more moderate drinking – say, between one and two drinks a day – doesn't seem to harm the bones, and some studies even suggest that it might be protective in women,^{83,127} though there's no real reason to believe that's true of men. If there is a bone-shielding effect, it might be related to the fact that a drink or two daily increase the body's formation of some estrogens from their precursors.¹³⁰

But the very changes in estrogen metabolism which might help shield a woman's bones can also promote breast cancer – and even one drink a day is linked to greater risk of this killer, especially (though not exclusively!) if you're taking estrogen replacement therapy.¹³¹ Throw in the well-known heart-health benefits of moderate drinking, and trying to fit together the total puzzle of alcohol's risks and benefits can be a frustrating, dizzying challenge. Best advice: don't start or increase your drinking just to support your bones – but if you already make a glass of wine a part of your dinner every day, talk with your doctor, weigh your priorities and family history, and choose carefully.

To some, this "to do" list for bone health will seem too long, and they may become discouraged. But remember that each of these choices also has positive impacts on other aspects of your lifestyle. And there really aren't that many steps along the way. A single, well-designed multinutrient bone-health supplement can help ensure that you're getting the right kind and amounts of the basic vitamins and minerals you need for bone health. The shift to a diet rich in fruits and vegetables, which includes adequate protein, is a simple goal which can be reached in easy – and delicious! – steps. Exercise and a healthy weight are good for you in a lot of ways, and can be rewarding in themselves; alcohol is a grey zone, where individual priorities play heavily into the mix. And if you smoke, quitting is a contest that you can win – and the greatest prize (your health) is then yours to reclaim.

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