

# The Harms of Phosphate

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## STORY AT-A-GLANCE

- › If you eat a typical Western diet high in processed foods, meat and grains, it is very easy to overdo your phosphorus intake; this can be detrimental for your health, particularly in combination with low levels of calcium
- › Phosphate can act on your mitochondria, leading to increased production of reactive oxygen species (ROS), which causes oxidative stress in the body; the increased oxidative stress due to high phosphate levels can lead to vascular calcification
- › High phosphate levels can harm the heart and accelerate aging
- › An ideal calcium to phosphate ratio (Ca:P) is 1:1 to 1.3:1, but many people consume high amounts of phosphate and low amounts of calcium
- › Fast food and ready-to-eat processed foods are the main contributors to rising dietary consumption of phosphate

Phosphate is a charged particle (ion) that contains the mineral phosphorus, which is present in our food. In your body, most phosphorus combines with oxygen to form phosphate, about 85% of which is found in your bones. Phosphate plays a number of important roles, from building bones and teeth to acting as a building block for compounds used for cellular energy, cell membranes and DNA.<sup>1</sup>

However, if you eat a typical Western diet high in processed foods, meat and grains, it is very easy to overdo your phosphorus intake. This can be detrimental for your health, particularly in combination with low levels of calcium.

# High Phosphate Intake May Affect Mitochondrial Function, Promoting Oxidative Stress

Research has shown that high intakes of bioavailable phosphate can lead to oxidative stress and vascular calcification by affecting mitochondrial function.<sup>2</sup> Interestingly, maintaining adequate magnesium levels may help protect against these harmful effects.

In your body, phosphate can act on mitochondria, the powerhouses of your cells, to increase their membrane potential. This heightened membrane potential leads to increased production of superoxide, a type of reactive oxygen species (ROS), which causes oxidative stress in the body.

The increased oxidative stress due to high phosphate levels can lead to vascular calcification. In chronic kidney disease (CKD), high phosphate levels promote a transition of vascular smooth muscle cells to a bone-like state, contributing to the hardening of blood vessels.<sup>3</sup>

The hormone fibroblast growth factor 23 (FGF23), which is elevated in response to high phosphate levels, also contributes to oxidative stress and vascular damage. FGF23 activates specific pathways in heart cells and blood vessel linings, further promoting these harmful effects.

Adequate levels of magnesium in the body, meanwhile, may help counteract the harmful effects of high phosphate levels.<sup>4</sup> Magnesium can mitigate the increase in mitochondrial membrane potential caused by phosphate, thereby reducing oxidative stress and preventing vascular calcification.

In studies, dietary magnesium has shown protective effects against these issues, suggesting that maintaining adequate magnesium levels could serve as an antidote to the negative impacts of high phosphate intake.

The proposed mechanism involves magnesium's ability to counteract phosphate's effects on mitochondrial membrane potential.<sup>5</sup> This interaction may explain why magnesium is beneficial in preventing vascular calcification. Furthermore, it suggests

that magnesium could have broader protective effects against the harmful impacts of high phosphate levels in the blood, known as hyperphosphatemia.

## **Your Dietary Calcium to Phosphate Ratio Is Important for Metabolic Health**

Your dietary **calcium to phosphate ratio** (Ca:P) is important for optimal metabolic health. Calcium is the most plentiful mineral found in your body – phosphorus is the second.<sup>6</sup> However, your body cannot make this vital mineral. Almost all calcium – 99% – is found in your teeth and bones. The rest is found in your nerve cells, body tissues, blood and other body fluids.

Calcium is so vital for proper function that your body tightly controls how much is in your blood to a fairly narrow level of 8.5 to 10.5 mg/dl of extracellular fluid.<sup>7</sup> For optimal health, you want to keep calcium in your bones; health challenges occur when it instead becomes stored in soft tissues.

Unfortunately, dietary calcium has received a bad rap recently largely due to the fear of calcification, or the buildup of calcium in body tissue. This buildup can form hardened deposits in soft tissues, arteries and other areas, and can interfere with organ function, such as in the case of hardened blood vessels in the heart.

However, dietary calcium is not the cause of this calcification. Low dietary calcium is. According to Dr. Ray Peat:

*“It is extremely important to realize that calcium deposits in soft tissues become worse when the diet is low in calcium ... It is counterproductive to eat a calcium-deficient diet, since that leads to an increase in intracellular calcium at the expense of calcium from the bones.*

*... There are several such paradoxes: As bones lose calcium, the soft tissues calcify; when less calcium is eaten, blood calcium may increase, along with calcium in many organs and tissues; if an organ such as the heart is deprived of*

*calcium for a short time, its cells lose their ability to respond normally to calcium, and instead they take up a large, toxic amount of calcium.”*

In fact, dietary calcium deficiency is a big problem worldwide, leading to bone problems, increases in parathyroid hormone (PTH) levels and increased calcification of soft tissues. With low dietary calcium, your body compensates in order to keep your blood calcium concentration in the desired range.

If you consume inadequate dietary calcium to satisfy your body’s calcium needs, your parathyroid glands almost immediately release PTH into your blood to bring your calcium level back up to normal. As noted in the Journal of the American College of Nutrition, “Low calcium intake increases ... parathyroid hormone (PTH), causing calcium influx into vascular smooth muscle cells.”<sup>8</sup>

## **An Ideal Calcium to Phosphorus Ratio Is Close to or Above 1:1**

An ideal Ca:P ratio is 1:1 to 1.3:1.<sup>9,10,11</sup> However, phosphate intake is two to three times higher than recommended levels in many countries,<sup>12,13</sup> while total dietary calcium remains below the recommended values,<sup>14</sup> leading to lower levels of Ca:P ratios.<sup>15</sup> However, when your calcium is low, the subsequent release of PTH triggers a stress response in your body signaling that there’s not enough calcium coming in.

PTH signals to your tissues to convert the storage form of vitamin D into 1,25 D (also known as calcitriol or activated vitamin D), which provides the signal to pull calcium out from your bones and into the bloodstream.

Calcium is not the only nutrient that works to suppress the antimetabolic PTH. We also need adequate levels of magnesium and vitamin D. All of these work in concert to keep PTH levels in check. Further, as noted in Nursing Times, phosphate homeostasis is equally complex:<sup>16</sup>

*“There is some variation in the normal plasma phosphate levels quoted in the literature, but values of 0.70-1.50mmol/L are typical of those cited ... The*

*homeostatic control of phosphate is complex, primarily involving PTH, fibroblast growth factor 23 (FGF23) and vitamin D.*

*In addition to its role in calcium homeostasis, PTH increases the release of phosphate from the mineral stores in bone, while simultaneously enhancing the elimination of phosphate in the urine.*

*Similarly, FGF23 also enhances renal elimination of phosphate; together PTH and FGF23 collectively reduce plasma phosphate concentrations. Conversely, vitamin D acts antagonistically to PTH and FGF23, increasing the plasma phosphate concentration by enhancing phosphate absorption in the gut.”*

## **Too Much Phosphate May Harm Your Heart, Accelerate Aging**

Maintaining the right balance of phosphate is crucial for life and, as such, you have developed a complex system to regulate phosphate levels. However, since your kidneys are responsible for eliminating phosphate, people with reduced kidney function often have too much phosphate in their bodies.

Excess phosphate is known to cause problems with bones and minerals in people with CKD. Recent studies have also shown that high phosphate levels can harm the heart and accelerate aging.<sup>17</sup> In fact, phosphate toxicity is one of the reasons why CKD promotes premature aging.<sup>18</sup> Increased levels of FGF23 and PTH contribute to these negative health effects.

Managing phosphate levels in people with advanced CKD is common practice. However, given the potential for too much phosphate to act as a poison for humans, researchers wrote in *Kidney International* that “the general population may also be viewed as a target for phosphate management.”<sup>19</sup> Peat noted:

*“Recent publications are showing that excess phosphate can increase inflammation, tissue atrophy, calcification of blood vessels, cancer, dementia, and, in general, the processes of aging ... Keeping a high ratio of calcium to phosphate helps to oppose the stress metabolism.”*

## How to Improve Your Ca:P Ratio

Fast food and ready-to-eat processed foods are the main contributors to rising dietary consumption of phosphate. Phosphates are extensively used in processed foods as preservatives and flavor enhancers. Our estimated daily intake of [phosphate-containing food additives](#) has more than doubled since the 1990s.<sup>20</sup>

On food labels, phosphates can appear under various names such as sodium phosphate, calcium phosphate, monopotassium phosphate and pyrophosphate. They're commonly found in frozen pizzas, soda, processed cheese, processed meat and many other ultraprocessed foods. Phosphates are also found in meat, seeds, beans, nuts and whole grains.

Although I don't agree, DiNicolantonio recommends a plant-based diet to moderate dietary phosphate absorption, along with optimizing magnesium, vitamins K and D, and other strategies:<sup>21</sup>

*“Dietary phosphate absorption can be moderated by emphasizing plant-based dietary choices (which provide phosphate in less-bioavailable forms), avoidance of processed foods containing inorganic phosphate food additives, and by ingestion of phosphate-binder drugs, magnesium supplements, or niacin, which precipitate phosphate or suppress its gastrointestinal absorption.*

*The propensity of dietary phosphate to promote vascular calcification may be opposed by optimal intakes of magnesium, vitamin K, and vitamin D; the latter should also counter the tendency of phosphate to elevate parathyroid hormone.”*

As mentioned, while I don't recommend vegan or vegetarian diets, I do suggest making dietary adjustments to help restore a balanced Ca:P ratio. In addition to avoiding ultraprocessed foods, meat is a phosphorus-rich food, so it must be balanced with optimal levels of dietary calcium. The best sources of dietary calcium include:

Milk

Cottage cheese

Greek yogurt

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**Egg shells** are made almost entirely of calcium carbonate, which is what makes up your nails, teeth and bones. The calcium in this whole food source is properly balanced with 27 other minerals, making it easier for your body to absorb and assimilate the nutrients in the shells.

Egg shells also have one of the lowest levels of toxic heavy metals, especially relative to bone meal powder.<sup>22</sup> Bones, especially from older cows, can be high in toxic heavy metals like lead and mercury.

Consuming 1/4 teaspoon three times a day with meals for about 800 to 1,000 mg of calcium on top of your diet is a great starting point if you are not consuming a lot of dairy. If you experience constipation, supplement with magnesium at the same time.

You can use a food tracking app such as **Cronometer** to find out your total phosphorus and calcium intake. Divide your total calcium intake by your total phosphorus intake to get your calcium to phosphorus ratio. Again, the ideal ratio is close to or slightly above 1:1.

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