

# Beverages and Bone Health

## Robert P. Heaney MD, FCAP, FASN



Dr. Heaney is John A. Creighton University Professor and Professor of Medicine at Creighton University in Omaha, Nebraska. A recognized expert in the field of osteoporosis, vitamin D and calcium physiology, he has worked for more than 50 years in the study of osteoporosis and bone physiology. Dr. Heaney was a member of the Panel on Calcium and Related Nutrients involved in the development of the IOM's Dietary Reference Intakes for these nutrients, and his laboratory has done bioavailability testing for many of the major food companies in North America. Dr. Heaney has received many honors and awards and is a member of numerous professional organizations as well as being published widely in peer-reviewed journals.

## A Conversation with Dr. Robert P. Heaney

*The US National Osteoporosis Foundation predicts that by 2010, about 12 million people over the age of 50 will have osteoporosis and another 40 million will have low bone mass. These numbers are expected to continue climbing.<sup>1</sup> What's causing this public health crisis? It's well-known that meeting recommendations for calcium and vitamin D is critical for bone health—but is it enough? Is a high-protein diet good or bad for bones? Are soft drinks or ingredients like caffeine and phosphoric acid a factor? Is milk essential? Are fortified beverages helpful? To answer these questions and to gain insight into the latest scientific understanding about bone health and beverages, the Beverage Institute for Health & Wellness (BIHW) of the Coca-Cola Company talked with noted bone biology and calcium nutrition expert Dr. Robert P. Heaney.*

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### **BIHW:** *Why has poor bone health become so endemic?*

**Dr. Heaney:** In simple terms, to be healthy, bones need two basic requirements: food and work. As recently as two generations ago, people ate a lot of food—3,000 or 4,000 calories a day—which made them more likely to get needed nutrients. They also walked everywhere and did a lot of physical work. Today, a typical female is sedentary and might eat only 1,400 calories a day, mostly from nutrient-poor foods. So, generally, we're not meeting the basic requirements needed for strong, healthy bones.

### **BIHW:** *How does weight-bearing exercise strengthen bones?*

**Dr. Heaney:** Our bones contain a sophisticated sensor system that monitors and responds to the amount of impact—or mechanical load—they receive. When bones bend under the impact of weight-bearing exercise like walking, aerobic dancing, lifting weights or doing manual labor, the sensors signal the body to add more bone, which strengthens them. When someone is sedentary and the bones don't bend enough, the sensors signal the body to get rid of bone, which, over time, weakens them.

### **BIHW:** *You advise against people taking a “mono-nutrient approach” to healthy bones. What does this mean?*

**Dr. Heaney:** Scientists tend to study one nutrient or body system at a time, which is why we see a lot of attention to the role of calcium and vitamin D in bone health. But what's most important for bone health is an overall healthful diet that supplies recommended amounts of all nutrients. After all, we eat food, not nutrients, and nutrients work “hand in hand” in the body.



*The Beverage Institute  
For Health & Wellness*

The Beverage Institute For Health & Wellness of The Coca Cola Company supports research and educational outreach, with a primary focus on beverage nutrition and science. The Beverage Institute is responsible for clinical research programs related to existing brands and the development of new beverages. The Institute also serves as a resource for health professionals and others seeking science-based information about beverages, their ingredients, and their role in active, healthy lifestyles. For more information, visit [www.beverageinstitute.org](http://www.beverageinstitute.org).

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For instance, calcium, phosphorus and protein are important nutrients for bone health because bone is largely composed of these constituents. Vitamin C is important because it plays a role in the synthesis of collagen, the primary protein in the structural matrix that supports bone. Magnesium, the B vitamins, vitamin K, fluoride, zinc, manganese, and copper are other micronutrients that play a role in bone health. And, of course, bones need calcium and the body needs vitamin D to properly absorb calcium.

That's why a "mono-nutrient" approach, such as just taking a calcium supplement, isn't enough for healthy bones.

## **BIHW: You say protein is essential for bone health. How much is needed?**

**Dr. Heaney:** Probably more than is currently recommended, at least for women in mid-life.<sup>2</sup> We recently analyzed our large database of metabolic studies looking for relationships between protein intake and calcium balance in mid-life women.<sup>2</sup> We found that increased calcium intake was associated with increased calcium retention only in women whose protein intake was also relatively high—more than about 60 grams per day. When protein intake was less than this, increased calcium intake could not be used by the body.

This work agrees with other studies that have found a synergistic effect between calcium, vitamin D and protein on bone mineral density in elderly men and women<sup>3</sup> and increased bone loss in the elderly with low protein intakes.<sup>4</sup> It also suggests that current protein recommendations, which are 0.8 grams per kilogram of body weight per day,<sup>5</sup> might be too low for older women to get maximum benefit from a high-calcium diet. A level of 1.0–1.2 grams per kilogram per day is probably more beneficial.

## **BIHW: Haven't studies shown that too much protein causes the body to lose calcium?**

**Dr. Heaney:** This is a good example of how we're learning about the complex interactions of nutrients in health. Our study found higher protein intakes were associated with higher bone mass only when calcium intakes were also high. When calcium intakes fell below about 600 milligrams per day, this relationship became negative.<sup>2</sup>

We've known for nearly 80 years that increasing protein intake can sometimes increase urinary calcium loss.<sup>6</sup> So, since urinary calcium is the most important factor in calcium retention, all other things being equal, excess protein intake should be bad for bone. But historically, the research on this issue has been quite mixed.

Some studies do show that increasing protein intake triggers the body to lose more calcium in the urine.<sup>6,7,8</sup> But, generally, these were short-term studies in which subjects were fed pure protein or amino acids. Other studies using food sources of protein, such as meat or milk, don't show increased calcium loss in the urine.<sup>9,10,11</sup> Scientists aren't sure what's causing the difference in results, but it could be that other food components, such as phosphorus, prevent calcium loss to some degree.<sup>9,12</sup> Also, the studies that don't show a negative effect were longer-term, suggesting that it takes a while for the body to adjust its response to a change in protein intake.<sup>2</sup>

Often the most persuasive findings come from randomized controlled trials. These consistently show that rather than being harmful, higher dietary protein intakes substantially improve recovery after hip fracture and reduce age-related bone loss in the hip.<sup>13,14</sup>

## **BIHW: Does caffeine increase risk for osteoporosis?**

**Dr. Heaney:** A moderate amount of caffeine isn't harmful to bone health as long as people also consume enough calcium.

Controlled clinical studies show that although caffeine ingestion results in a small, temporary increase in calcium excretion, it has no effect on 24-hour urinary calcium loss.<sup>15, 16</sup> Studies have also shown that although caffeine can cause the intestine to absorb slightly less calcium when calcium intake is also low, this effect can be fully offset by as little as one to two tablespoons of milk.<sup>17</sup> This helps explain why the epidemiological studies regarding caffeine and bone health are mixed. All the observations in studies linking caffeine intake to osteoporosis were made in populations with calcium intakes far below recommended levels.<sup>18,19</sup> In studies where dietary calcium intakes were higher, at least 800 milligrams per day, caffeine intake has an almost negligible effect.<sup>20, 21, 22, 23, 24, 25</sup>

## **BIHW: Some people believe that sparkling soft drinks, particularly colas, adversely affect bone health. Is this true?**

**Dr. Heaney:** No. A few observational studies have found an association between high carbonated soft drink consumption and either increased fracture risk or decreased bone mineral density, and the usual explanation given has been that one or more constituents in these beverages, such as caffeine or phosphoric acid, increases urinary calcium losses.<sup>26, 27, 28</sup> But, this theory didn't hold up under experimental studies done in my lab using carefully controlled calcium-metabolic methods. We found that the net effect of carbonated soft drinks, including colas, on calcium retention was negligible.<sup>29</sup> As a result, it seems likely that colas' prominence in observational studies is due to their prominence in the marketplace. For example, 27 out of 30 subjects in our study reported being cola drinkers.

“ Our results showed that the effect of soft drinks on calcium losses, including those with caffeine and colas with phosphoric acid, is negligible. ”

The real issue is that people who drink a lot of soft drinks also tend to have an overall diet that is low in calcium and other important nutrients bones need. And, it's the poor diet and low calcium intake impacting skeletal fragility that need to be addressed—not whether or not they drink soft drinks per se.

## **BIHW: Could you explain your study on the impact of carbonated soft drinks on calcium in more detail?**

**Dr. Heaney:** In 2001, we published a calcium metabolic study in the American Journal of Clinical Nutrition that compared the impact of four different soft drinks, plus water and milk, on urinary calcium in adult women who normally consume soft drinks. Because that study evaluated a caffeine-free and a regular cola, both of which contained phosphoric acid, and a caffeine-free and a caffeinated citrus-flavored soft drink, neither of which contained phosphoric acid, we were able to evaluate the impact of soft drinks overall, as well as the individual and combined impact of these ingredients, on calcium balance. Our results showed that the effect of soft drinks on calcium losses, including those with caffeine and colas with phosphoric acid, is negligible.<sup>29</sup>

Specifically, we found that phosphoric acid had no impact at all: The caffeine-free cola did not increase urinary calcium losses. In addition, although both the caffeinated cola and caffeinated citrus soft drink caused a small increase in urinary calcium loss, it was about equal to that previously found for caffeine alone.

However, since the body can compensate for the small impact of caffeine by reducing calcium losses later in the day,<sup>15, 16</sup> we determined that soft drinks, including colas with phosphoric acid and those with caffeine, have essentially no impact on calcium balance.

**BIHW: Why do concerns over phosphoric acid in colas seem to linger? Is there something unique about phosphoric acid or phosphorus that negatively affects bone health?**

**Dr. Heaney:** No. The common myth that the phosphoric acid in colas draws calcium out of the bones is likely linked to a theory that an “acidic diet” causes minerals to be drawn from the bones to neutralize the impact of the acid on blood pH. But, as I explained earlier, our calcium-metabolic study found that the phosphoric acid in cola had no net impact on urinary calcium losses.<sup>29</sup> Now, I must admit that this finding was initially unexpected, but perhaps it should not have been, considering the body normally produces 50 to 100 mEq of acid a day during the metabolism of food.<sup>30</sup> The acid load imposed by a 20-ounce cola is only about 4.5 to 5.0 mEq, or substantially less than the amount produced by eating even a moderate protein breakfast.

Phosphorus Content	
FOOD/BEVERAGE	PHOSPHORUS (mg)
Cola (8 oz)	25 - 40
Orange Juice (8 oz), unfortified	27
Peanuts (1 oz), shelled	113
Chicken breast, roasted	124
Cheddar cheese (1 oz)	145
Milk (8 oz), 1%	232

Sources: The Coca-Cola Company and USDA/ARS. 2006. USDA National Nutrient Database for Standard Reference, Release 19. <http://www.ars.usda.gov/ba/bhnrc/ndl>.

There is also no plausible evidence that phosphorus in the diet is harmful to bone health in humans. This theory began with studies showing a harmful effect in animals and the findings were extrapolated to humans. But the animal diets contained amounts of phosphorus up to five times the amount in a typical human diet, so the findings aren't applicable to humans.<sup>31</sup> And, although phosphorus is widely believed to form insoluble complexes with calcium and is often listed as a potential anti-absorber on web sites, studies conducted more than 25 years ago in my lab and others showed that varying phosphorus intakes have little or no effect on overall calcium balance.<sup>6, 32</sup>

Phosphorus is actually quite plentiful in the food supply. For example, depending on the brand, 8 ounces of cola contains 25–40 milligrams of phosphorus, in the form of phosphoric acid, which is used as the acidulant. The same amount of orange juice has 27 mg of phosphorus and milk has 232 milligrams in 8 ounces. To put these amounts into perspective, national dietary surveys in the U.S. show that the highest level of phosphorus intake among individuals who

don't take supplements is about 2500 mg per day, which is well within the safe limits established by the Institute of Medicine.<sup>31</sup> The safe limits for phosphorus established by the Institute of Medicine are 4,000 mg (4 g) per day for individuals between the ages of 9 and 70 and 3,000 mg (3 g) per day for those over 70 and between the ages of 1 and 8.<sup>31</sup>

**BIHW: Does the carbonation in soft drinks harm bones?**

**Dr. Heaney:** No. In fact, research has shown that carbonated waters rich in calcium and other minerals can actually improve measures of skeletal metabolism in postmenopausal women with low calcium intakes.<sup>33</sup> And, as for carbonation in soft drinks, our calcium-metabolic soft drink study also exonerated carbonation when we determined that caffeine-free soft drinks had no net effect on urinary calcium loss.<sup>29</sup> This isn't surprising since the amount of carbon dioxide absorbed from a soft drink is relatively very small compared to the amount our cells continuously produce as a byproduct of energy production.

“ If childrens' bone health is at risk, it's not because they drink soft drinks or other beverages per se, but because it's harder for kids to get enough calcium now that milk is not the mealtime mainstay it once was. ”

**BIHW: Some studies suggest that soft drinks may be squeezing milk out of teens' diets. Should soft drinks be off limits to kids and teens?**

**Dr. Heaney:** That's not necessary. Kids can still enjoy a soft drink and have healthy bones as long as they eat a well-balanced diet with enough calcium and other nutrients important for bone health and get plenty of physical activity.

However, it is true that teens drink less milk today than they did 20 years ago. And, they drink more soft drinks, bottled waters, sports drinks, teas, coffee and other beverages. If children's bone health is at risk, it's not because they drink soft drinks or other beverages per se, but because it's harder for kids to get enough calcium now that milk is not the mealtime mainstay that it once was. Forty years ago, families sat down to dinner together every night with a pitcher of milk on the table. Things are different today. Everyone is busy and few families eat dinner together at home every night. And, kids clearly prefer many other beverage choices. So, getting enough calcium into kids today is more difficult and requires a conscious effort on the part of parents, children, educators, health professionals and even food companies.

**BIHW: Is drinking milk essential for bone health?**

**Dr. Heaney:** Physiologically, humans don't need milk to get enough calcium. In fact, primitive diets didn't include it. However, these hunter-gatherers consumed mostly low-calorie, mineral-rich leaves and roots that, when energy intake was adequate, also provided adequate amounts of calcium.

Today, few people eat enough mineral-rich vegetables to ensure adequate micronutrient intake, making it challenging to get enough calcium without consuming milk, which is rich in both calcium and the other

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nutrients bones need. However, other dairy foods like cheese and yogurt are also excellent sources of calcium, and leafy greens such as kale and collards contribute calcium, although, as I said, you have to eat a substantial amount.

## **BIHW: What is the role of fortified foods and beverages?**

**Dr. Heaney:** Fortifying foods and beverages like cereals and orange juice with calcium (and vitamin D) can supply significant amounts of calcium as long as the calcium in the product is available and well-absorbed. But, there are some issues to overcome here.

For example, my lab found that much of the calcium in some brands of fortified soy beverages settles to the bottom of the container and remains there even after the container is shaken. We also found that the form of calcium used was only about 75% as absorbable as the calcium from cows' milk. These factors reduced the amount of calcium actually available to the consumer to 50% or less of that listed on the label.<sup>34</sup> Fortified orange juice can have some of the same problems.<sup>35</sup> Right now the only way to know how much of the calcium added to a product is actually available to the body is to conduct time consuming and relatively expensive metabolic studies using isotopic tracers imbedded in the fortificants, which some companies are doing.

## **BIHW: What do you recommend we do today to ensure long-term bone health?**

**Dr. Heaney:** It goes back to the two basics I started with: food and work. A well-balanced diet that meets recommendations for all nutrients and regular weight-bearing physical activity are the two essential elements for having strong bones that last as long as you do. And it's never too early—or too late—to put these healthy habits into practice.

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## **FREE CPE PROGRAM:**

**Beverages & Bone Health**—A free self-study program based on a webinar presentation by Dr. Heaney on this topic has been approved for 1.5 CPE hours by the Commission on Dietetic Registration.

See: [www.thebeverageinstitute.org](http://www.thebeverageinstitute.org)

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