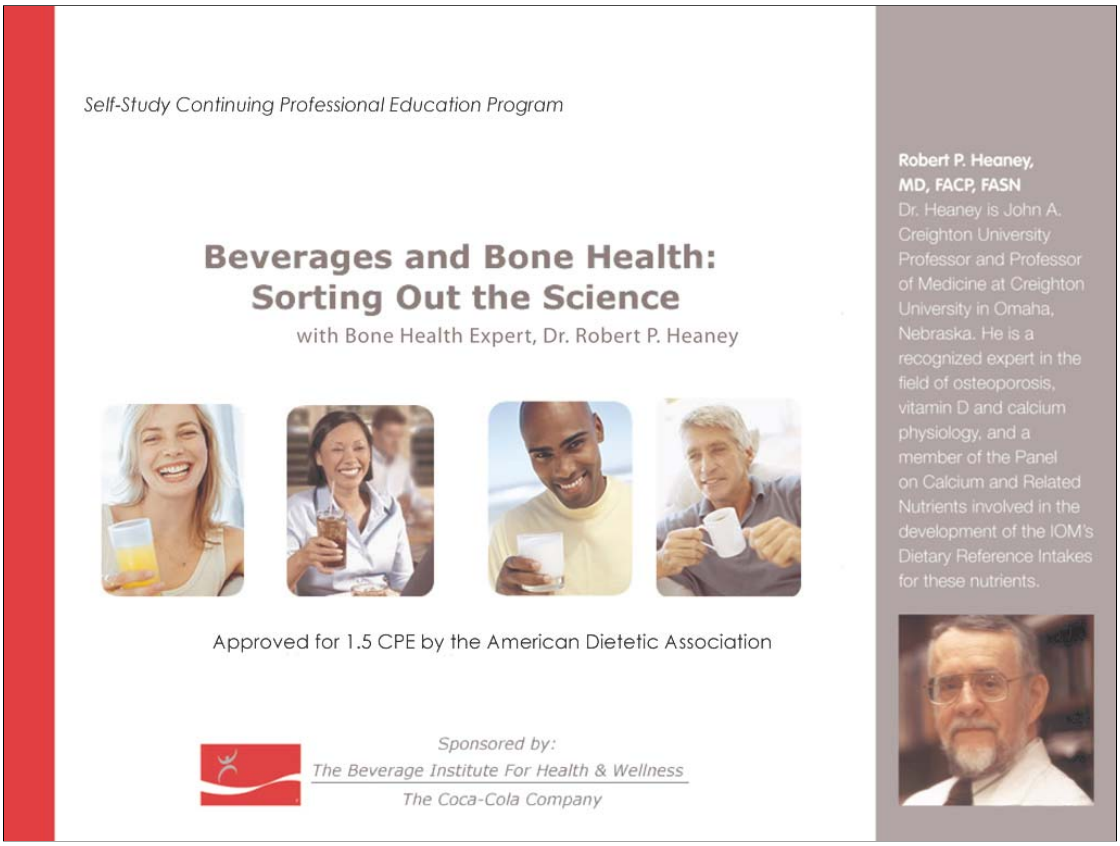


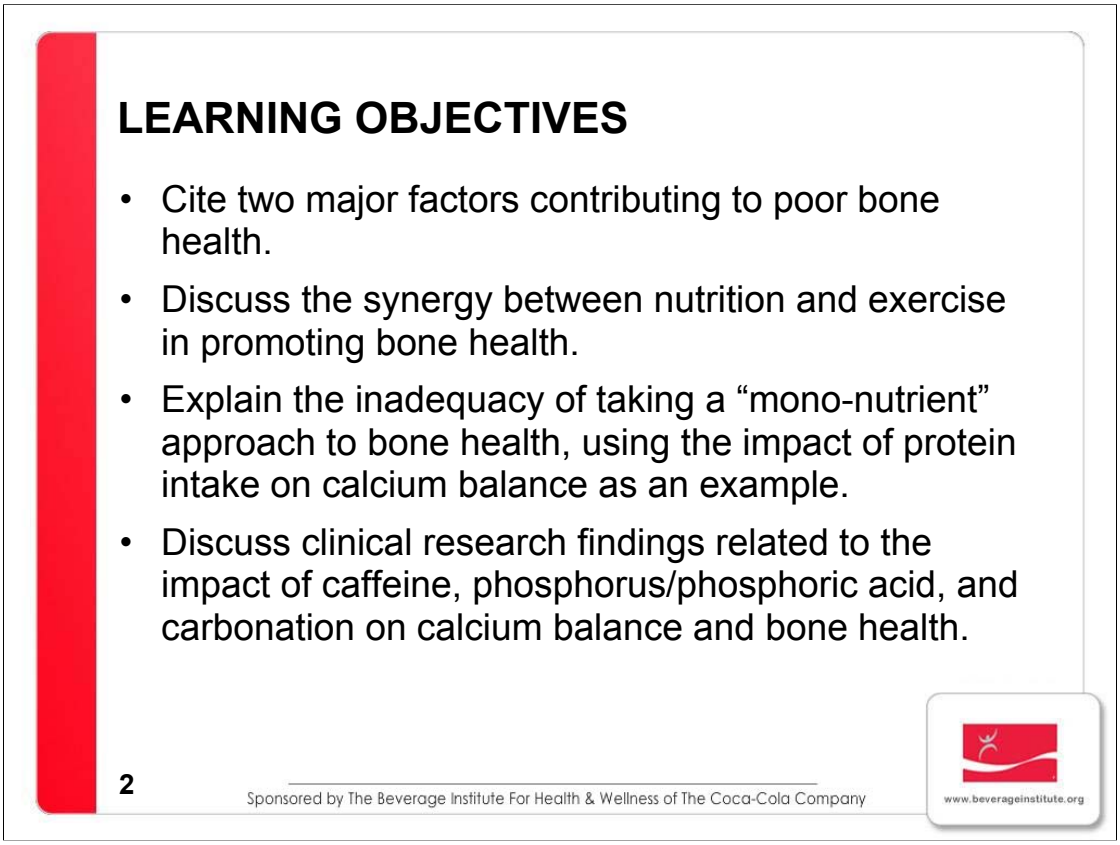
ABOUT THIS PROGRAM

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.

What is responsible for this public health crisis? It's well-known that meeting recommendations for calcium and vitamin D is critical for bone health—but is this enough? Is a high-protein diet good or bad for bones? Are carbonated beverages or their components, such as caffeine and phosphoric acid, harmful? Is milk essential? Are fortified foods and beverages helpful?

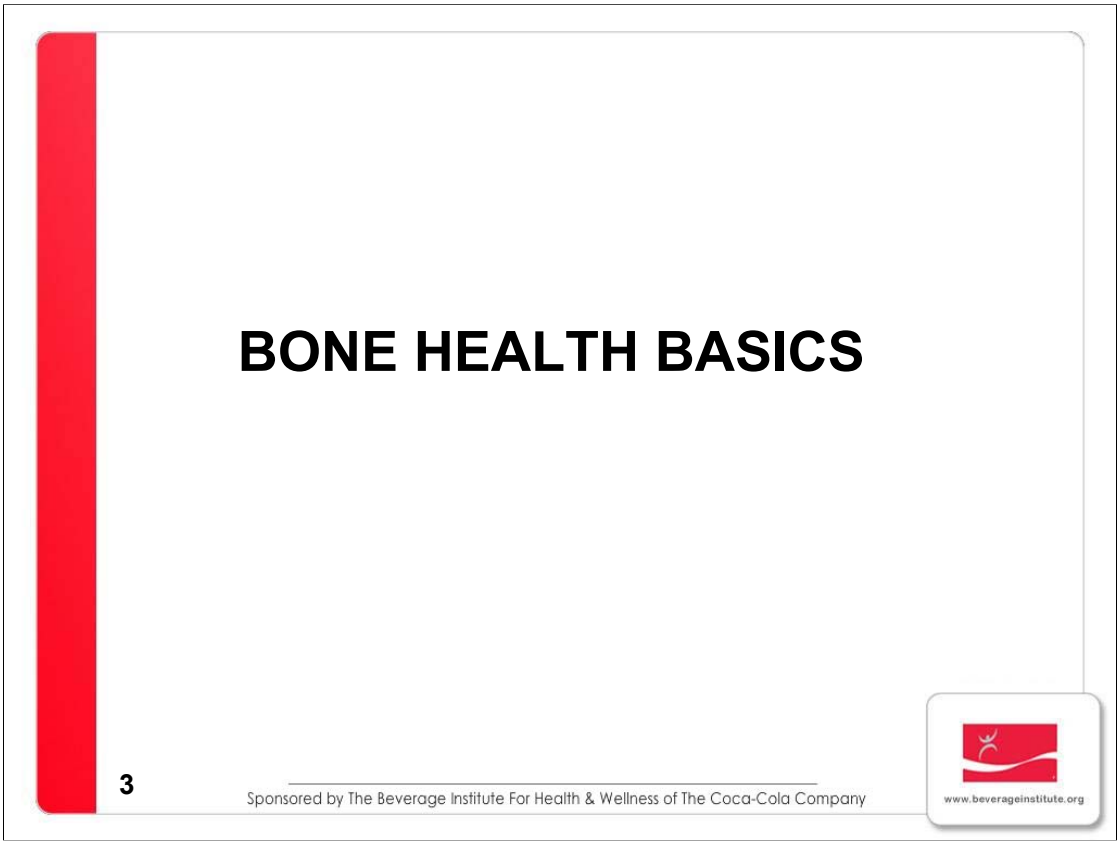
The following self-study program was developed in collaboration with bone health expert Dr. Robert P. Heaney. Through this program, Dr. Heaney shares the latest scientific understanding about bone health, with particular emphasis on research related to the effect of carbonated beverages, to help practicing nutrition professionals more effectively counsel their clients on diet and behavior issues related to bone health.

SOURCE: National Osteoporosis Foundation. Facts and statistics about osteoporosis and its impact. Available at: http://www.iofbonehealth.org/facts-and-statistics.html. Accessed December 13, 2007.



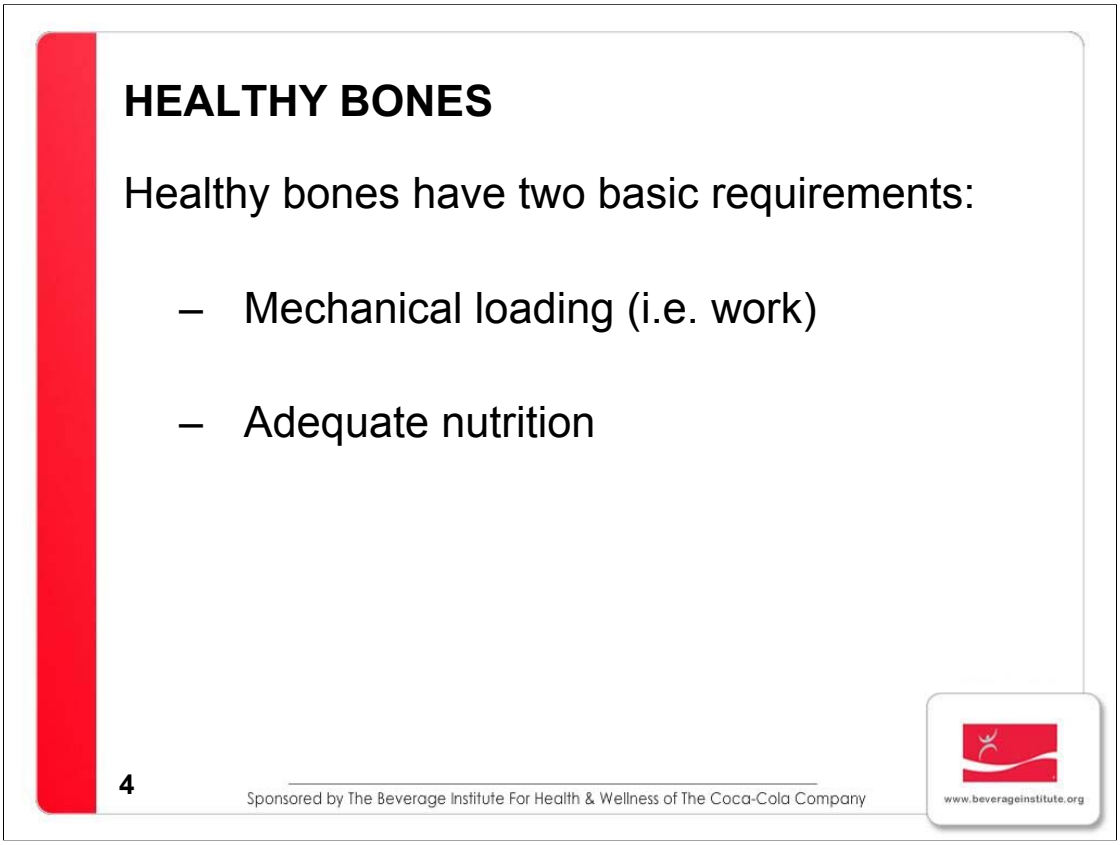
AFTER COMPLETING THIS SELF-STUDY LEARNING MODULE, THE DIETETIC PROFESSIONAL WILL BE ABLE TO:

- Cite two major factors contributing to poor bone health.
- Discuss the synergy between nutrition and exercise in promoting bone health.
- Explain the inadequacy of taking a “mono-nutrient” approach to bone health, using the impact of protein intake on calcium balance as an example.
- Discuss clinical research findings related to the impact of caffeine, phosphorus/phosphoric acid and carbonation on calcium balance and bone health.



BONE HEALTH BASICS

SPEAKER COMMENTS: Let’s begin by reviewing the basics of bone health and then look at factors that may influence bone health.



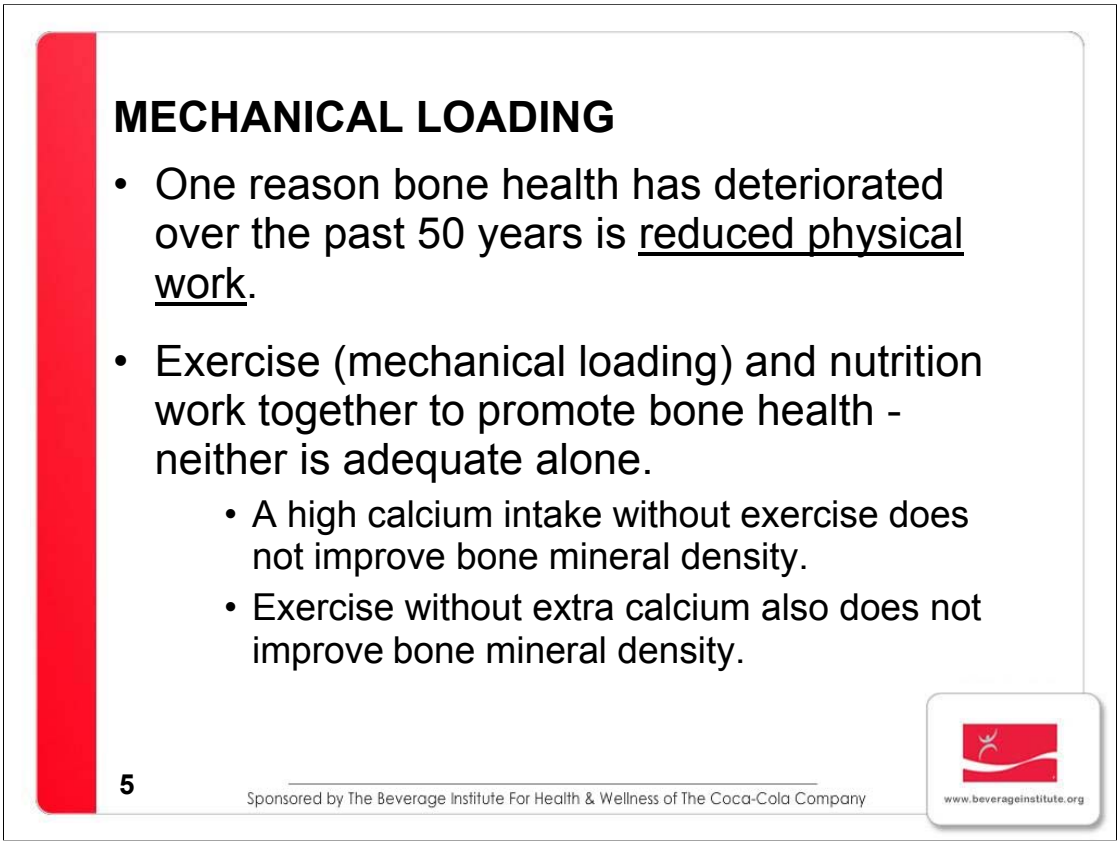
BONE HEALTH BASICS

SPEAKER COMMENTS: In general, our bone health, or skeletal status, has deteriorated over the past 50 years.

Healthy bones have two basic requirements:

- The first requirement is mechanical loading, which is the impact on bones from weight-bearing exercise like walking, lifting weights or manual labor. We can think of mechanical loading as a four-letter word—work.
- The second requirement is adequate nutrition.

Let's look more closely at these two requirements—and how they work together to promote healthy bones.



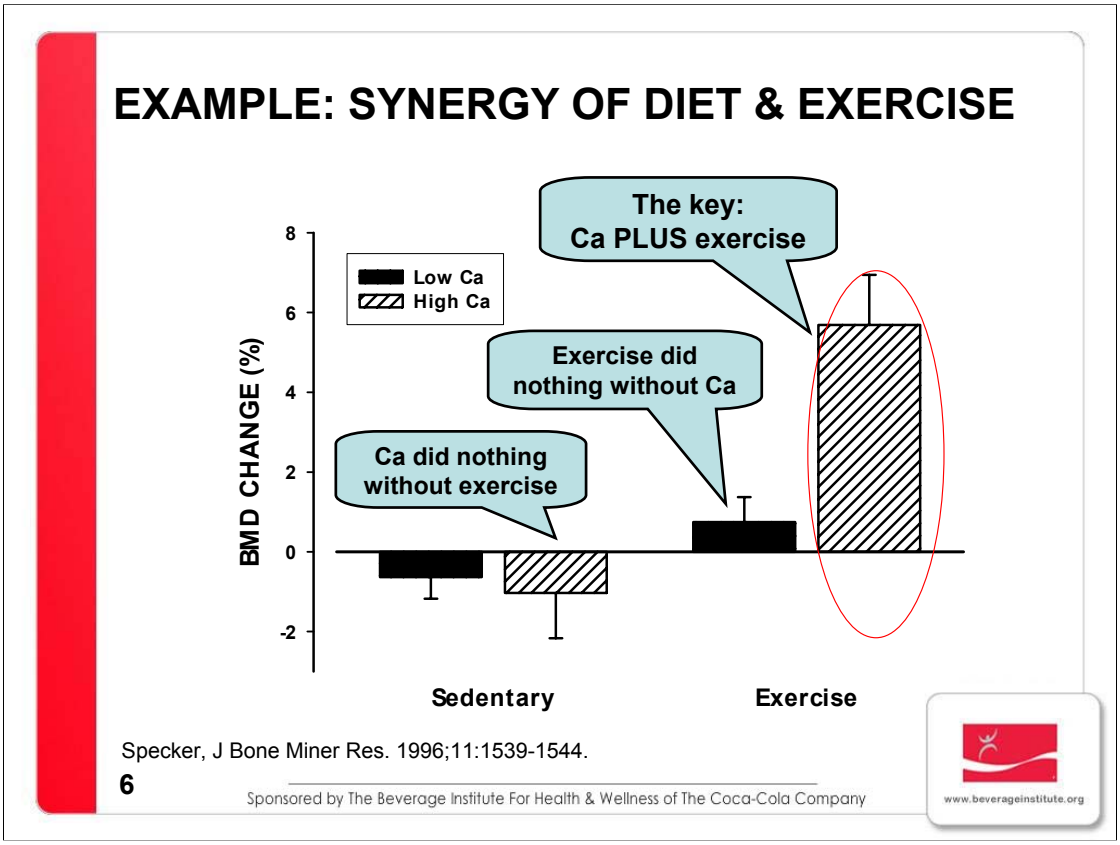
BONE HEALTH BASICS: MECHANICAL LOADING

SPEAKER COMMENTS: One reason bone health has deteriorated is that we do much less physical work today than our grandparents did, so we're not loading the skeleton nearly as much.

This is a recent change in how humans live and work. Today, we use power lawn mowers or pay someone to cut our grass. We ride instead of walk. We take an elevator or escalator instead of climbing stairs. We sit at a computer screen where we use energy in our brains but nowhere else in our bodies.

Physical work is key to bone health, because as the next slide demonstrates, a high calcium intake without exercise does not change bone mineral density, and conversely, exercise without extra calcium also does not change bone mineral density. Bones need both.

Now, let's see the evidence for this.



BONE HEALTH BASICS: MECHANICAL LOADING

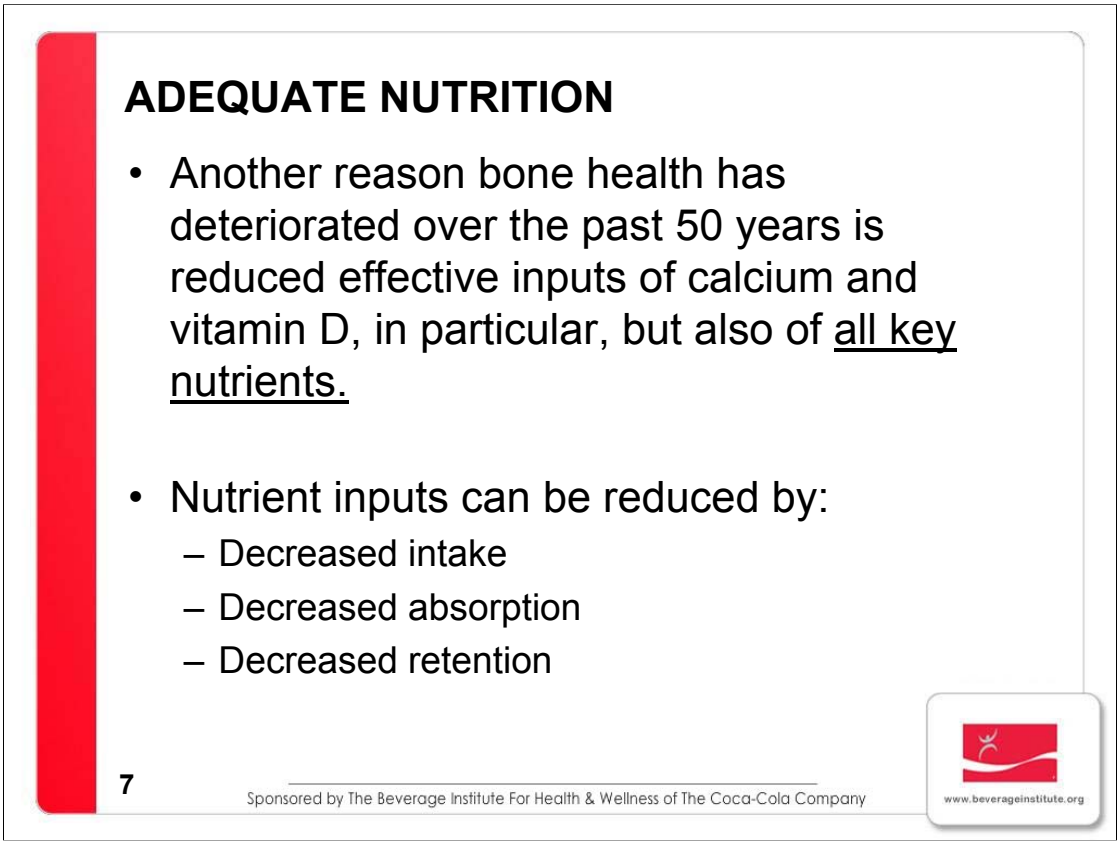
SPEAKER COMMENTS: This graph is from a 1996 review of 17 trials that looked at the effects of low calcium intakes (<1,000 mg/day) and high calcium intakes (1,000+ mg/day) and physical activity levels on change in bone mineral density (BMD).

As you can see:

- A high calcium intake without exercise does not change bone mineral density.
- Exercise without adequate calcium also has little to no impact on bone mineral density
- Exercise PLUS adequate calcium has a significant impact on bone mineral density

Conclusion: Evidence supports a synergy between calcium intake and exercise in supporting bone health. Neither exercise nor nutrition alone are adequate to promote bone health. Healthy bones need both.

SOURCE: Specker BL. Evidence for an interaction between calcium intake and physical activity on changes in bone mineral density. J Bone Miner Res. 1996;11:1539-1544.



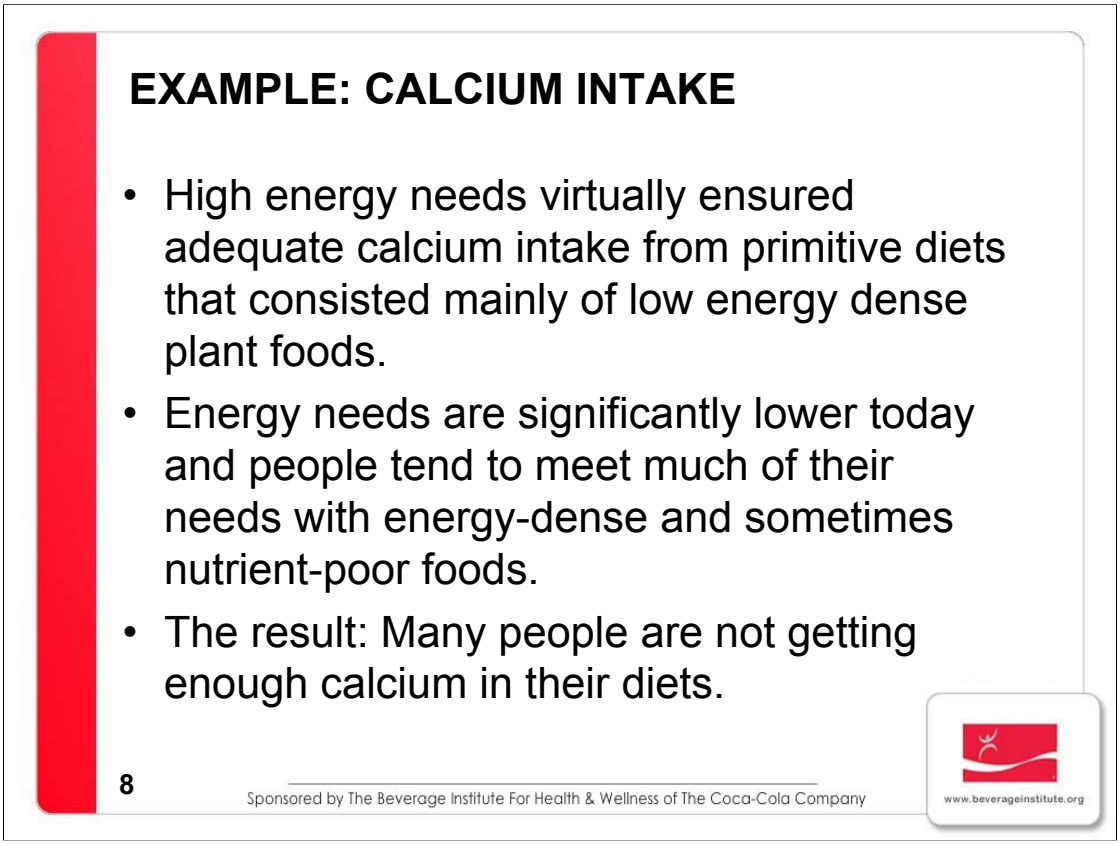
BONE HEALTH BASICS: ADEQUATE NUTRITION

SPEAKER COMMENTS: Another reason bone health has deteriorated is reduced effective inputs of calcium and vitamin D, in particular, but also of all key nutrients.

There are several reasons why effective inputs could be reduced:

- Decreased absolute intake coming into the mouth—for example, the diet might be too low in calcium or other nutrient(s).
- Decreased absorption at the intestine—some dietary components and medical conditions reduce the absorption of calcium and/or other nutrient(s).
- Decreased retention—some dietary components and medical conditions increase urinary losses of calcium and/or other nutrient(s).

The impact of each factor on BMD depends on the extent to which the body is able to adapt—for example, by increasing absorption and/or decreasing urinary losses of calcium and/or other nutrients when dietary intake is low.

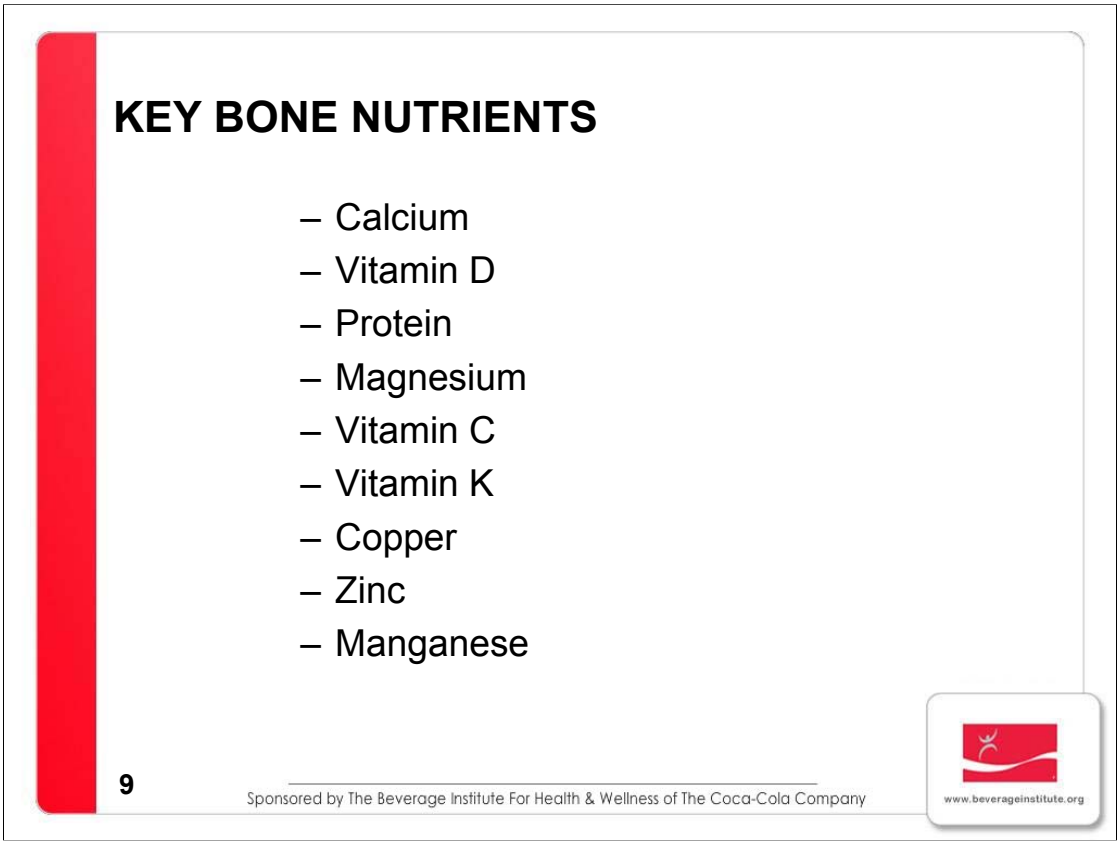


BONE HEALTH BASICS: ADEQUATE NUTRITION

SPEAKER COMMENTS: As an example, let's look at why effective inputs of calcium have declined since primitive times.

- The diet of our hunter-gatherer ancestors was high in calcium. Hunter-gatherers had high energy needs and their diet consisted mainly of low-energy-dense plant foods. Simply meeting energy needs virtually ensured that the diet provided enough minerals, including calcium.
- In contrast, our energy needs are much lower today, so we don't need to eat as much food to meet our needs. Also, modern diets often consist of energy-dense and sometimes nutrient-poor foods.

The result: Many people today are not getting adequate calcium in their diets to maintain bone health.



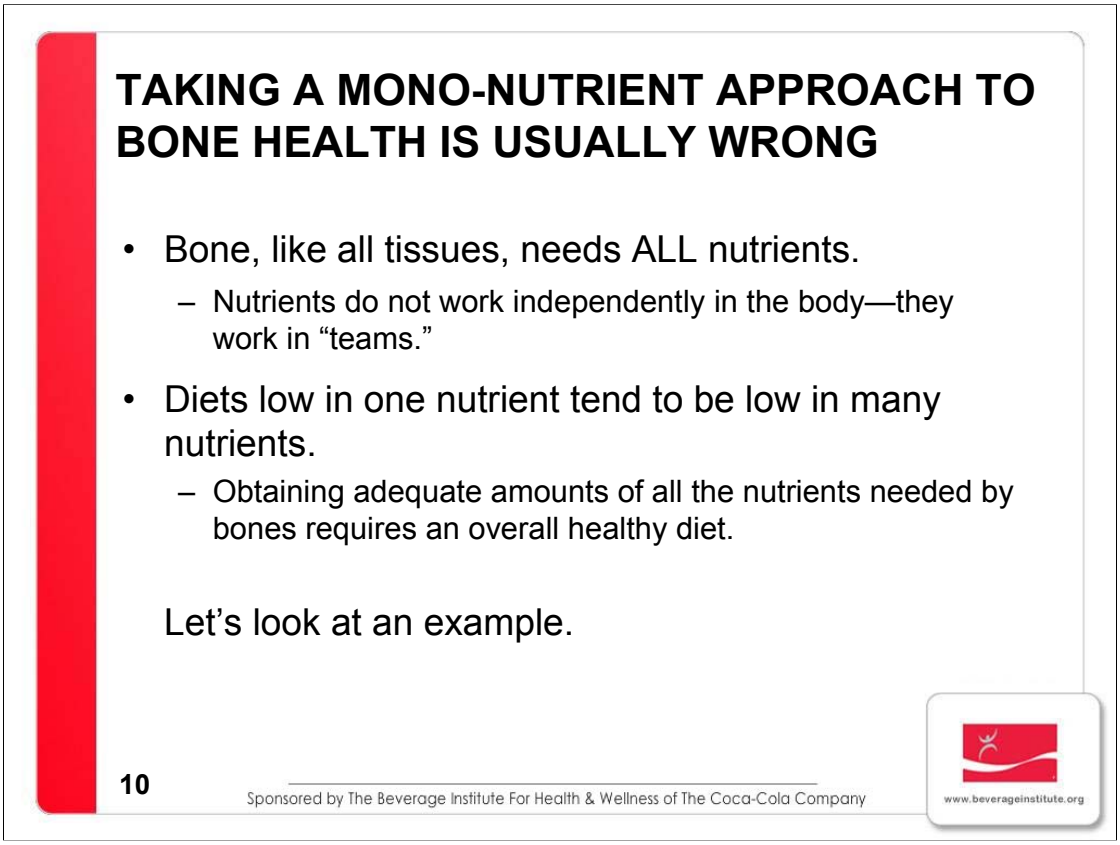
BONE HEALTH BASICS: ADEQUATE NUTRITION

SPEAKER COMMENTS: Over the past 25 years, research has focused almost exclusively on calcium, but animal and human studies clearly link many other nutrients to building and maintaining a strong skeleton. As a result, we must recognize the role of total nutrition and bone health. And the scientific community is starting to do just that.

For example:

- Vitamin D has become a point of considerable interest in the last five or six years.
- The important role of protein in bone health is just now emerging, although we should have known that all along because bone is 50% protein by volume.
- Other nutrients of interest include magnesium, vitamins C and K, copper, zinc and manganese.

However, it's important to remember that bone, like all tissues, needs ALL nutrients—not just those listed on this slide—and that taking a mono-nutrient approach to bone health is usually wrong.



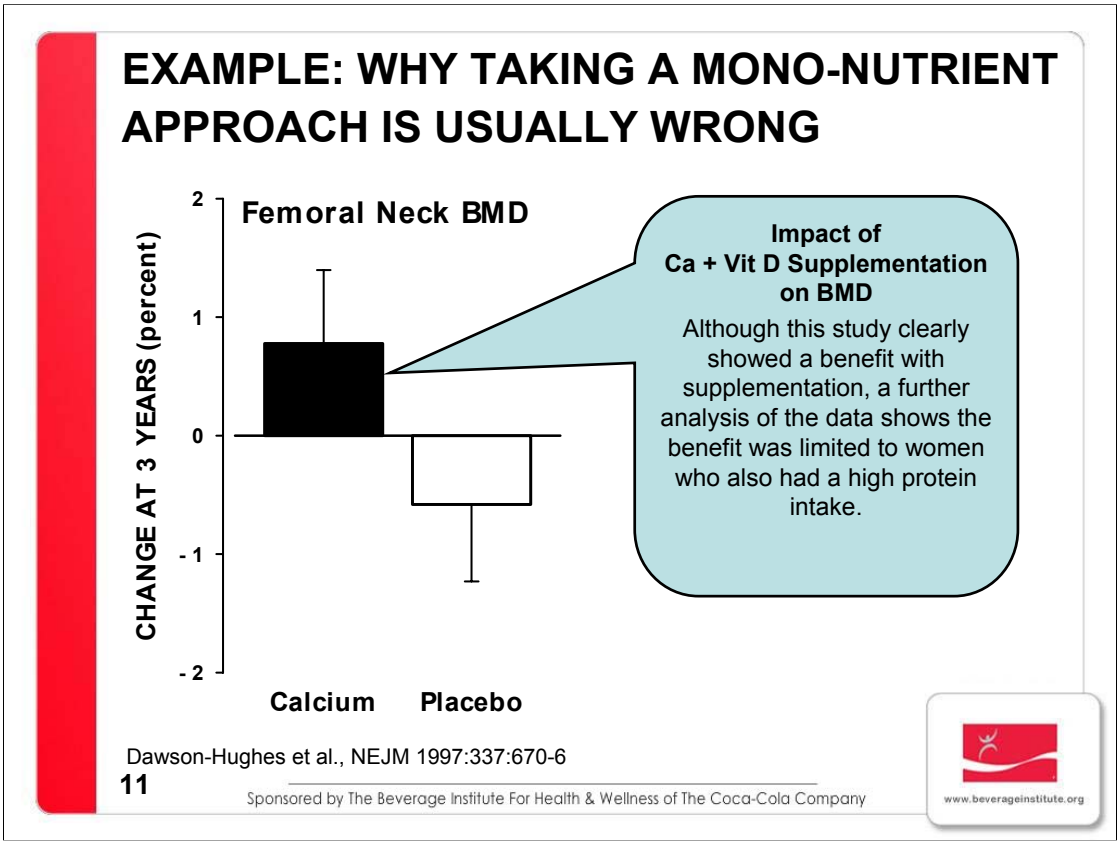
BONE HEALTH BASICS: ADEQUATE NUTRITION

Why Taking A Mono-nutrient Approach Is Usually Wrong

SPEAKER COMMENTS: All too often, possibly because of the way research is conducted and research results are reported, we tend to equate a single nutrient with a single organ system, and that simply is not correct.

- All tissues need all nutrients, and for that reason, a "mono-nutrient" approach will usually be wrong, or at least inadequate.
- Furthermore, diets low in one nutrient tend to be low in many nutrients, so mono-nutrient approaches are wrong on that count as well.

The next few slides look at an example of this: The impact of dietary protein intake on the effectiveness of calcium and vitamin D supplementation in women with the goal of improving calcium balance and bone mineral density (BMD).



BONE HEALTH BASICS: ADEQUATE NUTRITION

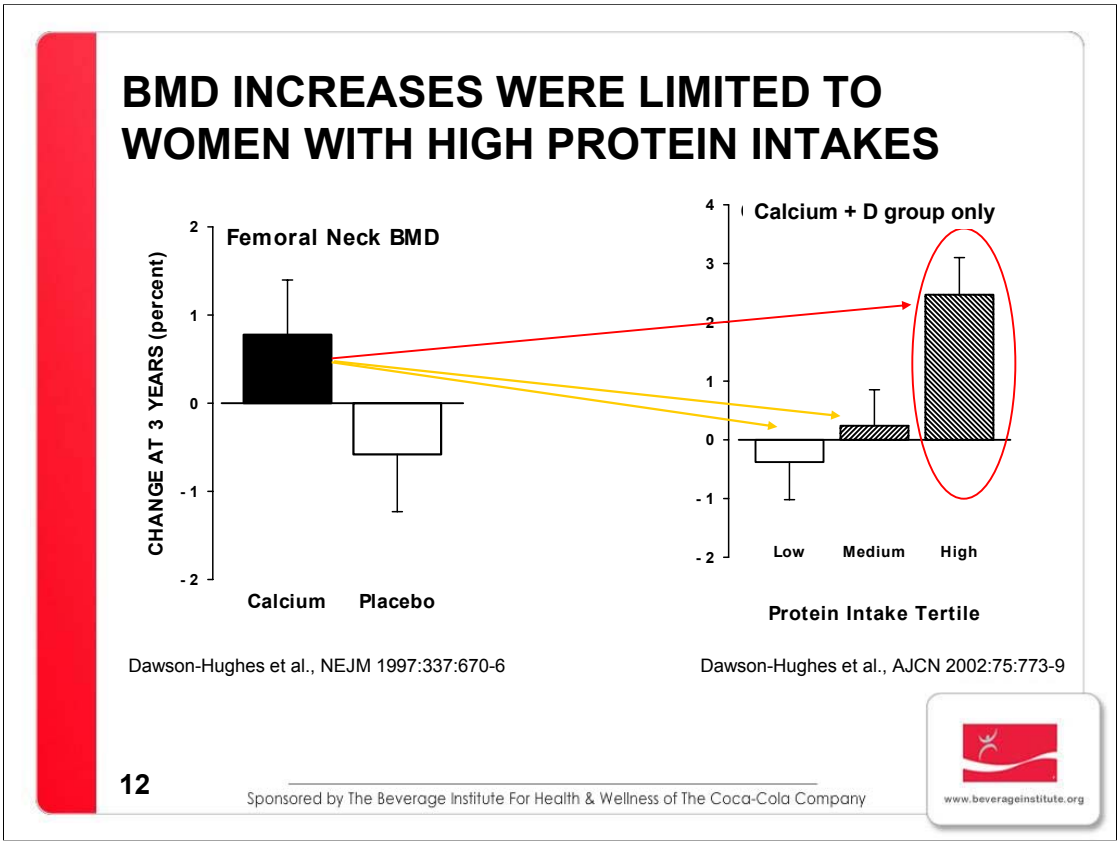
Example: Why Taking A Mono-nutrient Approach Is Usually Wrong

SPEAKER COMMENTS: This slide is from Dr. Bess Dawson-Hughes' landmark study showing increased BMD in healthy elderly subjects—men (N=176) and women (N=213) age 65 years and older—after 3 years of supplemental calcium and vitamin D.

The black bar on the left clearly shows an increase in bone mineral density at the femoral neck in subjects who received 500 mg calcium plus 700 IU of vitamin D3 (cholecalciferol) per day, as contrasted with the white bar, which shows a loss of bone in those given placebo.

Although Ca + Vit D supplementation was clearly beneficial, a further analysis of the data showed the benefit was limited to those women who had high protein intakes, as we shall see in the next slide.

SOURCE: Dawson-Hughes B, Harris SS, Krall EA, Dallal GE. Effect of calcium and vitamin D supplementation on bone density in men and women 65 years of age or older. N Engl J Med. 1997;337:670-676.



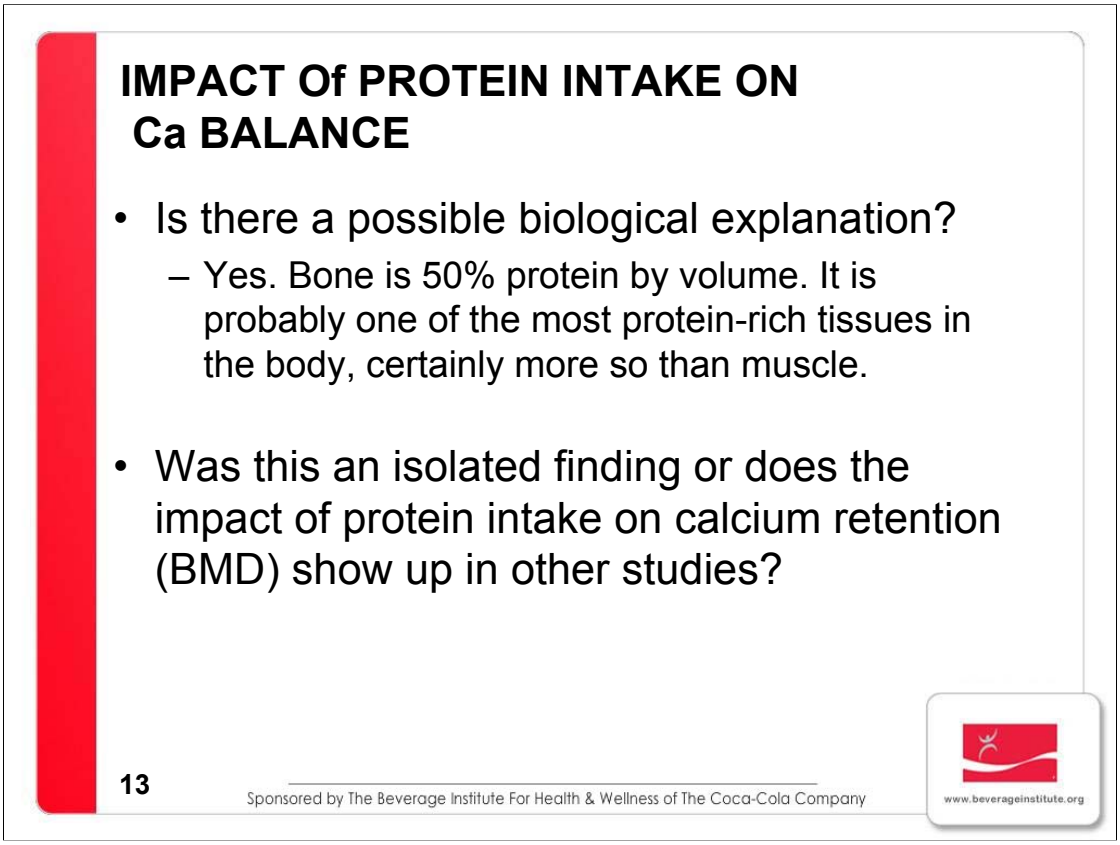
BONE HEALTH BASICS: ADEQUATE NUTRITION

Example: Why Taking A Mono-nutrient Approach Is Usually Wrong

SPEAKER COMMENTS: The graph on the left is simply a repeat of the previous slide showing increases in BMD in the calcium plus vitamin D supplemented group compared to placebo. The graph inserted on the right-hand side is the supplemented group's data broken out by three levels or tertiles of protein intake as a percent of energy: Low (9.64% - 15.49%), Medium (15.53% - 18.15%) and High (18.16% - 29.14%).

It is clear from the graph on the right that the bone gain at the femoral neck site was almost completely confined to those in the calcium and vitamin D group that had the highest protein intake. Conversely, subjects who received calcium and vitamin D, but had low protein intakes, did not show an improvement in bone mineral density.

SOURCE: Dawson-Hughes B, Harris SS. Calcium intake influences the association of protein intake with rates of bone loss in elderly men and women. Am J Clin Nutr. 2002;75:773-779.



BONE HEALTH BASICS: ADEQUATE NUTRITION

Example: Why Taking A Mono-nutrient Approach Is Usually Wrong

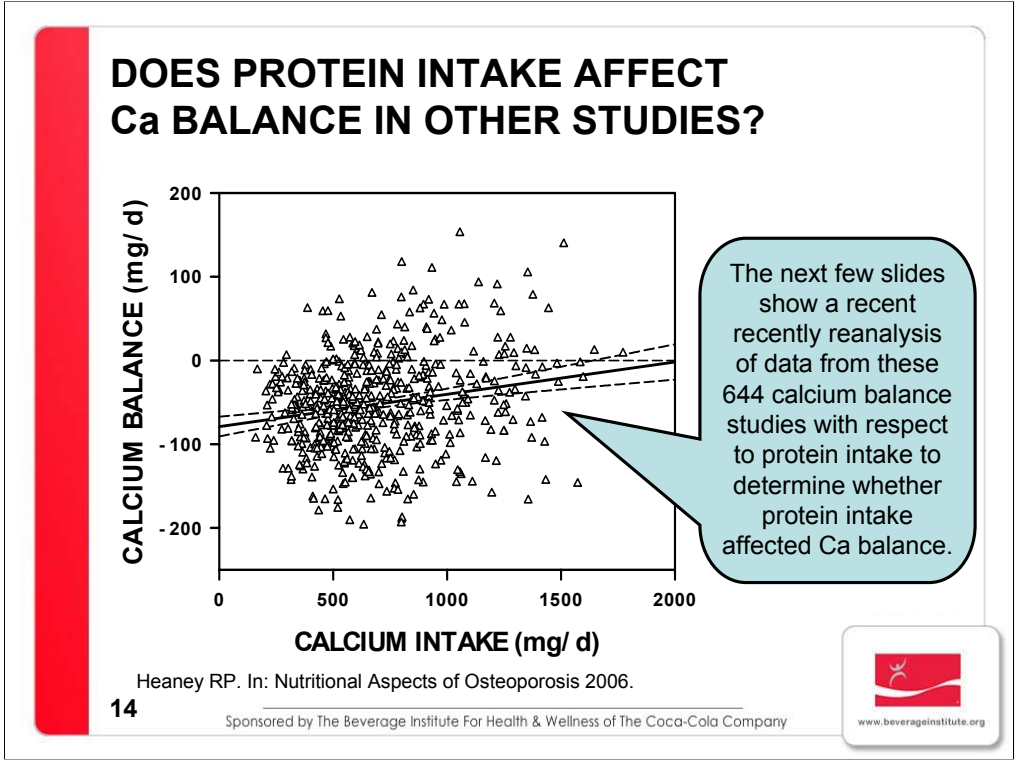
SPEAKER COMMENTS: Dawson-Hughes' findings bring up two questions:

1. Is there is a biological explanation for how protein intake could affect the impact of calcium and vitamin D supplementation on BMD?

   The answer is yes, there is. Bone is 50% protein by volume. In fact, bone is probably one of the most protein-rich tissues in the body, certainly more so than muscle. Protein intake also increases the concentration of IGF-1, which is trophic for bone, i.e., it helps to build bone. So it is not just the bulk raw material, but the effect that protein has on the growth environment itself that may be playing a role here. So it is reasonable to say that protein intake could be a limiting factor in BMD gains.

2. Was Dawson-Hughes' result an isolated finding or does the impact of protein intake on calcium retention (BMD) show up in other studies?

   We'll examine this second question in the next slide.



BONE HEALTH BASICS: ADEQUATE NUTRITION:

Why Taking A Mono-nutrient Approach Is Usually Wrong

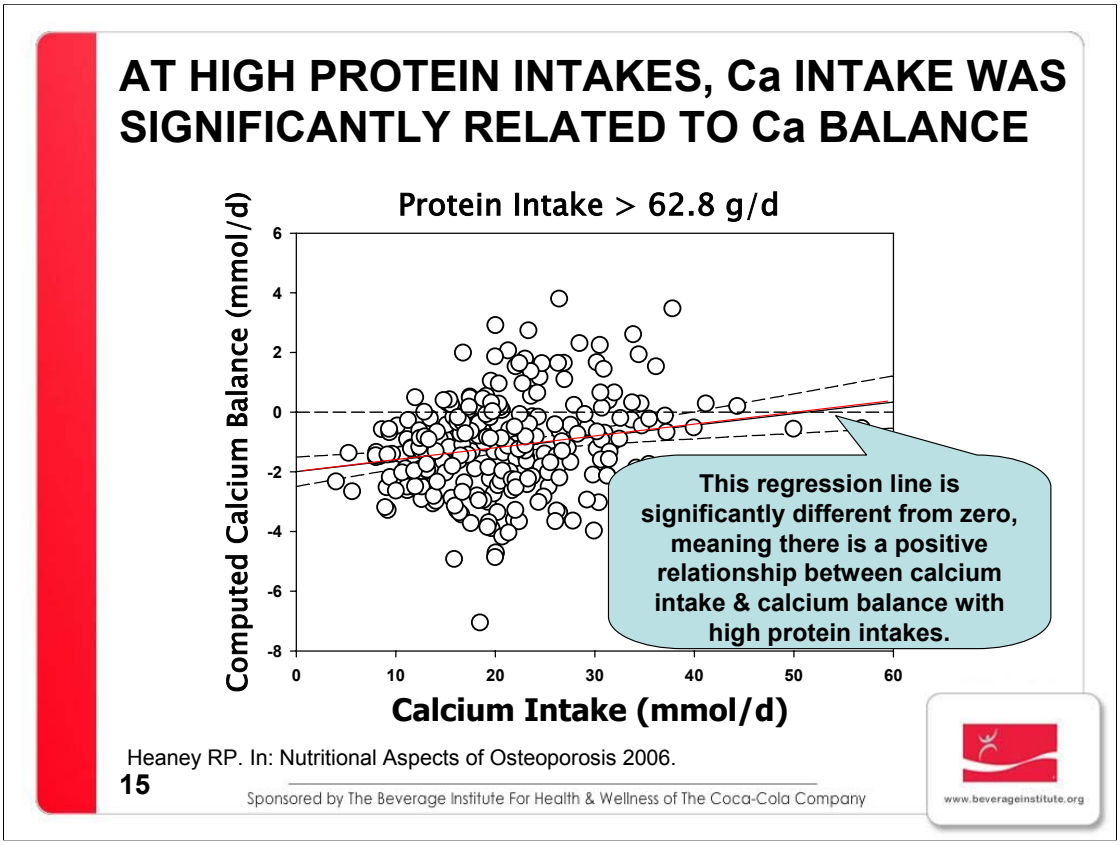
Example: Impact of Protein Intake on Calcium Balance

SPEAKER COMMENTS: The next few slides review an analysis done in my lab that answered the question of whether there is independent support for Dawson-Hughes' finding that protein intake affects the BMD gains associated with calcium and vitamin D supplementation.

About this slide: This graph plots calcium balance as a function of calcium intake for 644 metabolic calcium balance studies conducted on women (mean age was 50.2 years) over several years. In fact, these data were the basis for the original calcium intake recommendations of the National Institutes of Health Consensus Conference on Osteoporosis in 1984.

As you see, there is a highly statistically significant upward trend (line slope) showing higher calcium intakes associated with better calcium balance (retention). The findings make sense because the body can't retain much calcium if not enough calcium is consumed.

The next few slides will show a recent reanalysis of these data with respect to protein intake and its relationship to the slope of calcium balance on calcium intake. As a point of reference, a positive slope means that increasing calcium intake has a positive effect on calcium balance. A slope that's not positive means that increasing calcium intake doesn't do much to help calcium balance.

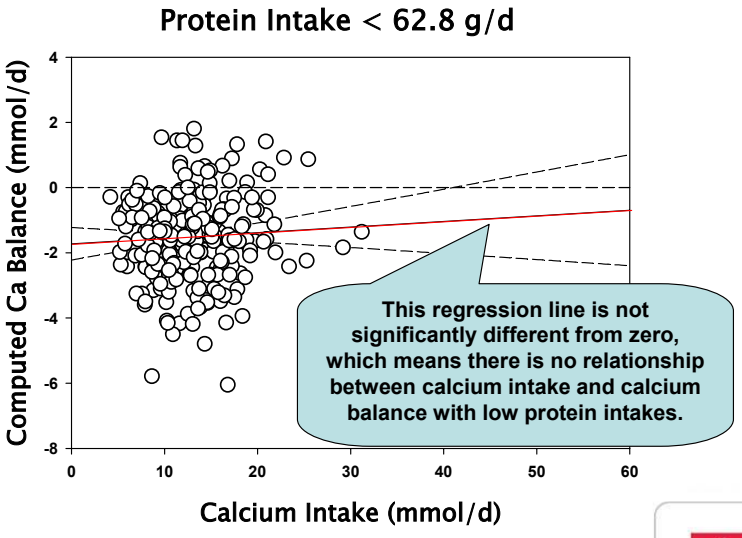


BONE HEALTH BASICS: ADEQUATE NUTRITION

Example: Impact of Protein Intake on Calcium Balance

SPEAKER COMMENTS: This is the same analysis as on the previous slide except confined to those who had protein intakes above the median for the group (62 g/d). The graph clearly shows that the slope of calcium balance on calcium intake is significantly positive (meaning that increasing calcium intake has a positive effect on calcium balance) in those whose protein intake was above the median of 62 grams per day.

AT LOW PROTEIN INTAKES, Ca INTAKE WAS NOT RELATED TO Ca BALANCE



Heaney RP. In: Nutritional Aspects of Osteoporosis 2006.

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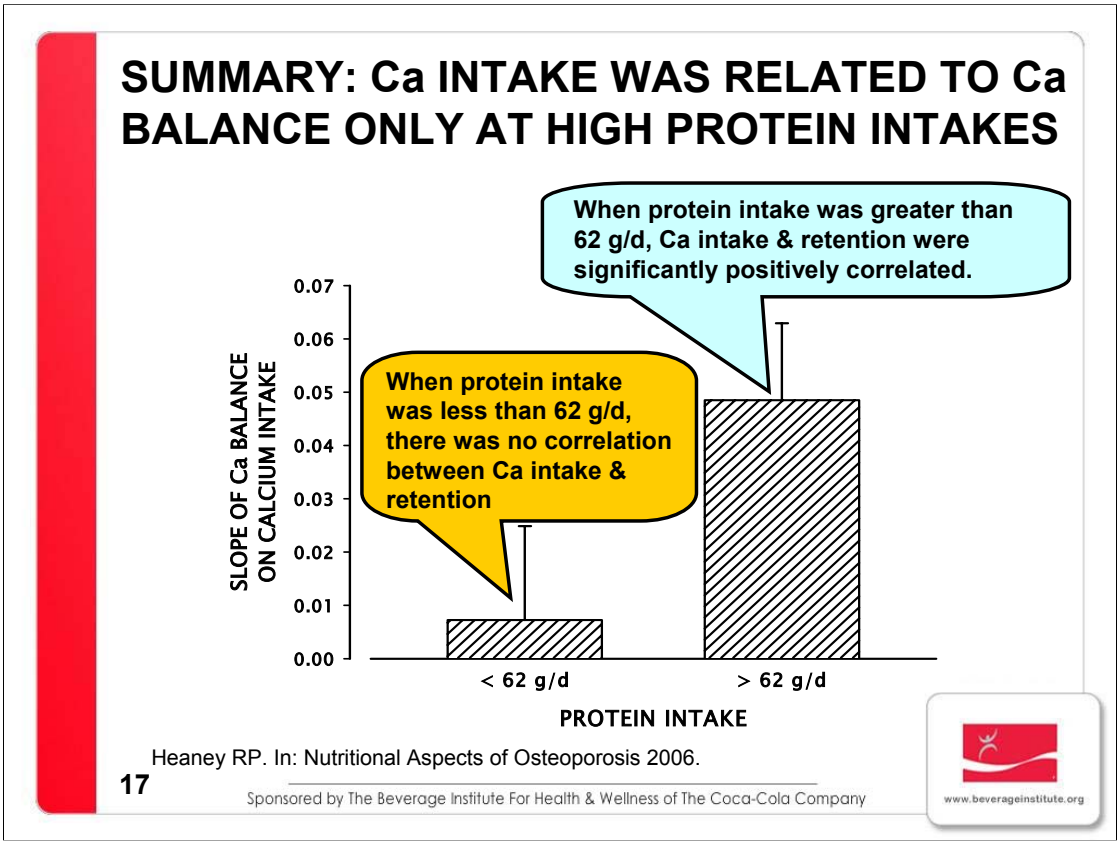
BONE HEALTH BASICS: ADEQUATE NUTRITION

Example: Impact of Protein Intake on Calcium Balance

SPEAKER COMMENTS: On the other hand, when protein intake was below the median of 62 grams/day, the slope that was observed was not statistically significantly different from zero, which translates to there is no effect of calcium intake on calcium retention in the absence of adequate protein intake.

This is important because it means that, on average, the women with lower protein intakes who took extra calcium did not have improved calcium balance.



BONE HEALTH BASICS: ADEQUATE NUTRITION

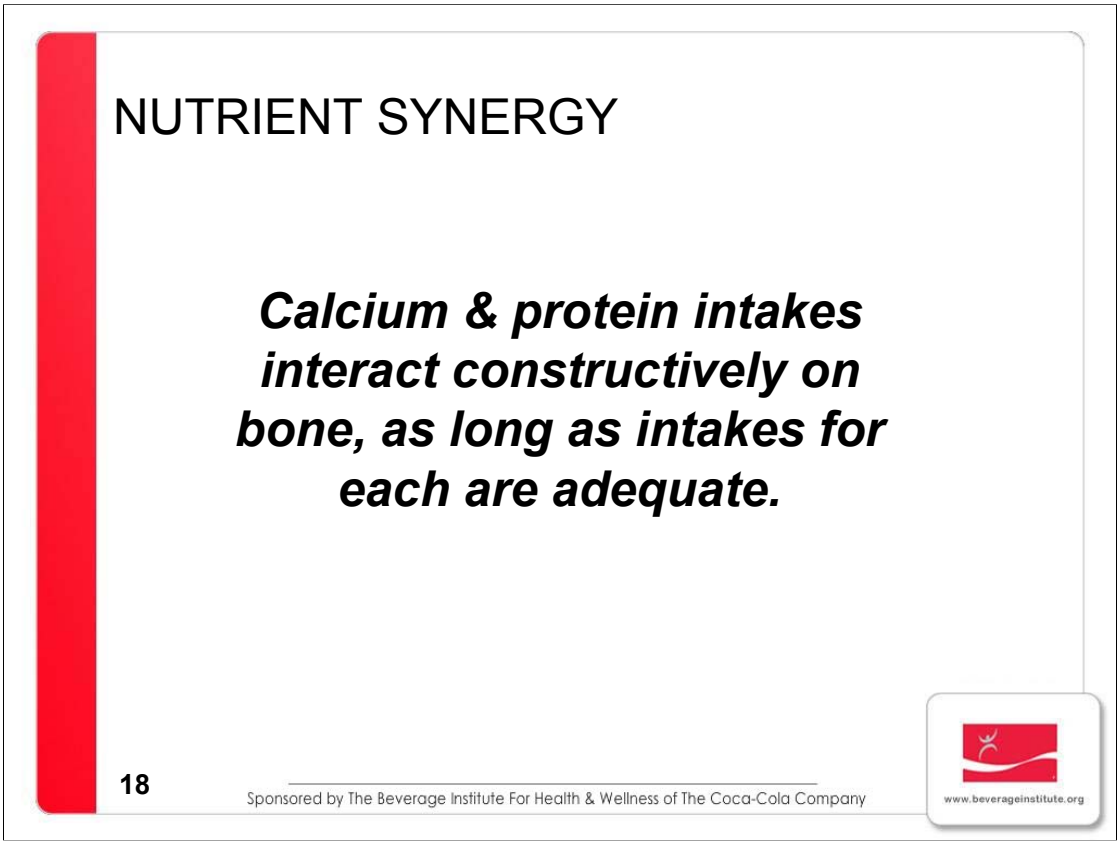
Example: Impact of Protein Intake on Calcium Balance

SPEAKER COMMENTS: This is the same data from the previous 2 slides in bar graph form comparing the impact of high and low protein intake on calcium balance. As you see, the results are quite striking. When protein intake was greater than 62 g/day, increased calcium intake was associated with increased calcium retention and BMD gains. However, when protein intake was lower, increased calcium intake had no impact on calcium retention.

Thus, independent research supported Dawson-Hughes findings that calcium and protein intakes interact constructively on bone, as long as intakes for each are adequate.

[It's also interesting to note that 62 grams/day, which was the amount of daily protein that appears to make a significant difference in BMD gains, is at or above the 0.8 g/kg of protein currently recommended for adults, suggesting that current recommendations might be too low for some women.]

SOURCE: Heaney RP. Effects of protein on the calcium economy. In: Nutritional Aspects of Osteoporosis 2006. Burckhardt P, Heaney RP, Dawson-Hughes B, eds. Elsevier Inc., Amsterdam, 2007, pp. 191-197.

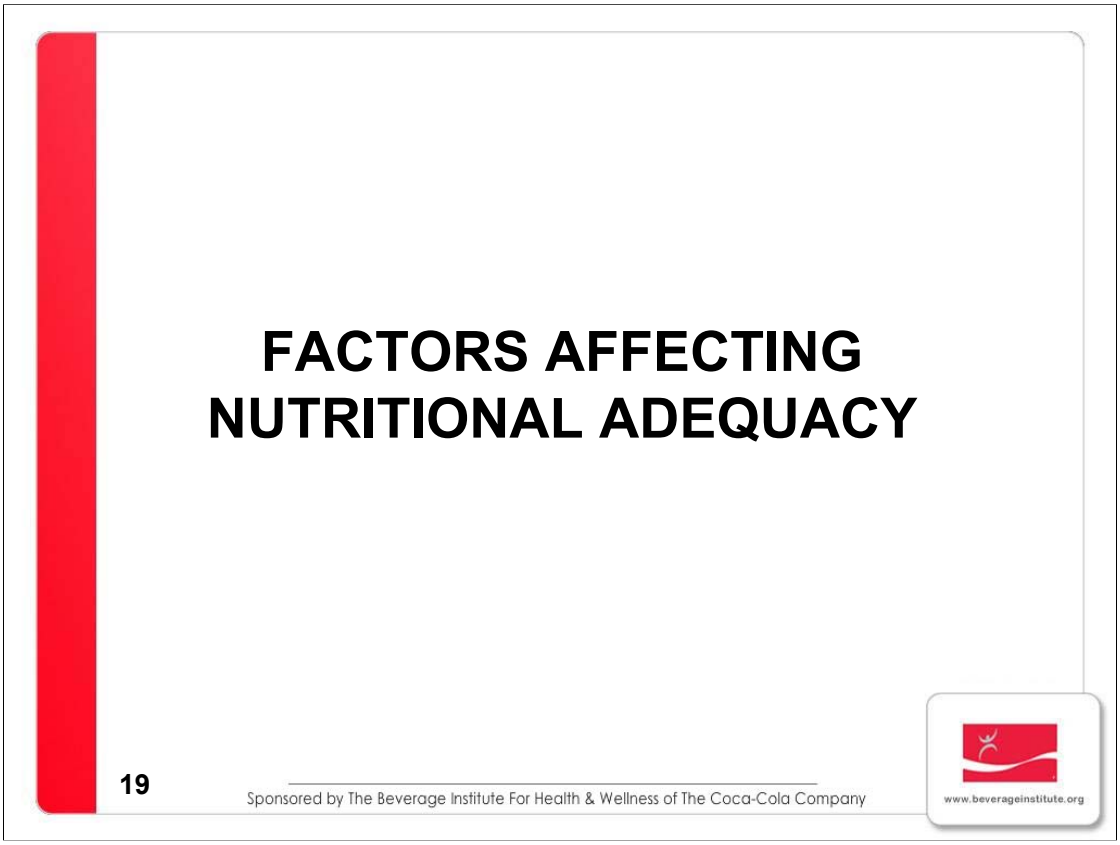


BONE HEALTH BASICS: ADEQUATE NUTRITION

Summary: Why Taking A Mono-nutrient Approach Is Usually Wrong

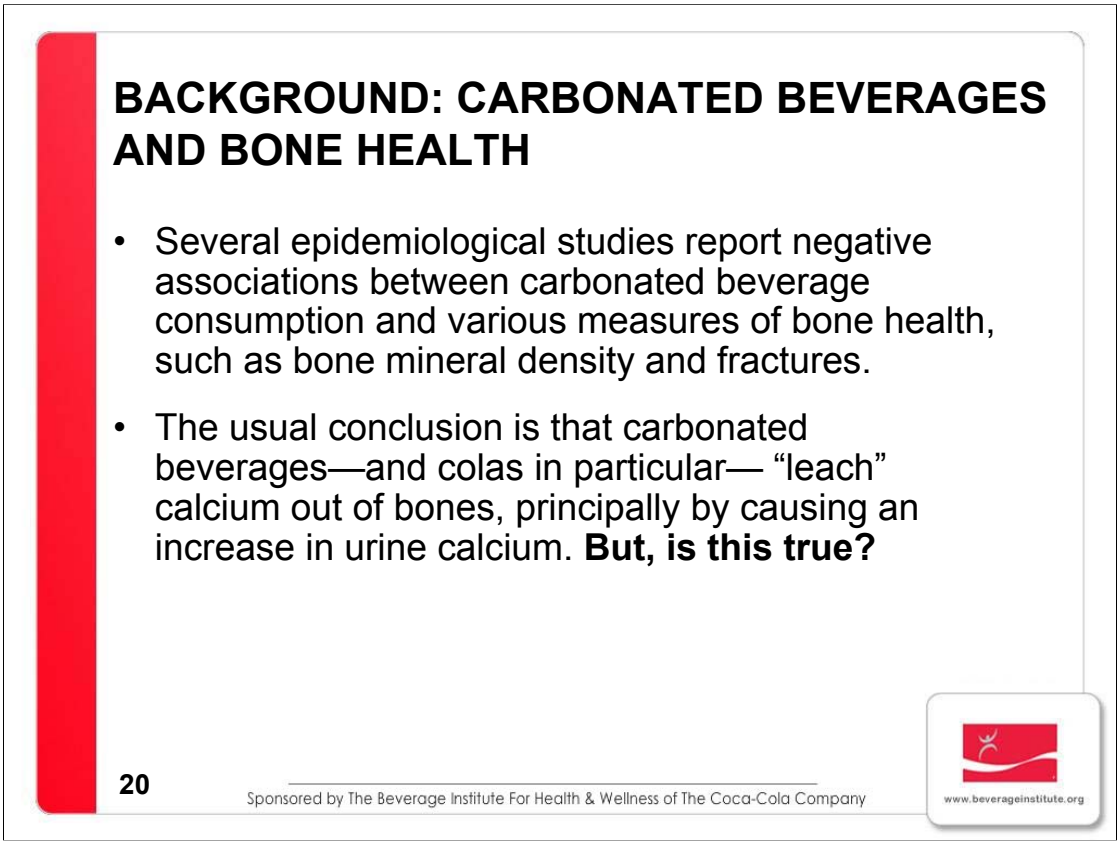
SPEAKER COMMENTS: I think this point is worth repeating: calcium and protein intakes interact constructively on bone, as long as intakes for each are adequate.

Now, keep in mind that this is just one recent example of how we are learning about the synergistic way nutrients work together in the body -- and why focusing exclusively on one or two individual nutrients is usually wrong. This synergy between nutrients is why we must focus on ensuring the overall diet is adequate in all nutrients.



FACTORS AFFECTING NUTRITIONAL ADEQUACY

SPEAKER COMMENTS: With that background, let's look at factors that may influence the nutritional adequacy of the diet, with particular emphasis on the issue of carbonated beverages.

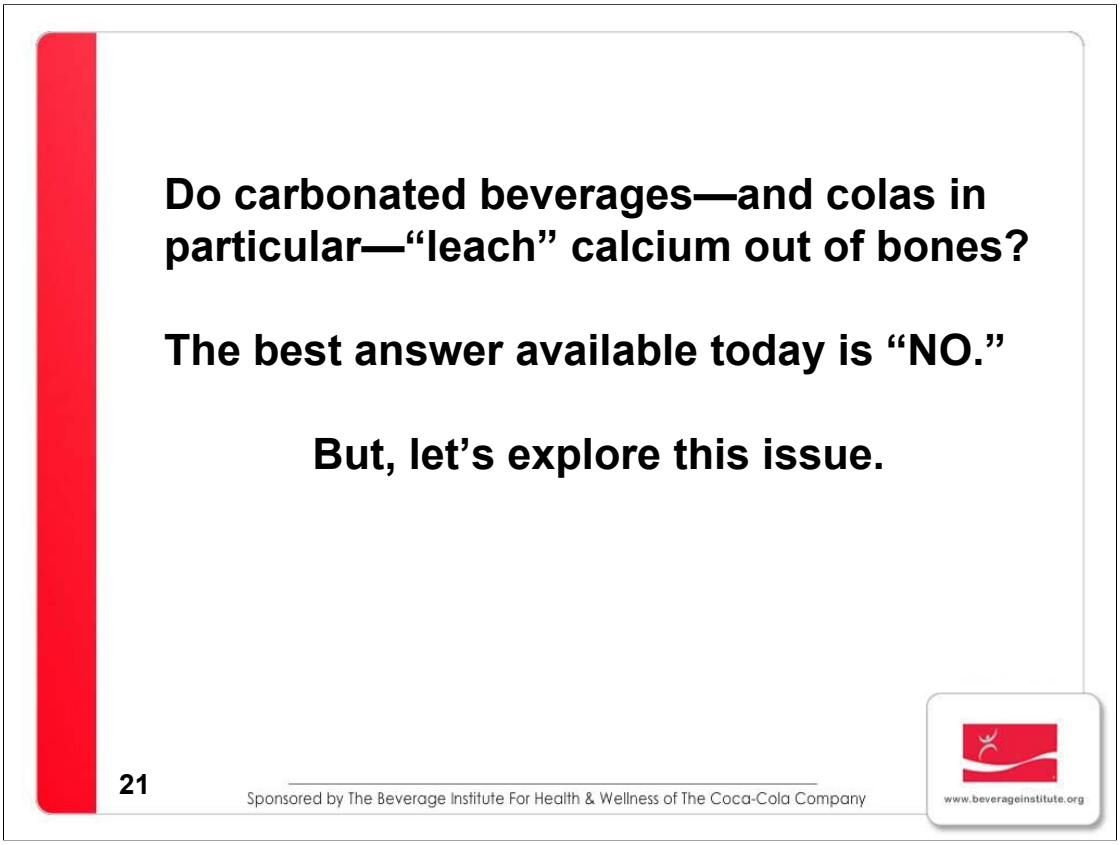


FACTORS AFFECTING NUTRITIONAL ADEQUACY

SPEAKER COMMENTS: Many studies report negative associations between carbonated beverage consumption and various measures of bone health or bone status, such as bone mineral density and fractures. These studies are published at the rate of one or two a year.

The usual conclusion drawn by some researchers—or at least by the media—is that carbonated beverages, and colas in particular, "leach" calcium out of bones, principally by causing an increase in urinary calcium excretion. In other words, they supposedly cause decreased calcium retention, which is one of the three reasons for reduced effective inputs of calcium we reviewed earlier.

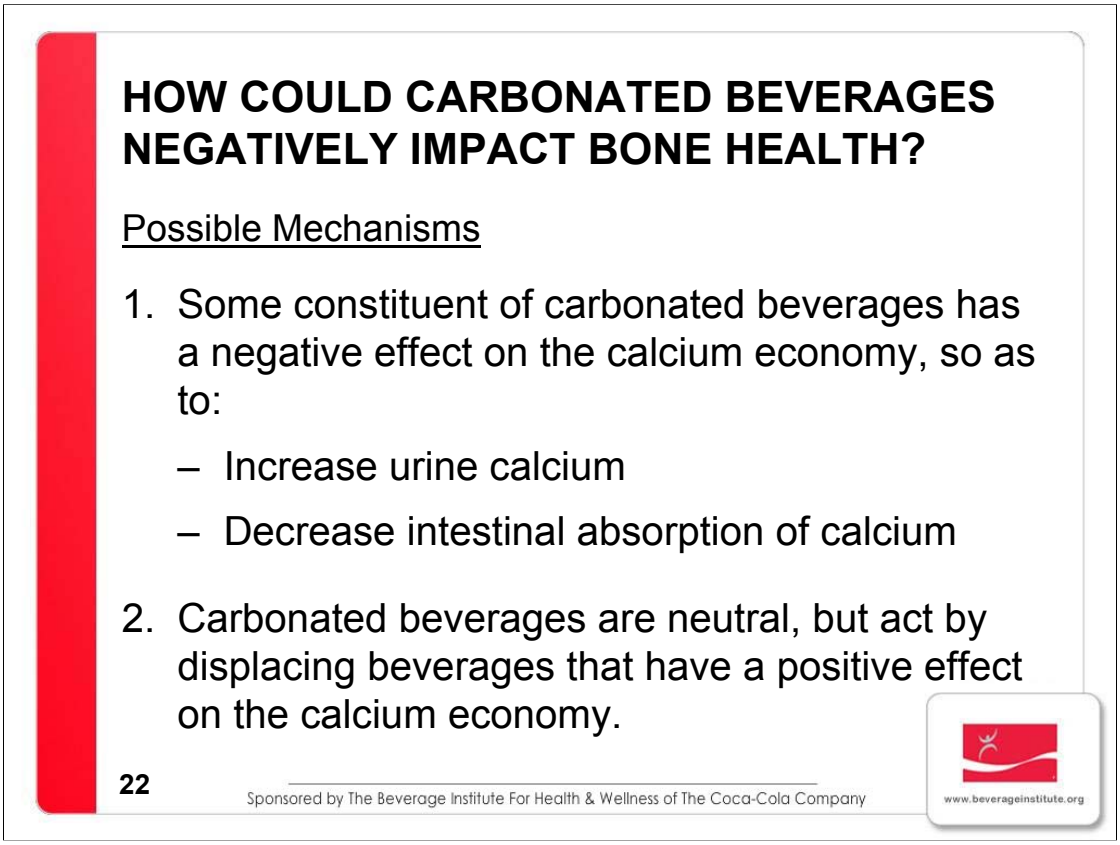
As a reminder, the other two reasons for reduced effective inputs of calcium are decreased absorption and decreased intake.



FACTORS AFFECTING NUTRITIONAL ADEQUACY

Do carbonated beverages "leach" calcium from bones and increase urinary calcium losses?

SPEAKER COMMENTS: Is the common conclusion to this question correct? The best answer available today is "no." Let's explore this issue to see why.



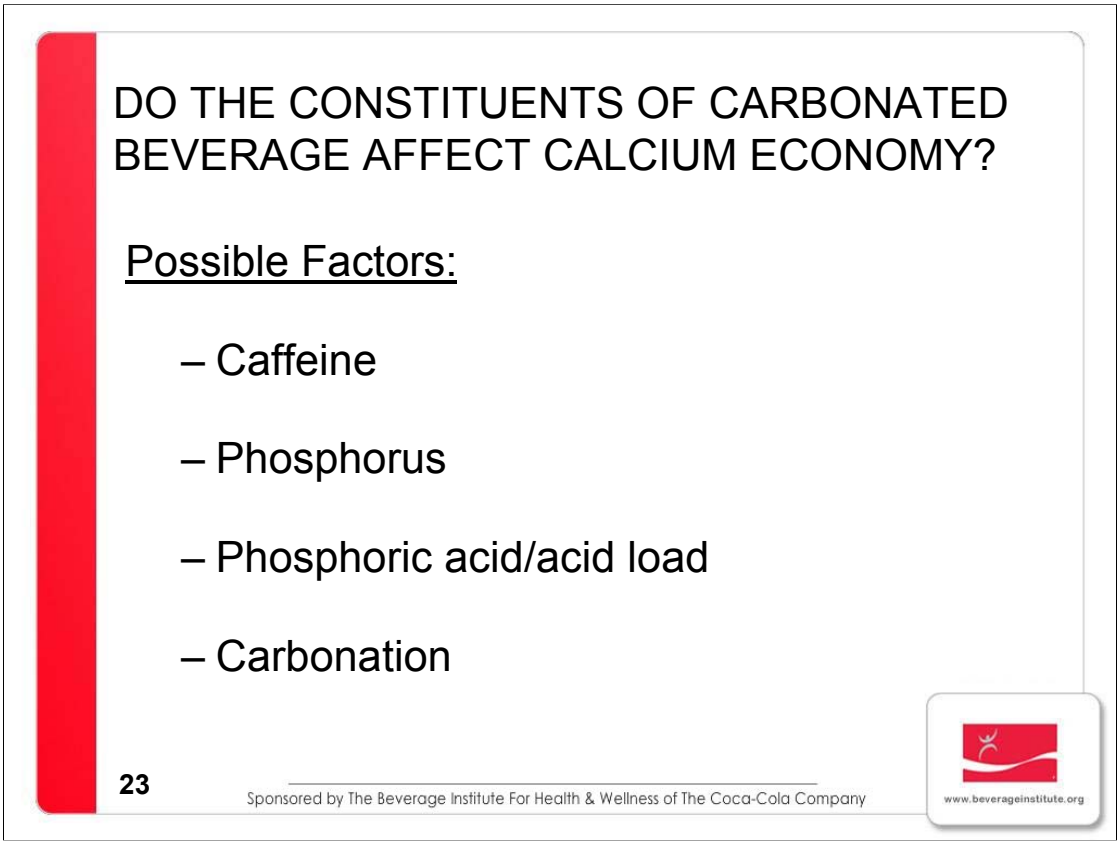
FACTORS AFFECTING NUTRITIONAL ADEQUACY

How could soft drinks negatively impact bone health?

SPEAKER COMMENTS: One possible mechanism is that a constituent of a carbonated beverage negatively affects calcium economy by increasing urinary calcium losses or decreasing intestinal absorption.

The second possible alternative is that carbonated beverages are neutral in themselves but act by displacing beverages such as milk that have a positive effect on the calcium economy. So, carbonated beverages would take away a positive effect rather than contribute a negative effect.

Now, let's look at the research related to each of these possible mechanisms.



FACTORS AFFECTING NUTRITIONAL ADEQUACY

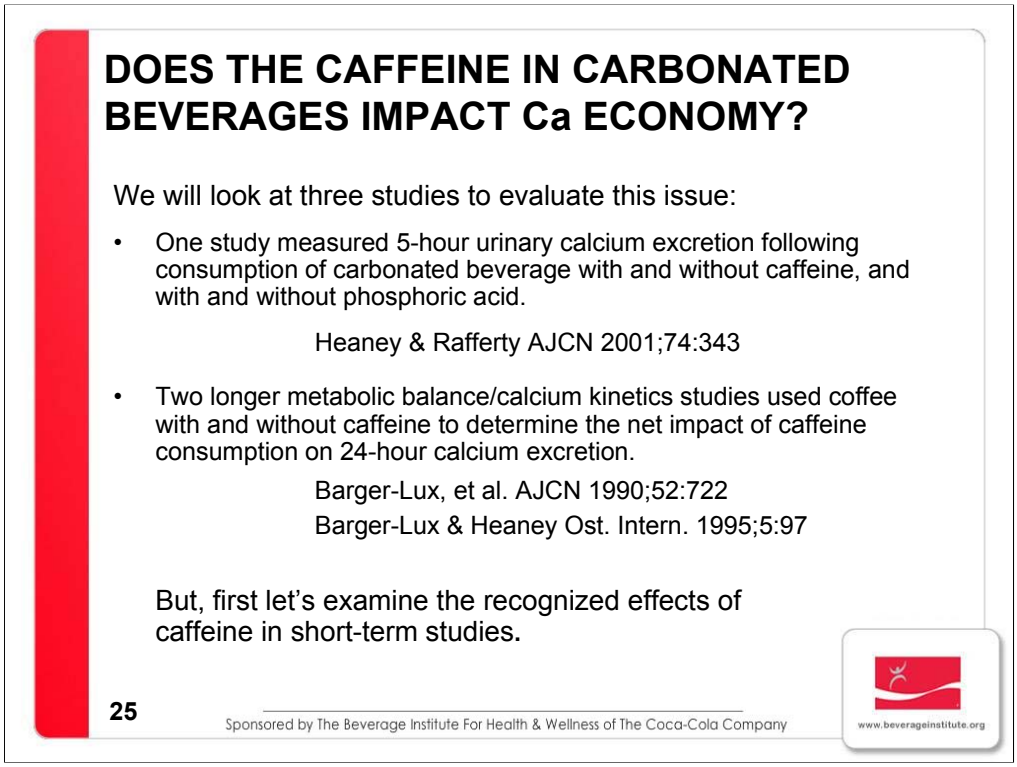
Do any the constituents of carbonated beverages increase urinary calcium losses?

SPEAKER COMMENTS: Let's look at the mechanism of increased urinary calcium. Possible culprits in carbonated beverages are caffeine, phosphorus, acid load related to phosphoric acid, and carbonation. We'll focus primarily on the first three factors, because the best data are available for them.

FACTORS AFFECTING NUTRITIONAL ADEQUACY

Do any the constituents of carbonated beverages increase urinary calcium losses?

SPEAKER COMMENTS: Let's start with caffeine.



FACTORS AFFECTING NUTRITIONAL ADEQUACY:

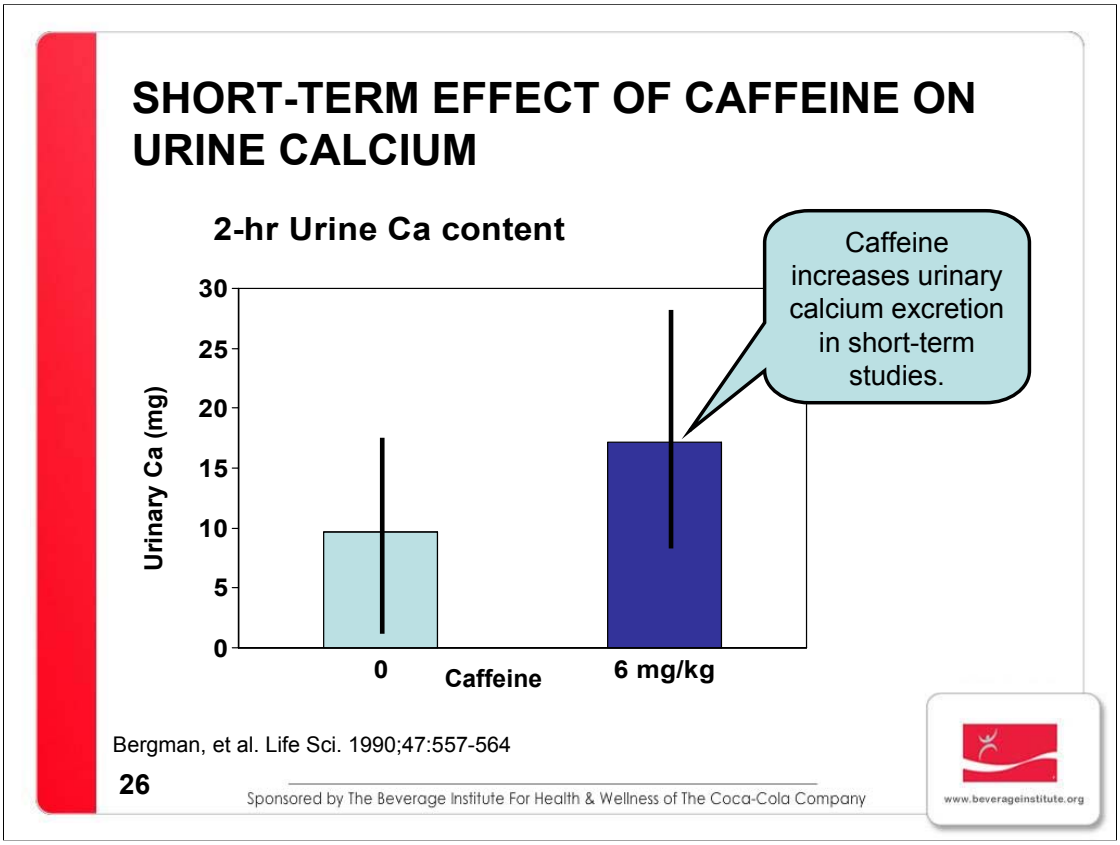
Does the caffeine in carbonated beverages affect calcium economy?

SPEAKER COMMENTS: We'll review three studies to evaluate this issue:

The first is a large study conducted here at Creighton that examined the effect of a variety of carbonated beverages on calcium balance. The study used a complex crossover design that looked specifically at the effects of beverages with and without caffeine, and with and without phosphoric acid over a 5-hour period. (Heaney RP, Rafferty K. Carbonated beverages and urinary calcium excretion. Am J Clin Nutr. 2001;74:343-7.)

The other two are metabolic balance calcium kinetic studies involving coffee with and without caffeine. These longer studies used a double-blind placebo control design—that is, subjects consumed decaf coffee and either a placebo capsule without caffeine or a capsule containing caffeine to determine the net impact of regular caffeine consumption on 24 hours calcium excretion. (Barger-Lux MJ, Heaney RP, Stegman MR. Effects of moderate caffeine intake on the calcium economy of premenopausal women. Am J Clin Nutr. 1990;52:722–725 and Barger-Lux MJ, Heaney RP. Caffeine and the calcium economy revisited. Osteoporos Int. 1995;5:97-102.)

But, before we review these studies in more detail, let's start by examining the recognized effects of caffeine in short-term studies.



FACTORS AFFECTING NUTRITIONAL ADEQUACY

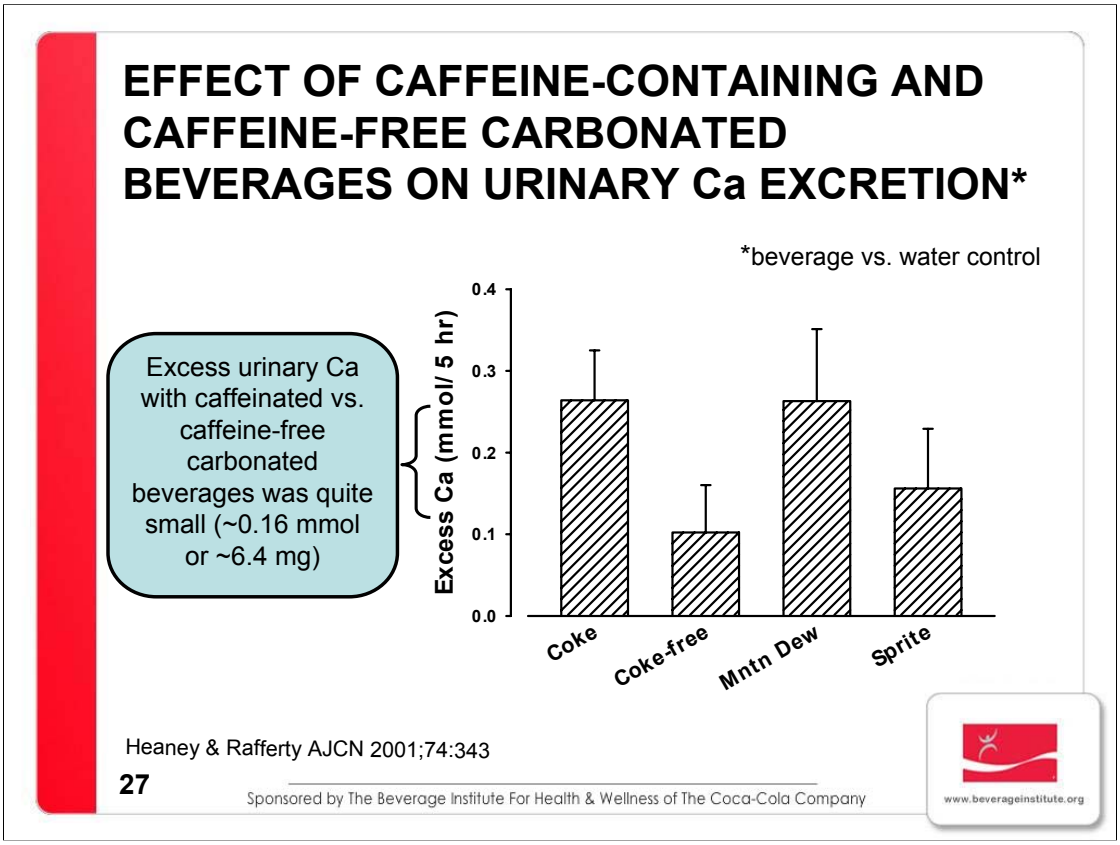
The recognized effects of caffeine on urinary calcium in short-term studies.

SPEAKER COMMENTS: We've known for a long time that caffeine increases urinary calcium in short-term studies—that is, when measured within two to five hours after consumption.

This graph is from a 1990 study showing urine calcium losses two hours following administration of a beverage that was either caffeine-free or contained a high dose of caffeine (6 mg caffeine/kg). As a point of reference, for a 70 kg person, the amount of caffeine would have been 420 mg —or about three cups of strong coffee —in a single dose. As you see, a large dose of caffeine increased urinary calcium excretion.

However, subsequent studies have shown that the body compensates by conserving calcium following caffeine intake, So if you look at 24-hour urine calcium excretion, there's no difference between subjects who received the caffeine and subjects who didn't.

SOURCE: Bergman EA, Massey LK, Wise KJ, Sherrard DJ. Effects of dietary caffeine on renal handling of minerals in adult women. Life Sci. 1990;47:557-564.



FACTORS AFFECTING NUTRITIONAL ADEQUACY:

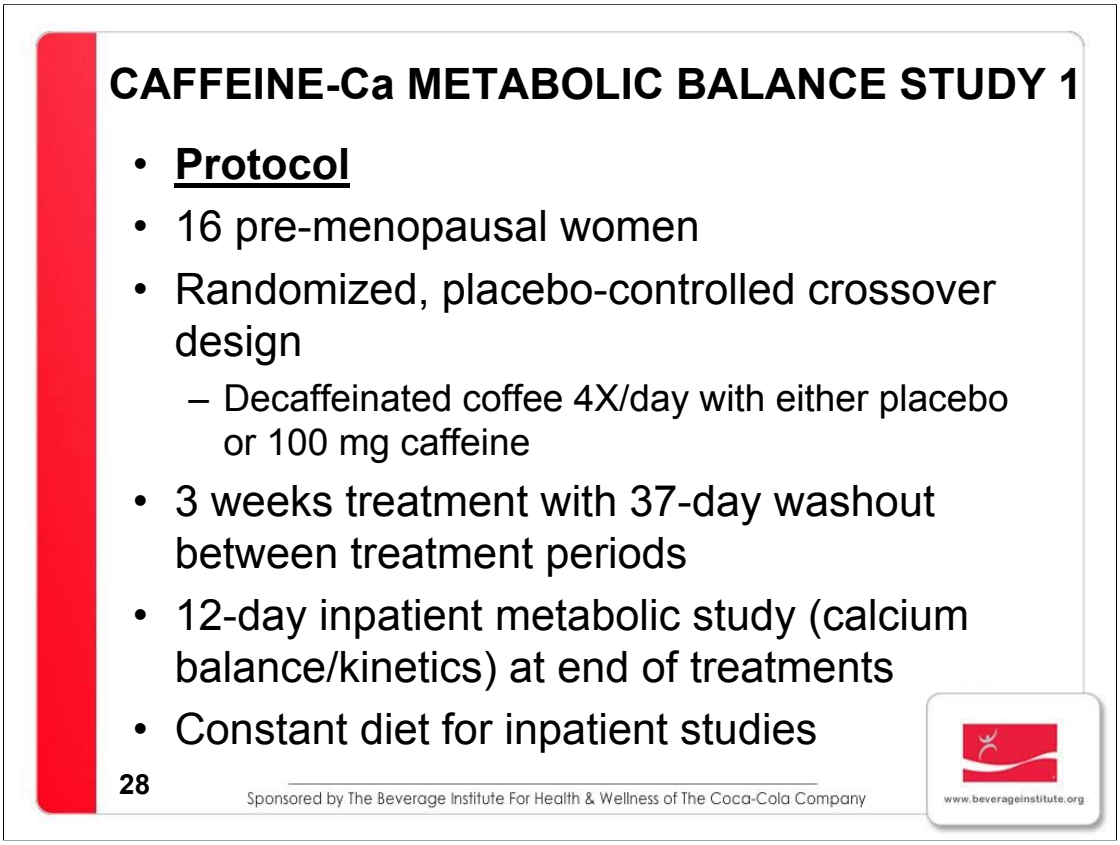
Do Caffeinated Soft Drinks Increase Urinary Calcium Losses?

SPEAKER COMMENTS: With that background, let's look at the results from the crossover beverage consumption study conducted in my lab in which we looked at the effect of caffeinated soft drinks on 5-hour urinary calcium excretion.

This graph shows excess urinary calcium excretion following consumption of our 4 test beverages: Coca-Cola Classic and Mountain Dew, which contain caffeine, and caffeine-free Coca-Cola and Sprite, which don't contain caffeine.

As you can see, calcium excretion was greater with the caffeine-containing beverages than those without caffeine, which is consistent with the study by Bergman, et al. reviewed on the previous slide. However, because the amount of caffeine in these beverages is much lower (about 50 mg/12 oz), the effect is also quite small. Even over a five-hour period, the caffeine-containing beverages increased urinary calcium by about six milligrams compared to the caffeine-free beverages and about 12 milligrams compared to the plain water control. And as you will see in the next slides, this translates to zero in the final analysis.

SOURCE: Heaney RP, Rafferty K. Carbonated beverages and urinary calcium excretion. Am J Clin Nutr. 2001;74:343-7.



FACTORS AFFECTING NUTRITIONAL ADEQUACY

Does Caffeine Increase Urinary Calcium Losses?

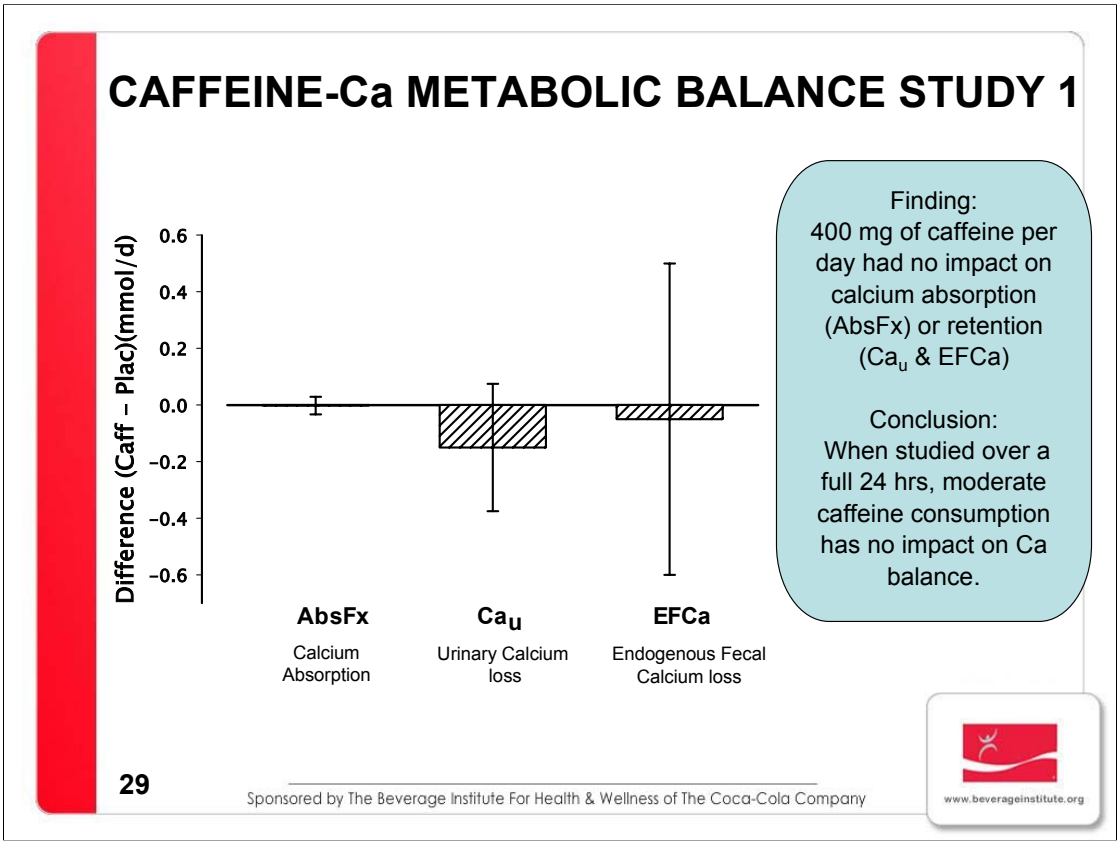
SPEAKER COMMENTS: Let's look at the two calcium balance studies involving caffeine. This slide reviews the protocol of the first study, which looked at the effect of caffeine on 24-hour urinary calcium excretion.

The subjects were 16 pre-menopausal women in a randomized, placebo-controlled crossover study. They received decaffeinated coffee four times a day, along with a capsule containing either placebo or 100 milligrams of caffeine. The treatment period lasted for three weeks, with a 37-day washout between the treatment periods to allow the body time to adjust to the different regimens.

At the end of each three-week period, the subjects entered our clinical research center unit for a 12-day inpatient metabolic study where we performed calcium balance and calcium kinetic measurements. It's important to note that the women consumed the same diet under all conditions. So, whether or not they received caffeine, the foods and nutrients consumed were identical.

We will see the results of this study on the next slide.

SOURCE: Barger-Lux MJ, Heaney RP, Stegman MR. Effects of moderate caffeine intake on the calcium economy of premenopausal women. Am J Clin Nutr. 1990;52:722–725.



FACTORS AFFECTING NUTRITIONAL ADEQUACY

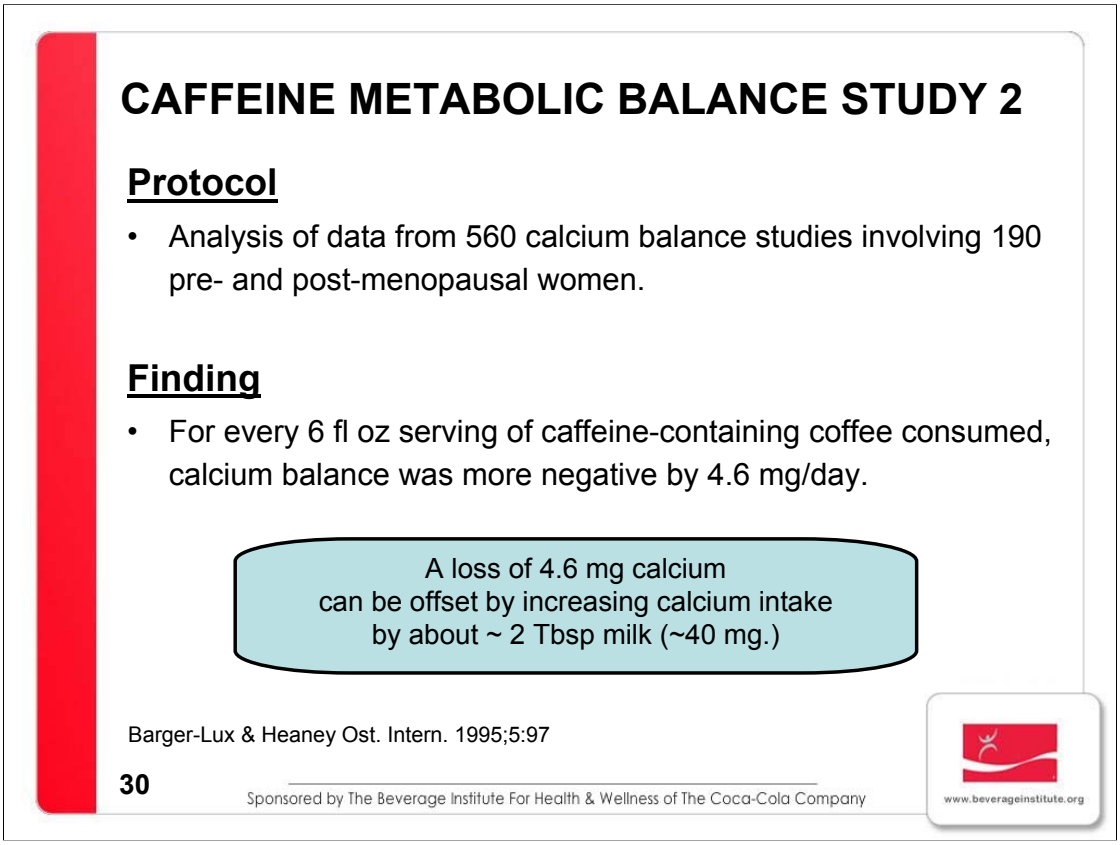
Does caffeine impact calcium inputs (decrease absorption, increase urinary losses)?

SPEAKER COMMENTS: This graph is the findings from the caffeine balance study outlined in the previous slide.

This study found that 100 mg. of caffeine consumed four times a day had no significant effect on calcium absorption efficiency (AbsFx), urine calcium (Cau) or endogenous fecal calcium (EFCa)* or over a 24-hour period. Our conclusion was that caffeine had no effect on these measurements at a dose of 400 milligrams of caffeine per day. As a result, we can conclude that although caffeine has a short-term acute effect on calcium losses, the effect is quite small and doesn't last. And over a 24-hour period, caffeine for all practical purposes has no negative effect.

*Endogenous fecal calcium is the calcium in the digestive secretions that escapes reabsorption as it passes through the intestine. It is an important route of loss and, for most adults, is as large as urinary calcium loss.

SOURCE: Barger-Lux MJ, Heaney RP, Stegman MR. Effects of moderate caffeine intake on the calcium economy of premenopausal women. Am J Clin Nutr. 1990;52:722–725.



FACTORS AFFECTING NUTRITIONAL ADEQUACY

Does Caffeine Negatively Impact Calcium Balance?

SPEAKER COMMENTS: In the second caffeine metabolic balance study, we analyzed data from 560 calcium balance studies conducted with 190 pre- and post-menopausal women.

We determined that for every 6 fl oz serving of caffeine-containing coffee consumed, calcium balance was more negative by 4.6 mg/day-- an amount that can be offset by increasing calcium intake by about two tablespoons of milk (~40 mg).

SOURCE: Barger-Lux MJ, Heaney RP. Caffeine and the calcium economy revisited. Osteoporos Int. 1995;5:97-102.

Conclusion:

Caffeine in moderate amounts does not negatively impact calcium inputs.

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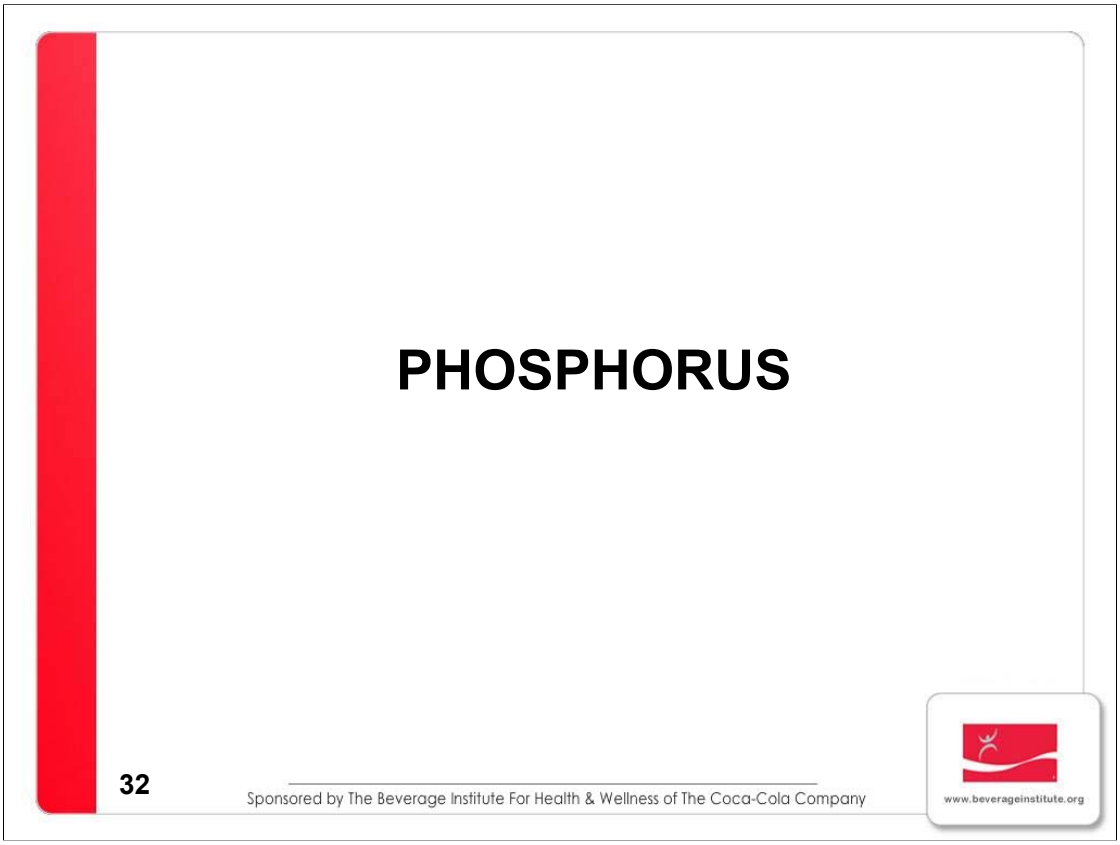
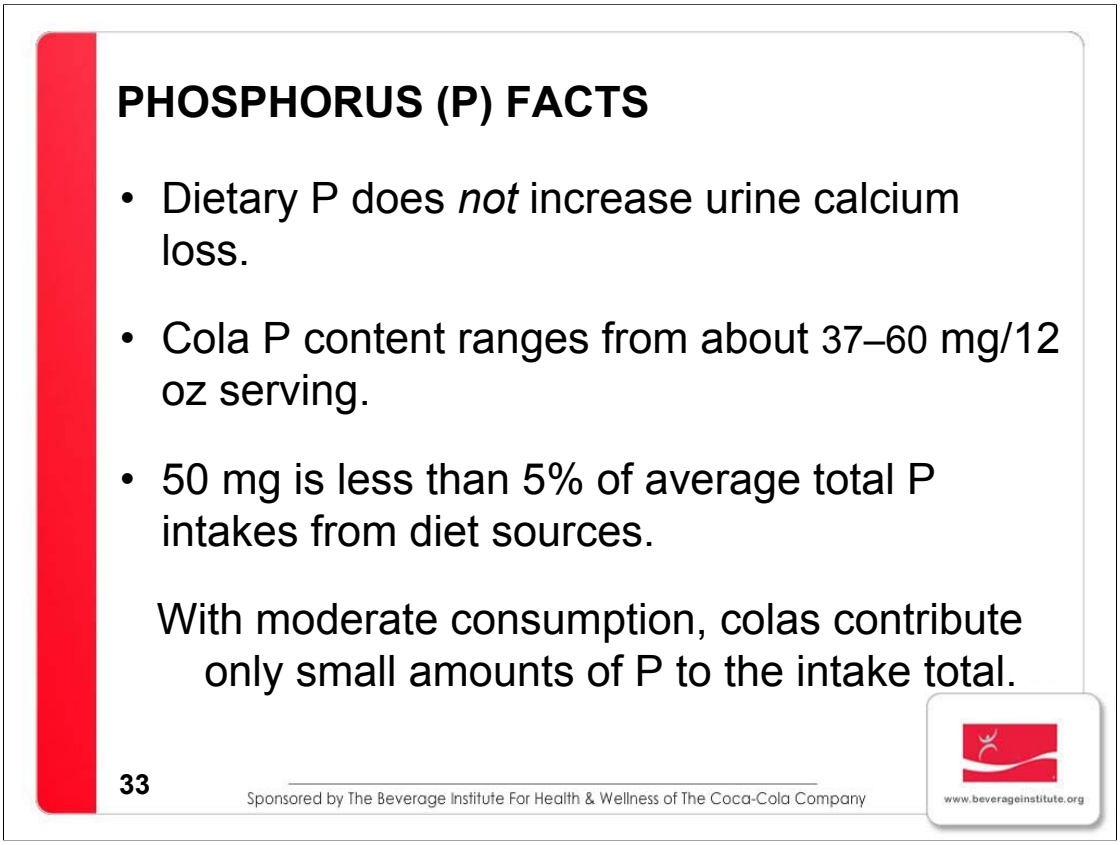


FACTORS AFFECTING NUTRITIONAL ADEQUACY

Does phosphorus in cola beverages impact calcium inputs (decrease absorption, increase urinary losses)?

SPEAKER COMMENTS: Cola soft drinks are often targeted as being bad for bone health because they contain “too much” phosphorus. Colas tend to use phosphoric acid as an acidulant, while citrus-type soft drinks use citric acid.

So, next we’ll look at phosphorus and bone health in general and then the specific issue of whether phosphoric acid and/or acid load related to soft drink consumption has a negative affect on calcium balance.



FACTORS AFFECTING NUTRITIONAL ADEQUACY:

Does phosphorus in cola beverages impact calcium inputs (decrease absorption, increase urinary losses)?

SPEAKER COMMENTS: Phosphorus is sometimes considered the “bad boy” of nutrients, partly because health professionals who deal with end-stage renal disease patients know that a high phosphorus intake can be a problem. However for the rest of us, phosphorus is not a problem. In fact, scientists have known for a long time that dietary phosphorus does not increase urinary calcium loss and, over the years, phosphorus supplements have been used to treat some patients with kidney stone disease because phosphorus tends to lower urinary calcium rather than raise it.

But do colas actually contain “too much” phosphorus? The answer is no. The amount of phosphorus in a cola ranges from about 37–60 mg per 12-ounce serving, or less than ~5% of the average total phosphorus intake from dietary sources. So, with moderate consumption, colas contribute only small amounts of phosphorus to the intake total.

PHOSPHORUS FACTS

Phosphorus content of common foods:

Food	P content
Cola (12 oz)	37-60 mg
Orange juice (8 oz)	27 mg
Orange juice-fortified (8 oz)	Up to 90 mg
Peanuts (1 oz)	113 mg
Milk (8 oz)	232 mg
Tuna, light, canned in oil (3 oz)	264 mg

SOURCES: The Coca-Cola Company and USDA/ARS. 2006.
USDA National Nutrient Database for Standard Reference, Release 19.

FACTORS AFFECTING NUTRITIONAL ADEQUACY

Does phosphorus or phosphoric acid in cola beverages impact Ca inputs (decrease absorption, increase urinary losses)?

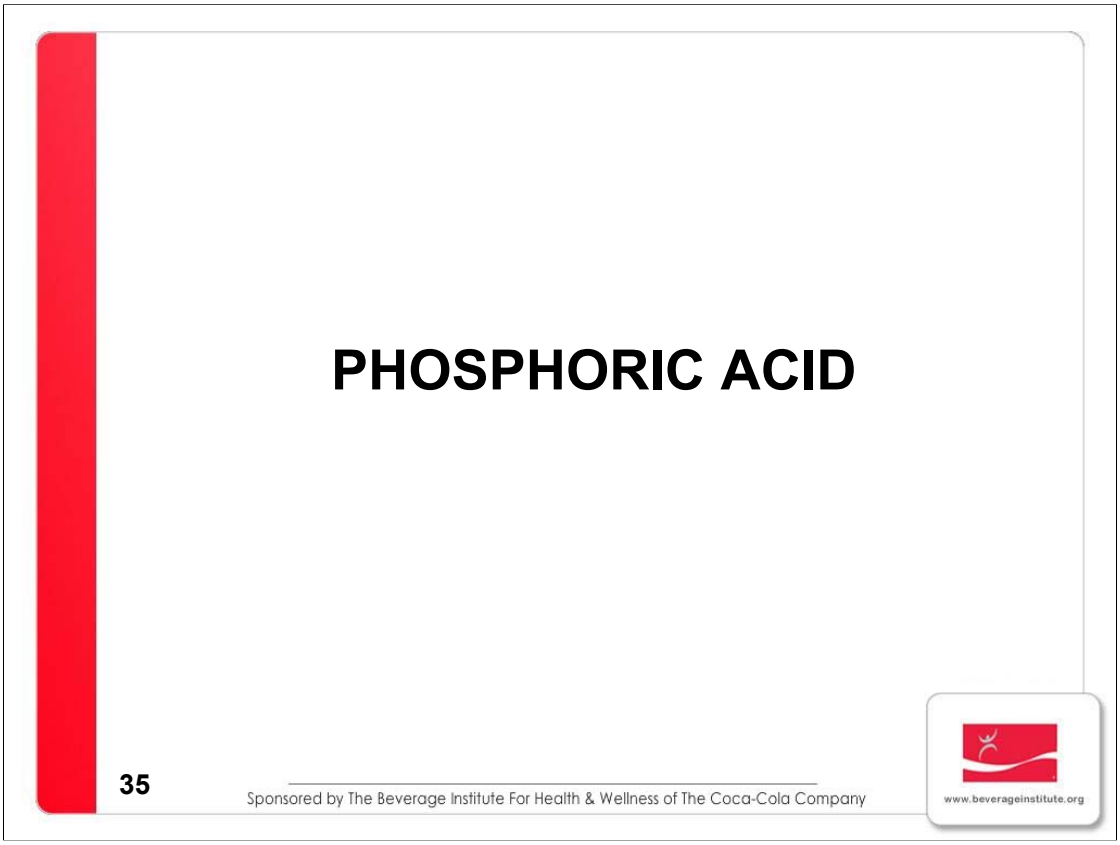
SPEAKER COMMENTS: This chart compares the phosphorus content of colas to several common foods and beverages.

It's interesting that some people say colas have "too much" phosphorus, but we don't hear the same comment about other common foods that contain much more phosphorus. As mentioned previously, the phosphorus in a 12-ounce can of cola ranges from about 37-60 milligrams. This is similar to plain orange juice, which contains 27 milligrams of phosphorus per 8 ounces, while calcium-fortified orange juice can contain up to 90 milligrams of phosphorus depending on whether the fortificant contains phosphorus.

Most phosphorus in the diet actually comes from protein-rich foods. For example, peanuts contain 113 milligrams of phosphorus per ounce, while a cup of milk has 232 milligrams, and tuna, which is generally considered a "healthy" food, has 264 milligrams of phosphorus.

The message here is that moderate consumption of colas (one to two cans/day) contributes only about 5% to 10% to the total phosphorus intake of many people.

However, it is also true that the phosphorus in colas is in the form of phosphoric acid. So we'll look at that next.

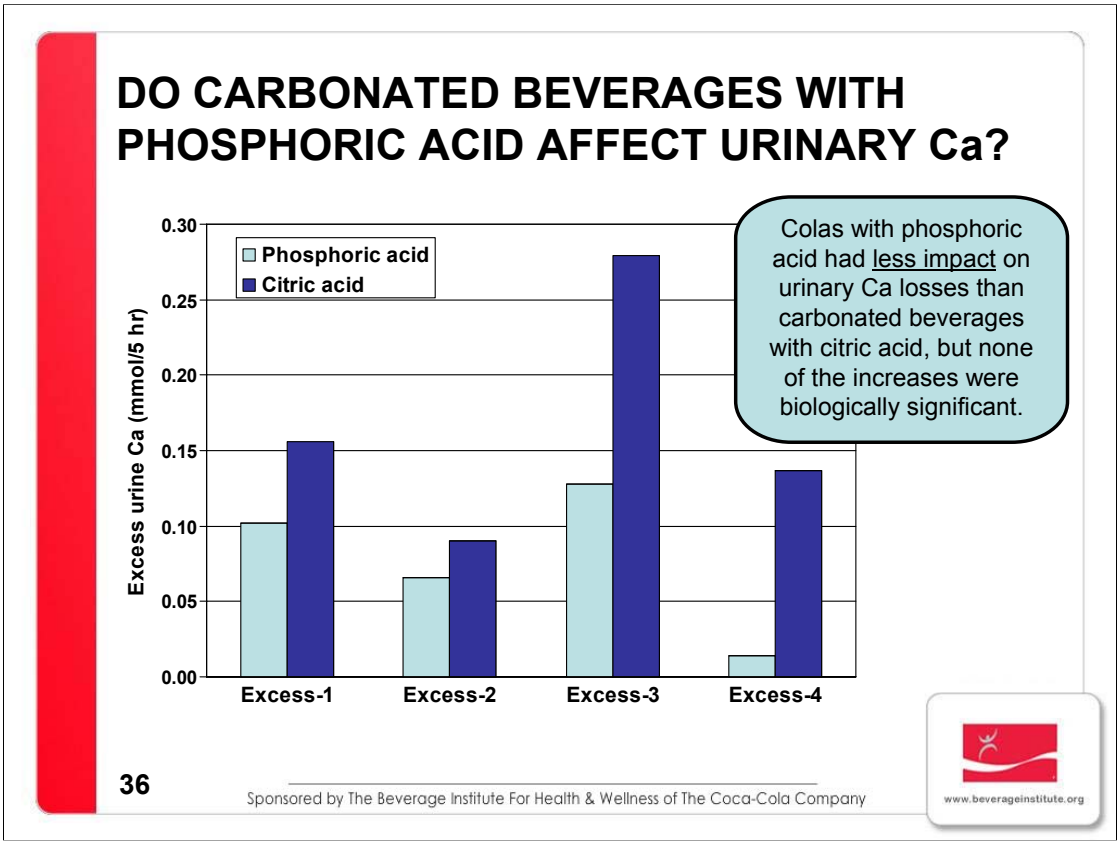


FACTORS AFFECTING NUTRITIONAL ADEQUACY

Does phosphoric acid in soft drinks impact calcium balance?

SPEAKER COMMENTS: Now, let's look at phosphoric acid, which is a constituent used in colas as an acidulant. The common belief that the phosphoric acid in colas draws calcium out of the bones is likely linked to a theory that an "acidic diet" draws calcium out of the bones to neutralize the impact of the acid on blood PH. The truth is that the acid load from the phosphoric acid in colas is relatively minor compared with the amount we produce when metabolizing the protein in a typical breakfast— in other words, it's just not a lot of acid.

But let's examine this issue anyway by looking again at the large beverage crossover study we reviewed earlier. You'll recall that we examined a variety of carbonated beverages in a complex crossover design and looked specifically at the effects of beverages with and without caffeine, and with and without phosphoric acid.



FACTORS AFFECTING NUTRITIONAL ADEQUACY

Does phosphoric acid in soft drinks impact calcium balance?

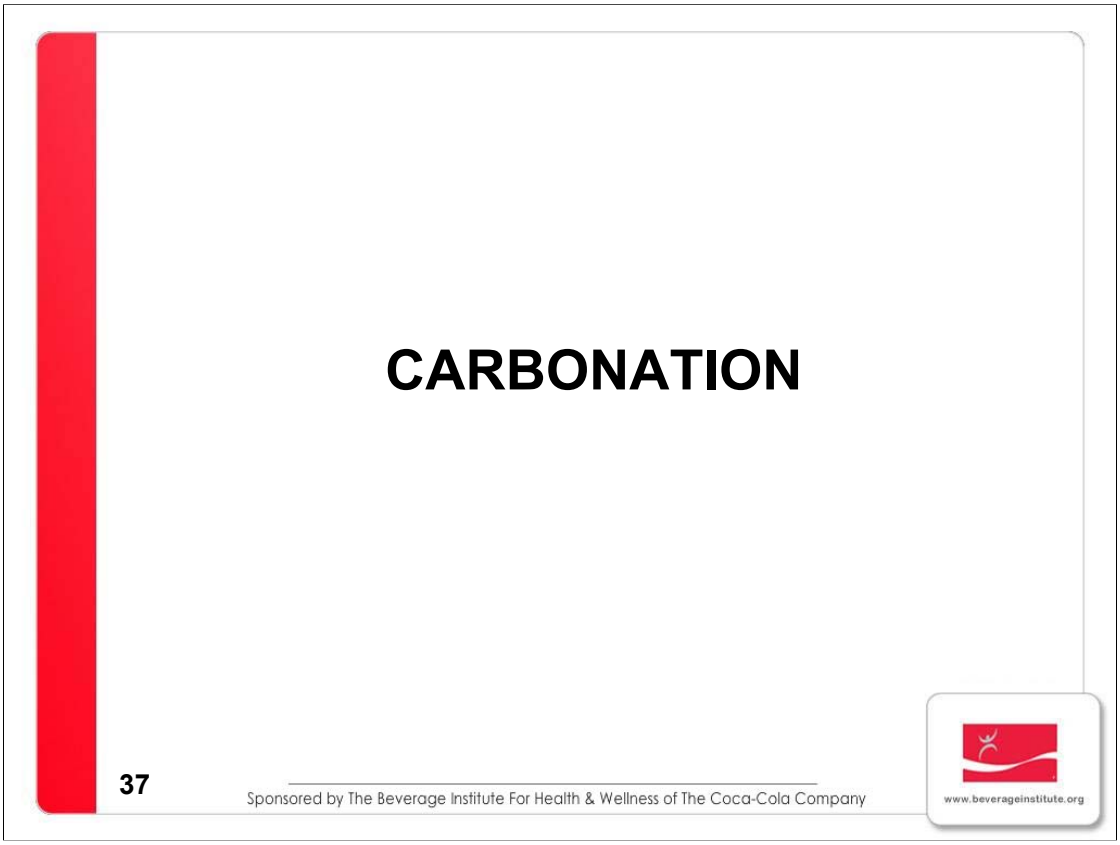
This graph contrasts the excess urine calcium for colas that use phosphoric acid as the acidulant with citrus-based beverages that use citric acid as the acidulant. Since citric acid is metabolized to carbon dioxide and water, it doesn't produce any net acid residue, so is generally considered a stand-in for a "healthy" source.

The bars show excess urine calcium following consumption of Coca-Cola Classic, Caffeine-Free Coca-Cola (both of which contain phosphoric acid), Mountain Dew and Sprite (which contain citric acid) calculated four different ways (Excess-1 through Excess-4). And, once again, this study uses plain water as the control.

By looking at the height of the light blue (phosphoric acid) versus dark blue (citric acid) bars, it's clear that the carbonated beverages with phosphoric acid actually had less of an impact on urinary calcium than those that contained citric acid as the acidulant, but that all the increases are quite small (0.10 mmol = 4 mg calcium).

The conclusion: even when calculated four different ways, there's no evidence that the phosphoric acid in colas has a negative effect on calcium balance.

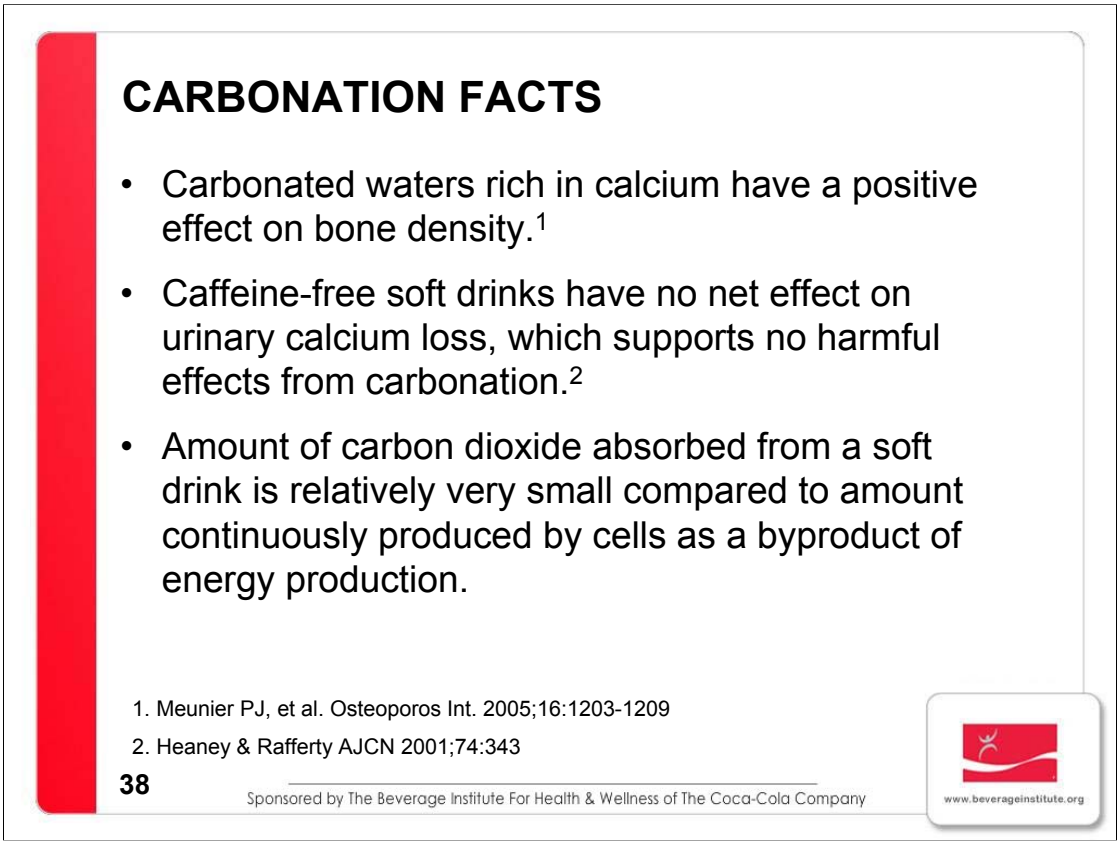
SOURCE: Heaney RP, Rafferty K. Carbonated beverages and urinary calcium excretion. Am J Clin Nutr. 2001;74:343-7.



FACTORS AFFECTING NUTRITIONAL ADEQUACY

Does carbonation associated with soft drinks impact calcium balance?

SPEAKER COMMENTS: We also hear speculation that the carbonation in soft drinks is harmful to bones, but this isn't true either. Let's look at some facts about carbonation.



FACTORS AFFECTING NUTRITIONAL ADEQUACY

Does carbonation negatively impact calcium balance?

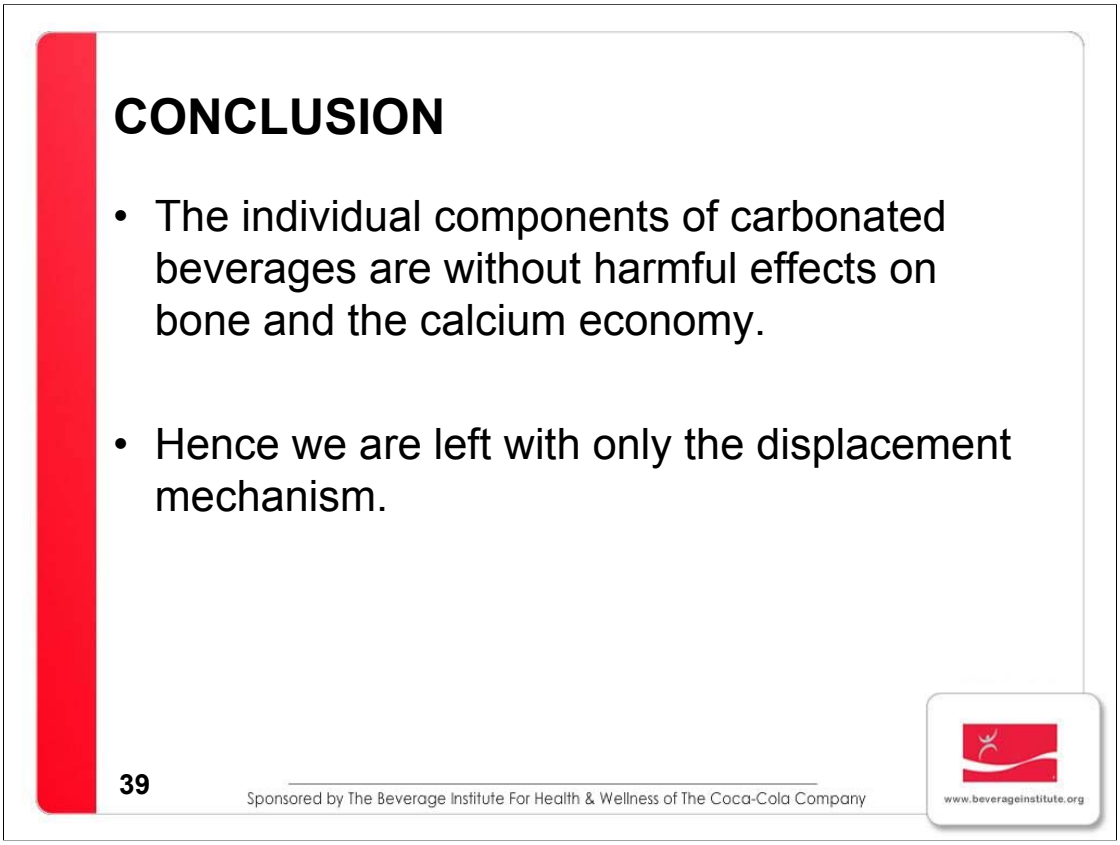
SPEAKER COMMENTS: Research and facts about carbonation and carbon dioxide suggest carbonation from soft drinks is not harmful to bones.

- Research by Meunier, et al., 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.
- The calcium-metabolic soft drink study from our lab also exonerated carbonation when we determined that caffeine-free soft drinks had no net effect on urinary calcium loss. 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.

SOURCE:

Meunier PJ, Jenvrin C, Munoz F, de la Gueronnière V, Garnero P, Menz M. Consumption of a high calcium mineral water lowers biochemical indices of bone remodelling in postmenopausal women with low calcium intake. Osteoporos Int. 2005;16:1203-1209.

Heaney RP, Rafferty K. Carbonated beverages and urinary calcium excretion. Am J Clin Nutr. 2001;74:343-7.



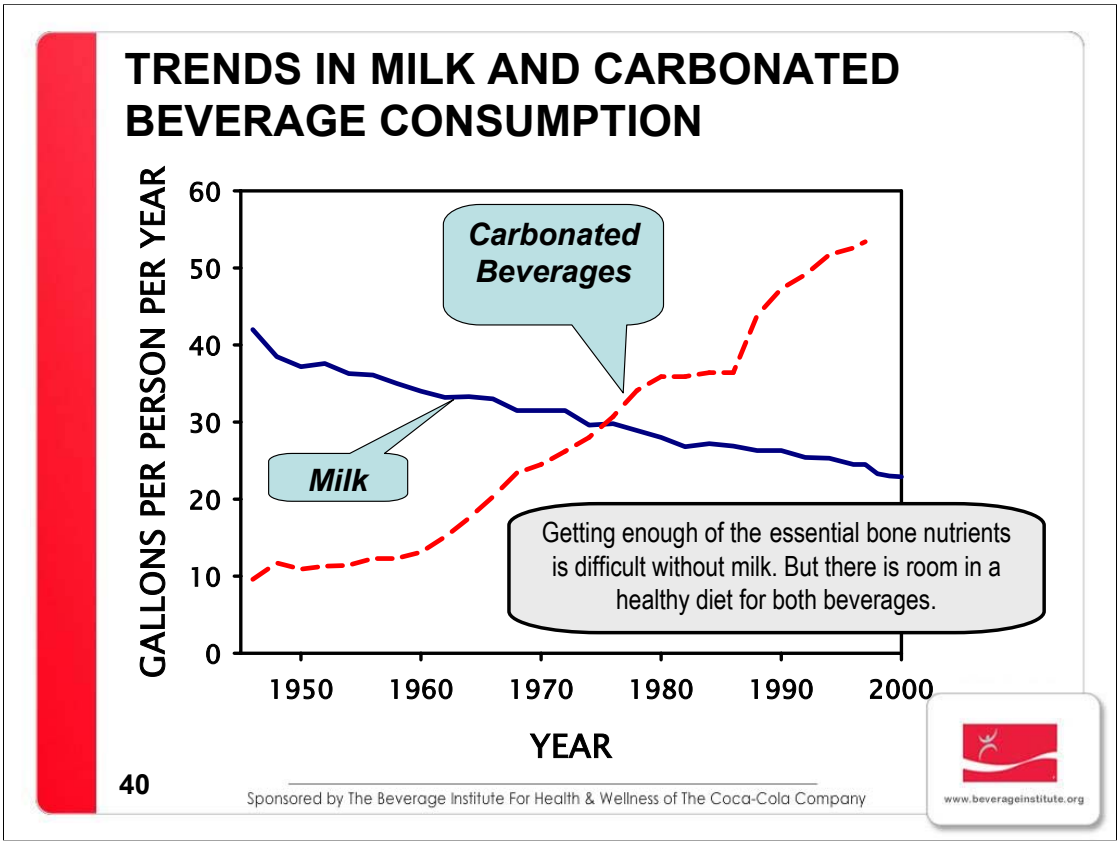
FACTORS AFFECTING NUTRITIONAL ADEQUACY

Do Any of the Components of Carbonated Soft Drinks Negatively Impact Calcium Balance?

SPEAKER COMMENTS: The bottom line is that the individual components of carbonated beverages are without harmful effects on bone and the calcium economy.

So, the displacement mechanism is the most likely explanation for observations from epidemiological studies showing a negative association between carbonated beverage intake and bone status.

Let's take a look at those data.



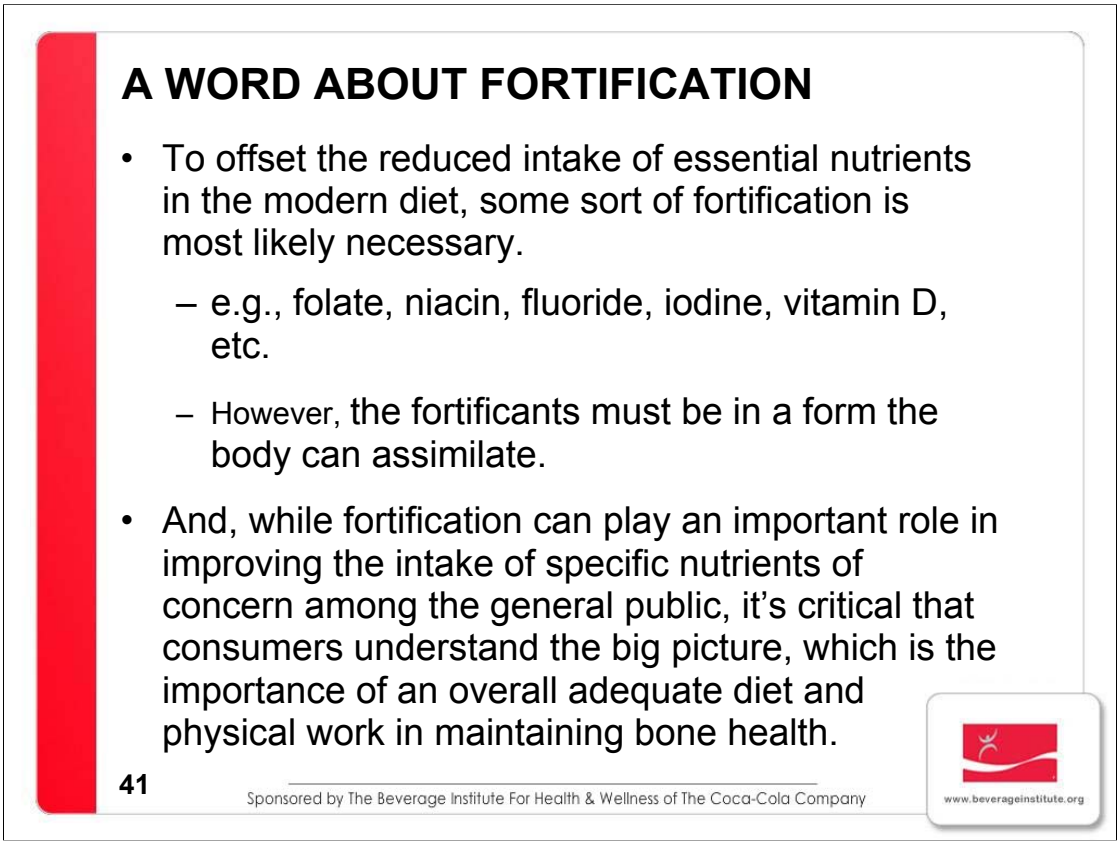
FACTORS AFFECTING NUTRITIONAL ADEQUACY: Displacement

SPEAKER COMMENTS: Let's look at trends in beverage consumption over the last 50-plus years.

The solid blue line shows that per capita milk consumption has dropped by nearly 50% since the end of World War II. Of course, milk is a good source of calcium, vitamin D and protein, so that's one reason for a change in status of the critical nutrients.

The dotted red line shows that carbonated beverage intake has more than quadrupled over the same time period, so it's likely that carbonated beverages are displacing some of the milk. However, what's important on this graph is not the rise in carbonated beverage consumption per se, but that there has been a steady decline in milk consumption, which is contributing to decreases in bone status. Getting enough essential bone nutrients is difficult without milk.

The key issue is how do we deal with the fact that consumption of milk—the source of several essential nutrients for bone health—has gone down? The challenge for practitioners is how to help people understand there is room in a healthy diet for both carbonated beverages and milk while making it clear that improving the overall quality of their diets, including increasing their intake of key bone nutrients, is absolutely critical to bone health.



FORTIFICATION

SPEAKER COMMENTS: To offset the reduced intake of essential nutrients without increasing calories exorbitantly, some sort of fortification is likely necessary.

The tendency today toward energy-dense, nutrient-poor diets and the trend of decreasing milk intake suggests a potential role for food fortification. We're all familiar with many examples of fortification such as the addition of folate and niacin to cereal grain products, fluoride to the water supply, iodine to salt, and vitamin D to various products, particularly milk in North America and more recently to calcium-fortified juices.

However, it's important that the fortificants added to foods be in a form the body can assimilate. That topic is beyond the scope of this program, but know that it's an important challenge for food manufacturers.

As for working with patients, we need to emphasize that while fortification (and supplementation) can certainly play an important role in improving the intake of specific nutrients of concern among the general public, it's critical that we help them understand the big picture, which is the importance of an overall adequate diet and physical work in maintaining bone health.

For more information on calcium bioavailability see "Further reading on calcium bioavailability" at the end of this presentation.

SUMMARY

- Bone health requires both adequate **total nutrition** and **work** (weight-bearing exercise).
- Taking a mono-nutrient approach to bone health is usually wrong.
- The key components of carbonated beverages (caffeine, phosphoric acid, citric acid, carbonation) do not negatively impact calcium balance.
- Declining milk consumption is of great concern because it is difficult to get enough key bone nutrients from the diet without it. But there is room for both milk and carbonated beverages in a healthy diet.
- Some sort of fortification is most likely necessary, but, the fortificants must be in a form the body can assimilate.

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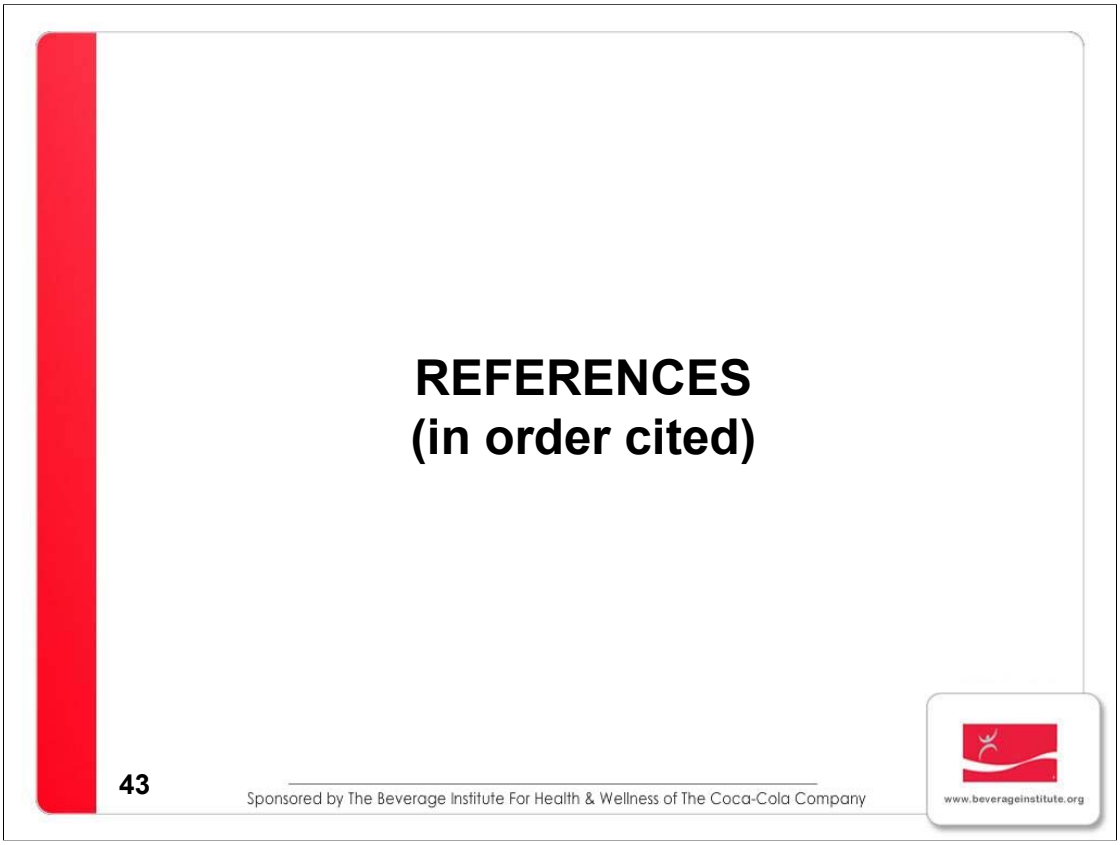
SPEAKER COMMENTS:

- Bone health, and in fact total body health, absolutely require adequate total nutrition and work. As we've clearly seen, bones won't thrive unless we feed them right and use them often.
- Taking a mono-nutrient approach to bone health is usually wrong. Nutrients work in "teams" in the body and diets low in one nutrient are usually low in several.
- The components of carbonated beverages, including caffeine, phosphoric acid and carbonation, have a small and biologically insignificant impact on urinary calcium losses and are not harmful to bone health.
- Declining milk consumption is of great concern because it is difficult to get enough key bone nutrients from the diet without it. But there is room for both milk and carbonated beverages in a healthy diet.
- Some sort of fortification is most likely necessary to offset the reduced intake of essential nutrients in the modern diet. However, the fortificants must be in a form the body can assimilate.



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Specker BL. Evidence for an interaction between calcium intake and physical activity on changes in bone mineral density. J Bone Miner Res. 1996;11:1539-1544.

Dawson-Hughes B, Harris SS, Krall EA, Dallal GE. Effect of calcium and vitamin D supplementation on bone density in men and women 65 years of age or older. N Engl J Med. 1997;337:670-676.

Dawson-Hughes B, Harris SS. Calcium intake influences the association of protein intake with rates of bone loss in elderly men and women. Am J Clin Nutr. 2002;75:773-779.

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Heaney RP, Rafferty K. Carbonated beverages and urinary calcium excretion. Am J Clin Nutr. 2001;74:343-347.

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Barger-Lux MJ, Heaney RP. Caffeine and the calcium economy revisited. Osteoporos Int. 1995;5:97-102.

Bergman EA, Massey LK, Wise KJ, Sherrard DJ. Effects of dietary caffeine on renal handling of minerals in adult women. Life Sci. 1990;47:557-564.

Further reading on calcium bioavailability:

- Heaney RP, Rafferty K and Bierman J. Not all calcium-fortified beverages are equal. Nutrition Today 2005; 40(1).
- Heaney RP, Rafferty K, Dowell MS and Bierman J. Calcium Fortification Systems Differ in Bioavailability. JADA 2005;105:807-809.

Further reading on bone health:

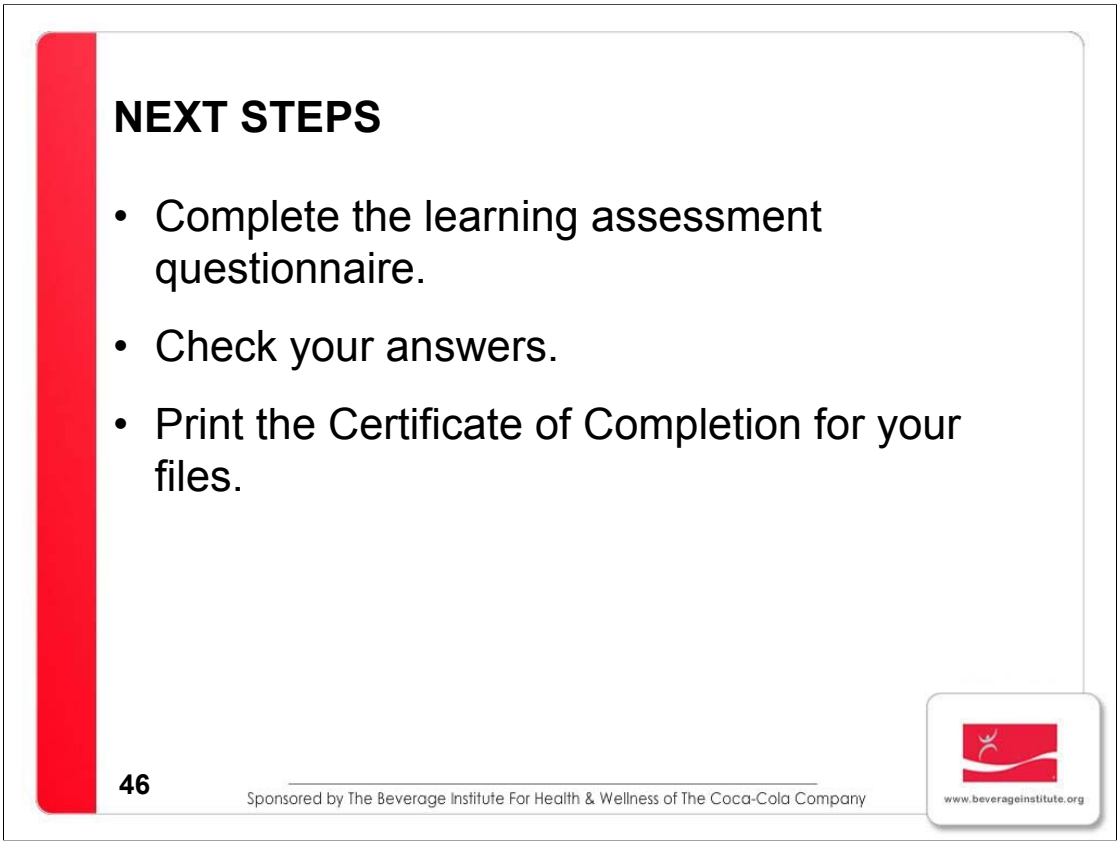
- Bone Health and Osteoporosis: A Report of the Surgeon General (2004). Found at http://www.surgeongeneral.gov/library/bonehealth/content.html
- The NIH Osteoporosis and Related Bone Diseases—National Resource Center. Found at http://www.niams.nih.gov/Health_Info/Bone
- International Osteoporosis Foundation. Found at http://www.iofbonehealth.org/home.html

SPEAKER BIOGRAPHY

Robert P. Heaney MD, FACP, FACN

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, Dr. Heaney was a member of the Institute of Medicine panel for the 1997 Dietary Reference Intakes for calcium and related nutrients. He chaired the Scientific Advisory Panel on Osteoporosis, Office of the Technology Assessment of the U.S. Congress, and is an emeritus member of the board of trustees of the National Osteoporosis Foundation and an honorary member of the American Dietetic Association. His research has been published widely in peer-reviewed journals.



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