

Does Consumption of Cola Beverages Cause Bone Fractures in Children?

To the editor: I read with interest the informative and thorough review by Dr Fitzpatrick¹ on secondary causes of osteoporosis. An additional possible cause of bone mineralization reduction and fractures in children is the consumption of cola beverages.

Drinking cola beverages, which contain phosphoric acid and often caffeine, may increase the fragility of bones in children and adolescents through interactions with the bone mineral content² and has been found by several investigators to be associated with an increased risk of bone fractures. Consumption of cola beverages was positively associated with bone fractures in girls in 9th and 10th grade,³ in girls aged 8 to 16 years,² and in children aged 7 to 14 years.⁴ The amount of cola beverages involved is minimal: consumption of 0.7 or more cans or bottles of cola beverages per day resulted in a statistically significant increase in bone fractures in girls younger than 17 years.²

Noncola carbonated soft drinks, however, do not contain phosphoric acid and often do not contain caffeine, and several studies have found that noncolas are not specifically associated with increased fracture risk among school-aged children.²⁻⁴ In a study of 460 teenaged girls, Wyshak³ showed an increased risk of bone fractures in active girls who drank colas but not noncolas; conversely, there was no increased risk of fractures in active girls who drank noncolas but not colas. However, active girls who drank both colas and noncolas had an increased risk of fractures.

Phosphoric acid is associated with altered calcium homeostasis and development of hypocalcemia.^{5,6} Consumption of approximately 0.6 or more cans or bottles of cola beverages per day is a risk factor for the development of hypocalcemia in children 14 years of age or younger.⁶ Similarly, the consumption of 1 or more bottles of cola beverages per day is associated with hypocalcemia in postmenopausal women.⁵ Garcia-Contreras et al⁷ showed that rats that drank cola beverages developed hypocalcemia and lower femoral mineral density compared with control rats that drank water.

Caffeine is also present in most cola beverages and may affect bone health. Ohta et al⁸ showed that caffeine intake affected the content and crystallite size of bone minerals and that the femurs of rats fed caffeine tended to be weaker compared with controls. Wyshak and Frisch³ found no association, however, between total caffeine intake and the risk of fractures among girls or boys.

Maximizing peak bone mass during childhood and adolescence may be important in preventing osteoporosis.⁹ Although noncolas have not specifically been associated with increased fracture risk among school-aged children, replacing milk in the diet with soft drinks of any type may interfere with the attainment of maximum peak bone mass in adolescents and young adults. Consumption of soft drinks increased dramatically from 1965 to 1996 among US children and adolescents,

whereas milk consumption decreased.¹⁰ Harnack et al¹¹ found that soft drink consumption was inversely associated with consumption of milk in children and adolescents. Whiting et al¹² showed that replacing milk in the diet with carbonated and other low-nutrient-dense beverages was negatively related to total body bone mineral content in girls at the time of peak bone mass accrual (mean age, 12.5 years for girls; range, 10.5-14.6 years¹³).

The adverse effect of carbonated soft drinks on bone health, whether by possible phosphoric acid- and caffeine-related mechanisms in colas or by replacement of calcium-rich milk with soft drinks of any type, is of substantial public health concern, particularly for girls and women because of their proneness to osteoporosis in later life.² Even more troubling is that no current pharmacological treatment is able to completely revert the damages caused to bone mass and bone architecture.¹⁴

Michelle A. O. Kinney, MD
Mayo Clinic
Rochester, Minn

1. Fitzpatrick LA. Secondary causes of osteoporosis. *Mayo Clin Proc.* 2002;77:453-468.
2. Wyshak G, Frisch RE. Carbonated beverages, dietary calcium, the dietary calcium/phosphorus ratio, and bone fractures in girls and boys. *J Adolesc Health.* 1994;15:210-215.
3. Wyshak G. Teenaged girls, carbonated beverage consumption, and bone fractures. *Arch Pediatr Adolesc Med.* 2000;154:610-613.
4. Petridou E, Karpathios T, Dessypris N, Simou E, Trichopoulos D. The role of dairy products and non alcoholic beverages in bone fractures among schoolage children. *Scand J Soc Med.* 1997;25:119-125.
5. Guerrero-Romero F, Rodriguez-Moran M, Reyes E. Consumption of soft drinks with phosphoric acid as a risk factor for the development of hypocalcemia in postmenopausal women. *J Clin Epidemiol.* 1999;52:1007-1010.
6. Mazariegos-Ramos E, Guerrero-Romero F, Rodriguez-Moran M, Lazcano-Burciaga G, Paniagua R, Amato D. Consumption of soft drinks with phosphoric acid as a risk factor for the development of hypocalcemia in children: a case-control study. *J Pediatr.* 1995;126:940-942.
7. Garcia-Contreras F, Paniagua R, Avila-Diaz M, et al. Cola beverage consumption induces bone mineralization reduction in ovariectomized rats. *Arch Med Res.* 2000;31:360-365.
8. Ohta M, Cheuk G, Thomas KA, et al. Effects of caffeine on the bones of aged, ovariectomized rats. *Ann Nutr Metab.* 1999;43:52-59.
9. Heaney RP, Matkovic V. Inadequate peak bone mass. In: Riggs BL, Melton LJ III, eds. *Osteoporosis: Etiology, Diagnosis, and Management.* 2nd ed. Philadelphia, Pa: Lippincott-Raven Publishers; 1995: 115-131.
10. Cavadini C, Siega-Riz AM, Popkin BM. US adolescent food intake trends from 1965 to 1996. *Arch Dis Child.* 2000;83:18-24.
11. Harnack L, Stang J, Story M. Soft drink consumption among US children and adolescents: nutritional consequences. *J Am Diet Assoc.* 1999;99:436-441.
12. Whiting SJ, Healey A, Psiuk S, Mirwald R, Kowalski K, Bailey DA. Relationship between carbonated and other low nutrient dense beverages and bone mineral content of adolescents. *Nutr Res.* 2001;21:1107-1115.

13. Bailey DA, Martin AD, McKay HA, Whiting S, Mirwald R. Calcium accretion in girls and boys during puberty: a longitudinal analysis. *J Bone Miner Res.* 2000;15:2245-2250.
14. Ben Sedrine W, Reginster J-Y. Risk indices and osteoporosis screening: scope and limits [editorial]. *Mayo Clin Proc.* 2002;77:622-623.

In reply: I appreciate the thoughtful letter by Dr Kinney regarding the issues of phosphoric acid and bone loss. In the past, this area of bone metabolism has been confounded by multiple studies with differing results, but several panels of experts addressed this issue recently.

In 1994, the National Institutes of Health sponsored a Consensus Conference on Optimal Calcium Intake led by experts in the field of bone and dental health.¹ The conclusion, which was endorsed by the American Medical Association, was that the effect of phosphoric acid and phosphorus in cola products on calcium metabolism was physiologically trivial.

The 2000 National Institutes of Health Consensus Conference on Osteoporosis Prevention, Diagnosis, and Therapy is probably one of the most comprehensive reviews of the subject by a leading group of experts in the field of osteoporosis.² The objective was to provide state-of-the-art information on osteoporosis, and the participants consisted of a nonfederal, nonadvocate 13-member panel representing the fields of internal medicine, family and community medicine, endocrinology, epidemiology, orthopedic surgery, gerontology, rheumatology, obstetrics and gynecology, preventive medicine, and cell biology. In addition, 32 experts from these fields presented data to the panel, and the conference audience of 700 were allowed to comment. The conclusion of the conference was that any effect of cola beverages was due to milk displacement.³

Regarding the use of phosphoric acid in cola beverages, most of the past studies have been flawed because of inaccuracies on actual nutritional intake. When a person drinks too much soda, it is at the expense of not drinking milk, a beverage that contains much more calcium (and phosphate). If the body is nutritionally replete with calcium, then substances such as phosphoric acid (or caffeine) do not affect bone metabolism. Thus, it is the substitution of cola beverages for a more healthy beverage such as milk that is associated with the bone loss.

The article by Garcia-Contreras et al cited by Dr Kinney is an excellent example of this nutritional issue. Although this study was performed in animals, it is a prospective study in which all the important elements can be measured. If one looks at the group of mice that drank cola, one can clearly see

that the animals drank 4 times the amount of liquid in the form of cola drinks compared with the group that drank water (141±5 mL/d vs 35±7 mL/d). As a result, intake of solid food was significantly less in the cola group because the animals were consuming more of their calories through the cola beverage. Thus, since the rats consuming cola beverages had a 3-fold higher liquid intake than those consuming water and the daily food intake of rats consuming cola soft drinks was one half of that of the rats consuming water, these data suggest that the group consuming cola beverages was nutritionally depleted. Although the authors mentioned a pair-fed group of animals as controls, the appropriate control for the phosphoric acid cola group would have been a group of animals given a soda beverage without cola and phosphoric acid.

Similar problems occur in epidemiologic studies in which surveys often do not correct for the level of education, nutritional knowledge, whether a caretaker or mother is providing meals, and other issues that may influence the decision to serve young children cola instead of milk. In these studies, the intake of carbonated beverages is inversely related to the intake of milk.

On a historical note, Dr McCay of Cornell University testified about the dangers of cola products to the US House of Representatives in 1950. The misinformation has promulgated since that testimony. The 0.55% level of phosphoric acid in cola products is much lower than the 1.09% level in orange juice, a "natural" product. Phosphoric acid is also found in cheese, jams, jellies, and beer.

Overall, I agree with Dr Kinney that cola beverages are probably not the best fluids for young children and that they should maintain a nutritionally adequate, balanced diet to build bone during this vulnerable stage of their life by consuming calcium-containing dairy products.

Lorraine A. Fitzpatrick, MD
Mayo Clinic
Rochester, Minn

1. National Institutes of Health. Consensus statements: optimal calcium intake. 1994. Available at: http://odp.od.nih.gov/consensus/cons/097/097_intro.htm. Accessibility verified June 18, 2002.
2. National Institutes of Health. Consensus statements: osteoporosis prevention, diagnosis, and therapy. 2000. Available at: http://consensus.nih.gov/cons/111/111_intro.htm. Accessibility verified June 18, 2002.
3. Heaney RP, Rafferty K. Carbonated beverages and urinary calcium excretion. *Am J Clin Nutr.* 2001;74:343-347.

The Editor welcomes letters and comments, particularly pertaining to recently published articles in *Mayo Clinic Proceedings*, as well as letters reporting original observations and research. Letters pertaining to a recently published *Proceedings* article should be received no later than 1 month after the article's publication. A letter should be no longer than 500 words, contain no more than 5 references and 1 table or figure, be signed by no more than 3 authors, be in double-spaced, typewritten format, and not be published or submitted elsewhere. The letter must be signed and include the correspondent's full address, telephone and fax numbers, and e-mail address (if available). It is assumed that appropriate letters will be published, at the Editor's discretion, unless the writer indicates otherwise. The Editor reserves the right to edit letters in accordance with *Proceedings* style and to abridge them if necessary. Letters may be submitted by surface mail to Letters to the Editor, *Mayo Clinic Proceedings*, Room 770 Siebens Building, Rochester, MN 55905; by fax to (507) 284-0252; or by e-mail to proceedings@mayo.edu. (Note: Authors who submit letters by fax or e-mail must also send a copy by surface mail.)