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Bone Density and Consumption of Cola Beverages

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The purpose of *Linking Research to Clinical Practice* is to present evidence-based information to clinical dental hygienists so that they can make informed decisions regarding patient treatment and recommendations. Each issue will feature a different topic area of importance to clinical dental hygienists with A BOTTOM LINE to translate the research findings into clinical application.

Evaluation of the effect of cola drinks on bone mineral density and associated factors.

Ogor R, Uyal B, Ogor T, Yaman H, Ozlas E, Ozdemir A, Hasde M. Basic and Clinical Pharmacology and Toxicology. 100:334-338, 2007.

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Abstract

Background. The aim of this study was to determine bone mineral density changes caused by consumption of cola drinks and the associated factors.

Methods. Thirty Sprague-Dawley rats were divided into four groups. Groups 1 and 2, consisting of 10 male and 10 female rats, respectively were provided with as much food, water and cola drinks as they wanted. Groups 3 and 4, consisting of 5 rats each, received only rat chow and water. The bone mineral density of the rats was measured using dual energy X-ray absorptiometry at the end of 30 days. The blood values and weights of the animals were also determined. The esophagus and kidneys were removed for histopathological examination.

Results. The weight gain was higher in the groups consuming cola drinks than the control group rats ($p < .05$). Water consumption decreased 5.9 times while total fluid consumption increased 1.6-1.9 times in the group consuming cola drinks. No significant change was detected in the blood calcium levels. There was a significant decrease in the bone mineral density of test groups when compared to the control groups ($p < .05$). While we did not detect any pathological esophageal changes in the rats consuming cola drinks, examination of the kidneys revealed general glomerular congestion and intertubular bleeding.

Conclusions. We suggest that the decrease in bone mineral density might be related to the renal damage caused by cola drinks in addition to other related factors.

Commentary

Consumption of carbonated beverages continues to be of concern to health professionals as they have been linked to both dental caries and obesity. This study used an animal model to explore the potential for a causal relationship between bone mineral density and cola beverage consumption. The animal model design allowed researchers to control the animals' exposure to dietary forms of phosphoric acid other than that present in the cola. The cola was purchased from a public market and is a popular brand that is available worldwide. Additionally, the researchers periodically alternated the location of the water and cola containers in the animal enclosures to prevent animals returning to the same drinking location simply due to habit. It is important to note that the animals were given free access to as much food and water as they wanted, and for the test group, free access to cola as well. Animals were weighed twice weekly over the 30-day period, and then anesthetized to obtain bone mineral density measures, blood samples, and tissue samples. Change of pH in the cola beverage began immediately upon opening and was assessed over a 20-hour period.

Results from this study showed that, in the cola test group, females consumed significantly more ($p < .05$) cola than the males, at 76.2 mls versus 55.3 mls. Concomitantly, water consumption in this group decreased by 5.9 times, whereas total fluid consumption increased by 1.6 to 1.9 times. Both male and female rats having free access to cola gained more weight than the control rats, and these differences were statistically significant ($p < .05$). Moreover, the cola-consuming rats (both male and female) had a statistically significant decrease in bone mineral density (approximately 20% lower) compared to the control rats, although their serum calcium levels were not significantly different. Histopathological examination of the esophagus did not reveal any changes; however, there was evidence of renal damage in the cola-fed rats. The pH levels of the colas over the 20-hour period varied slightly between 1.4 and 1.7, but were not significantly different.

The authors compared their results to previously published studies in this area, and while there were some differences in outcomes among studies, the decrease in bone mineral density of about 20% for test rats were consistent with results obtained in previous studies. A hypothesized reason for this is that the high phosphate and high caffeine in colas may result in an increased acid load in the body, which can influence the calcium/phosphorous ratio and bone mineral density. The results regarding renal damage were not directly attributed to changes in bone mineral density, although the authors do propose the need for future studies to determine whether kidney damage might result in changes in the mineral balance of the body, which might influence bone mineral density. One issue not addressed by the authors was that the rats having free access to cola also consumed considerably more fluid overall than the control group rats. Whether this might influence renal damage and function is not discussed. Overall, this study does provide preliminary evidence of a relationship between cola consumption and bone mineral density in a rat model. As always with animal studies, one must be cautious in generalizing these results to a human population.

Colas, but not other carbonated beverages, are associated with low bone mineral density in older women: The Framingham Osteoporosis Study

Tucker KL, Morita K, Qiao N, Hannan MT, Cupples A, Kiel DP. American Journal of Clinical Nutrition 84: 936-942, 2006.

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Abstract

Background. Soft drink consumption may have adverse effect on bone mineral density (BMD), but studies have shown mixed results. In addition to displacing healthier beverages, colas contain caffeine and phosphoric acid (H₃PO₄) which may adversely affect bone.

Objective. We hypothesize that consumption of cola is associated with lower BMD.

Design. BMD was measured at the spine and 3 hip sites in 1413 women and 1125 men in the Framingham Osteoporosis Study by using dual-energy X-ray absorptiometry. Dietary intake was assessed by food-frequency questionnaire. We regressed each BMD measure on the frequency of soft drink consumption for men and women after adjustment for body mass index, height, age, energy intake, physical activity score, smoking, alcohol use, total calcium intake, total vitamin D intake, caffeine from noncola sources, season of measurement, and for women, menopausal status and estrogen use.

Results. Cola intake was associated with significantly lower ($p < 0.001-0.05$) BMD at each hip site, but not the spine, in women but not in men. The mean BMD of those with daily cola intake was 3.7% lower at the femoral neck and 5.4% lower at Ward's area than those who consumed <1 serving cola per month. Similar results were seen for diet cola and, although weaker, for decaffeinated cola. No significant relations between noncola carbonated beverage consumption and BMD were observed. Total phosphorus intake was not significantly higher in daily cola consumers than in nonconsumers; however, the calcium-to-phosphorus ratios were lower.

Conclusions. Intake of cola, but not of other carbonated soft drinks, is associated with low BMD in women. Additional research is needed to confirm these findings.

Commentary

Osteoporosis and associated bone fractures are important health issues for older adults. Hip fracture in older adults is associated with a risk of mortality of up to 20%. Previous studies suggest that cola consumption may predispose teenagers to increased risk of fractures; however, few studies have examined this effect in an adult population. The rationale for the current study was based on previous studies that suggest that phosphoric acid might decrease calcium absorption and interfere with normal mineral balances in the body. In addition, caffeine, which is present in cola drinks, has been associated as a risk factor for osteoporosis. These authors examined the hypothesis that cola beverages may increase individuals risk for low BMD in a large, federally funded nutrition study. The Framingham Osteoporosis study is a third generation study that includes a sample of offspring from the original 1948 Framingham Heart Study (FHS). In 1971, 5124 adult children of FHS participants were enrolled in the Framingham Offspring Cohort Study. Over the intervening 3 decades, these subjects were followed and examined at 7 different intervals. The data presented in this study were collected between 1996 and 2001 on subjects who were still being followed in the Cohort study and were not taking medications such as bisphosphonates, selective estrogen receptor modulators, or calcitonin, which might influence results. Standard methods were used to determine BMD. Dietary data were collected using a validated, 126-item questionnaire that queried subjects on frequency of food and beverage consumption. In order to account for other factors that might influence the results, the authors also obtained extensive information on health-related behaviors, physical status measures, and demographic variables.

The average age (SD) of female participants was 58.2 (9.4), with men being comparable at 59.4 (9.5). In addition, body mass index scores (BMI) were similar between gender groups, with men being slightly greater. Overall, women had lower BMD, lower physical activity scores, less caffeine intake, and less calorie intake than men. Women, did however have, on average, a higher intake of calcium and vitamin D. With regard to average consumption of carbonated beverages, men consumed 6 servings per week compared to women's 5 servings. Of those, colas comprised the most common selection of carbonated beverages. Multiple linear regression was used to predict BMD as a function of cola consumption while controlling for other relevant factors. Multiple linear regression is a well-accepted statistical strategy used to predict health outcomes while controlling for other explanatory factors. Given the sample size used in this study, one can expect that these analyses would provide stable estimates for associations under scrutiny. The results showed that there was not a significant association between carbonated beverages, in general, and BMD. However, in women there was a negative association between cola consumption and BMD such that higher consumption was associated with lower BMD. This association persisted for diet colas and decaffeinated colas. One result that gives additional support to this relationship was that caffeinated colas were more strongly associated with lower BMD than decaffeinated colas. Of interest, these associations were not observed in men.

The authors were quick to point out that higher cola intake was not related to lower milk intake, which has been considered in previous studies as a plausible factor in decreased BMD. Results from this study showed a consistent effect of cola consumption on lower BMD in women, even when decaffeinated colas were considered. They propose that the phosphoric acid, caffeine, and cola extract present in colas but not in other carbonated beverages to the same degree, are likely reasons

for decrease in BMD. Clearly, caffeine and phosphoric acid are biologically plausible culprits; however, not much is known about cola extract and what systemic effects it might have. Previous studies have shown that beverages with both phosphoric acid and caffeine increase urinary calcium excretion, which might be a reason for the reduced BMD. The authors conclude that women who are concerned about osteoporosis should avoid consumption of cola beverages.

The Bottom Line

Dental hygiene clinicians are often faced with patients who have high caries rates associated with consumption of sugar-sweetened cola beverages. A common recommendation during oral health education is to switch to diet cola beverages, and thus reduce risk for decay. However, as dental hygienists assume a greater role in the area of health advocacy, such recommendations may not be prudent given recent evidence on cola consumption and systemic health. In the past decade, significant shifts have occurred in dental hygiene practice where clinicians serve as a knowledge resource for their patients in areas that extend beyond the traditional boundaries of "the mouth". Certainly, one area in which this shift has occurred is in the area of periodontal disease and systemic health, particularly in cardiovascular, reproductive, and endocrine health. These 2 studies provide evidence that phosphoric acid and caffeine in colas, irrespective of whether they are sugar sweetened or not, may predispose individuals to BMD health risks.

Whether the link between consumption of cola beverages and BMD is causal or not, these 2 studies provide evidence that cannot be ignored. The role of the dental hygienist in providing accurate information and valid health recommendations is important. In patients with high caries rates, the dental hygienist should provide counseling on exposure to sugar in colas, but should also consider that the phosphoric acid and caffeine in sugared, artificially sweetened, and decaffeinated colas may predispose women to changes in BMD above those associated with hormones, diet, and activity level.

Therefore the following recommendations can be made based on the findings in these 2 studies:

- Consumption of cola beverages is a statistically significant and independent risk factor for lower BMD. This relationship is evident in an animal model as well as for women, in the human model.
- The mechanism by which cola beverages might influence BMD is still unknown, but may be related to change in the calcium/phosphorus ratio systemically.

Summary

The practice of dental hygiene continues to evolve as new evidence is published. Recent studies suggest that diet and decaffeinated cola beverages along with sugar sweetened colas may be a risk factor for lower bone mineral density, especially in women. This evidence has implications for clinicians who play a critical role in educating patients. When providing dietary recommendations for patients with high caries rates who consume cola beverages, clinicians should be cautious in recommending diet cola beverages. Certainly there is a need for additional research into the mechanism for this effect and to determine if occasional consumption of colas is a health risk.