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ORIGINAL ARTICLE

EFFECT OF PEPSI BEVERAGES ON URINE pH, CRYSTALLURIA, AND URINARY CALCIUM EXCRETION

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Summary

Background: Carbonated beverages are very popular worldwide. Carbonated beverage consumption vast increase raises great health concerns regarding their effect on calcium homeostasis besides obesity and renal function. Carbonated beverages sugar content, caffeine, and acidulant all can affect in a way or another calcium absorption, metabolism and excretion. The latter has direct effect on teeth, bone and general wellbeing. This study aims to reveal the effect of sub-chronic intake of carbonated beverage on urinary pH, crystalluria, calcium excretion.

Methods: 21 healthy volunteers have been recruited in this study (9 males and 12 females) abstain for any carbonated beverages for at least the previous 4 weeks before participating in this study. Urine has been collected over 24 hours, the next day each volunteer has to drink 250 ml of carbonated beverage (Pepsi®) daily for 3 weeks. On the last day, urine was collected again over 24hr. pH, crystalluria, and calcium in urine have been measured.

Results: Urine pH and crystalluria after 3 weeks' intake of 250 ml of carbonated beverage did not statistically differ from urine pH before the intake. Although, there was a trend toward reduction in pH and an increase in crystalluria. Total calcium excretion in urine increase was statistically significant when compared with calcium excretion at the study beginning.

Conclusion: The regular intake of carbonated beverage (Pepsi®) increase calcium excretion. Thus, it may be advisable to increase the intake of milk or other dairy product to overcome the adverse impact of carbonated beverages.

Key words: Pepsi; Calciuria; Beverages; Crystalluria

Introduction

Carbonated beverages first commercially produced was in 1884 in Lisbon Falls Maine the USA by a pharmacy (chemist) and was consist of cola extract, sarsaparilla and carbonated water called Moxie. Within a few years, later Coca-cola and Pepsi cola (which are based on the same formula) appeared and with industrial production

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and the invention of preservatives massive quantity produced (1). Nowadays, Carbonated beverages are one of the most popular beverages worldwide (2, 3). For instance, the British soft drinks association annual report in 2020 states that the consumption of soft drinks in general in the UK has increased from 13.2 billion litres in 2010 to 13.5 billion liters in 2020. More than 38.2% of this amount are carbonated beverages (britishsoftdrinks.com). Accordingly, increase intake of Carbonated beverages has been draw attention due to their possible association with many untoward effects which include but are not limited to dental erosion and severe tooth decay, esophagitis, psychological disorders, sleep disturbance, nephrolithiasis (4). The latter may be due to several components, for instance, the non-diet carbonated beverages have high sugar content so the consumption of these high sugar carbonated drinks increases not only the risk of obesity (5), but also the risk of developing cancer (6,7). An observational study by Wyshak, G *et al*. highlighted the association between the administration of nonalcoholic non-diet carbonated beverages and bone fracture in athletic females however, there was no significant correlation had been found between carbonated beverages and bone fracture in non-athletic females (8), which rise a question about this difference in why the effect of carbonated beverage on athletes' bone but not on non-athletes. In consistent with a later study, Robert P Heaney and Karen Rafferty reported in an experimental study an increase in calcinuria with excessive consumption of carbonated beverages is restricted to caffeinated beverages, not to sugar or phosphoric acid, an acidulant added to cola drinks to provide tartness, reduce the growth of bacteria and fungi, and prolong shelf-life. Citric acid, a substance inherently present in citrus drinks and added to many carbonated beverages, give a tangy flavour and also act as a preservative (9, 10). Citric acid has been reported to reduce cariogenic ability in low concentration by bacterial phosphofructokinase inhibition which is responsible for glycolytic enzymes (11), thus, hinder the acid formation in dental plaque by bacterial fermentation of sweets. In addition to it is the ability to stimulate salivary flow might lead to faster clearance of the mouth from acids (11). Less commonly, Malic acid is added to low caloric carbonated beverages to enhance taste and hence, reduce the number of added flavourings.

Another common component of carbonated beverages is caffeine which besides its stimulant effect can affect calcium deposition in the skeleton. In an observational study, the caffeine content of soft drink intake correlates with bone demineralization in old women especially spine (12).

On the other hand, the acidulant in these carbonated beverages can help enhance the bioavailability of certain medications for instance Dasatinib (a second-generation ABL kinase inhibitor that can be used to treat chronic myeloid leukaemia and other types of leukaemias) has poor absorption in high pH media and as many of patients who use it, have to administer proton pump inhibitors which interfere with Dasatinib absorption and coadministration with Pepsi® elevate stomach pH enhance bioavailability (13).

Another common component in Pepsi or Coca Cola is 4-methylimidazole which is used to give the caramel colour to these carbonated beverages however, compelled studies to connect the consumption of 4-methimazole with carcinogenicity (14, 15, 16, 17).

The current study aims to reveal the effects of subchronic administration of a moderate amount (250 ml) of carbonated beverage (Pepsi®) on several parameters in the urine associated closely with the formation of renal stone.

Subjects, materials, and methods

Twenty-one healthy volunteers 12 females and 9 males mean age is 31.25 years and 25.22 years respectively who were abstained from carbonated beverages for at least 4 weeks, consented to volunteer in this study by daily intake of at least 250 ml of Pepsi® for three weeks. The study plan was to collect urine for 24 hr. to measure the total urinary excretion of calcium and crystals pre and post-consumption.

Each volunteer had been provided with a sterile urine collection bag to collect urine starting from 12 pm to the next day 12 pm. The total urine collected over 24 hr is measured in a millilitre. A calcium assay kit provided by the Biomerieux company (France) enables colourimetric determination of calcium in sample preparation. In the calcium assay protocol, a chromogenic complex is formed between calcium ions and O-cresolphthalein. The complex is measured at OD = 575 nm by a microplate reader (18, 19). while crystal level measurement was achieved by counting crystals using specialized sild under a light microscope (20).

The statistical analysis of the data was using a paired t-test to compare the calcium level, crystals number, pH, and volume before and after two weeks of consumption of carbonated drinks were calculated using the SPSS system version 15. While figures were created using Excel sheet Microsoft office 365. The different variables were compared to each other; simple correlations were tested with the unpaired test. If the alpha error probability was higher than 0.5 ($P<0.05$) is regarded as a significant difference.

Results

The following table shows the changes in urine pH, crystalluria, calciuria before and after intake of Pepsi as a carbonated beverage.

Table 1. some of carbonated beverage composition and characteristics (8,10,21).

Carbonated beverage	pH	Sugar	acidulants	Caffeine mg/serving
Coca-cola ® Classic	2.37	Sucrose	Phosphoric acid	29.5
Pepsi ®	2.39	Sucrose	Phosphoric acid	31.7
7-Up ®	3.24	Sucrose	Citric acid and phosphoric acid	None detected
Light 7up ®	3.48	No	Citric acid and phosphoric acid	None detected
Coca-cola ® zero	2.96	No	Phosphoric acid	38.2
Diet Pepsi®	2.39			27.4

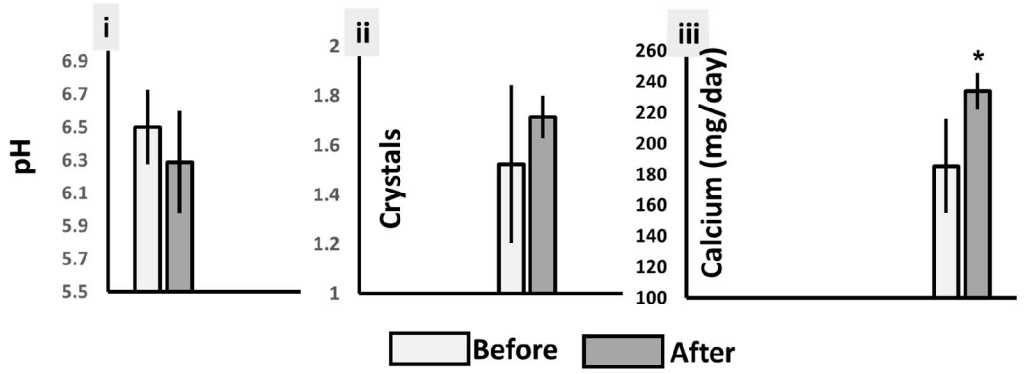

Figure 1. Pepsi drinks modulated measured urine parameters. The parameters include pH (i), crystals (ii), and calcium (iii). Data expressed as mean±SD, *$p<0.05$.

The statistics show significantly increased calcium excretions after daily intake of Pepsi the conclusion that these beverages are bad still early people indulgent with carbonated beverages are replacing their daily intake of calcium whether in form of pure milk or terms of chocolate milk drinks. We can, in general, recommend having a reasonable volume of carbonated beverages and they should not weigh out the milk or other milk-containing drinks.

Discussion

In this study, subchronic administration of a modest volume of cola beverage (250 ml of Pepsi®) increased urinary calcium excretion while there was a trend of reduction of pH and crystals however they were not statistically significant.

The increase in urinary calcium excretion has been reported in previous studies (22). The report showed that acute high amount intake of cola (2 litres) can cause an increase in urinary calcium excretion as oxalate or phosphate. The culprit of these increase in urinary calcium excretion is thought to be related not only to one component of cola

but several ingredients like the type of added sugar as sucrose or glucose can lower urine pH which in turn can enhance calcium excretion while fructose did not affect urine pH (23, 24). Also, add acidulants like phosphoric acid and citric acid to enhance flavour which leads to urine acidification. Finally, caffeine intake has been associated with a high rate of osteoporosis. Several studies have linked the intake of high caffeinated beverage intake with increase risk of osteoporotic fracture and bone demineralization (12, 25, 26, 27, 28, 29). In an experimental study, a high dose of caffeine (800mg) has been reported to increase calcium excretion (30). The mechanism of later effect has not been established however, Shirley *et al*. reported that intake of a combination of lithium carbonate (which is known to be reabsorbed through renal proximal convoluted tubules) with caffeine leads to increase the excretion of lithium which suggested the caffeine inhibit the reabsorption of lithium in a similar way it inhibits the reabsorption of sodium and calcium (31). Later the effect of caffeine block adenosine A1 and/or adenosine $A2_a$ receptor in renal proximal convoluted tubule which inhibits the active sodium reabsorption to the interstitial tissue which causes simple diffusion of water from the proximal convoluted tubule following the concentration gradient which in turn lead to reabsorption of calcium ion (32, 33)

In addition, the loss of calcium body content could be due to a decrease in milk intake as has been observed by report Heaney et al. (9). An observational study involved more than 200 healthy postmenopausal women reported that women with a daily intake of calcium of more than 740 mg/day of calcium were protected from high intake of caffeine when measured the bone mineral density using dual-energy x-ray absorptiometry (27). it is worth mentioning that most of the studies that related caffeine with bone mineral density reduction used a high dose of caffeine (800mg) while the content of 250 ml of Pepsi contain less than 30 mg which may indicate synergistic effect among sugar, acidulant, and caffeine in.

Conclusion

The results of this study further emphasise that continuous intake of carbonated beverages like cola even with modest amounts can still increase calcium excretion even without affecting pH significantly. These results showed that daily administration of cola could cause a negative impact on body calcium economy and it would be advisable to administer a sufficient amount of dairy product to make up for calcium excreted. Furthermore, a modest amount of cola (250ml) daily did not statistically significant increase in crystal in the urine. Further studies would be necessary to reveal the several quantities of cola with an increase in calcium excretion, crystal formation, and pH to determine at which point can cola start to have a negative impact on our body.

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Adherence to Ethical Standards

The study was approved by the Medical Research Ethics Committee in the university of Mosul, the study approval number and date UOM/COM/MREC/2018 (6) on 15/10/2018.

Conflict of Interest

The authors declare that no conflict of interest exists for this research

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