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Original Research Article

Effect of soft drinks on bone

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ABSTRACT

Introduction: Adolescence age group has significant impact of advertizing industry for use of soft drink and junk food. Present study is aimed to find out the alteration in the bone markers in medical and dental students, who regularly consume soft drinks.
Materials and Methods: Students from our institute were divided (n = 200) in two groups. Group A – Students who consume 200 ml or less than 200 ml of soft drink in a week. Group B - Students consuming more than 200 ml of either 'regular' soft drink (B1) or 'diet' soft drink (B2) per day**.**
Results: There is a significant decrease in the levels of bone density, calcium, phosphorous, vitamin D and increase in the activity of alkaline phosphatase in Group B2 than group A as well as B1.
Conclusion: Diet soft drinks are consumed instead of regular soft drinks, the decrease in the pH due to phosphoric acid and aspartame; may lead to bone demineralization resulting into decreased bone density. Inhibition of 1alpha hydroxylase may get inhibited due to acid pH caused by phosphoric acid from soft drinks. These changes may lead to develop tendency of bone fractures in the future life.

1. Introduction

Adolescence is the only time following infancy when the rate of physical growth actually augmented. At this time there is high requirement of nutrients and calories which are essential for physical growth and development, in a short period of time.[1] Corresponding to this, healthy eating and drinking habits are very crucial during this phase of development.

Adolescence age group has significant impact of advertizing industry for use of soft drink and junk food.[1] A soft drink is a beverage, often carbonated that does not contain alcohol. The soft drinks usually contains the following components, phosphoric acid, caffeine, sugar or aspartame or saccharine, caramel, coloring agents, carbon dioxide.[2] The sour taste of phosphoric acid is compensated by adding lots of sugar.

Students of adolescence age group consume caffeinated beverages to be active and alert while studying. These soft drinks do not have any nutritional value and further they lead to long term medical problems.[3] One or more soft drinks a day can increase the risk of numerous health problems like obesity, diabetes mellitus, tooth decay, osteoporosis, nutritional deficiencies, heart diseases and many neurological disorders.[4] WHO has reported rising incidence of obesity and chronic diseases in individuals who consume more of soft drink.[5]

Normally bone calcification takes place in the first 25 years of life. For this adequate calcium in the diet is required; i.e. food rich in calcium especially milk and milk derivatives.[6] However the trend of today is currently shifting from milk intake towards increased consumption of soft drinks.[7] Phosphoric acid from soft drink is a calcium binder. Calcium binders are water soluble substances. Anionic part of these reacts with calcium cations. Phosphates interferes the assimilation of calcium.

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Calcium binders react with calcium and produce calcium salt which is insoluble. These insoluble salts are not assimilated, will not be available for bone formation.

$HPO_4^{-2} + Ca^{++} \rightarrow CaHPO_4$

In industries phosphoric acid is used to produce soft water as a softener, which removes calcium and magnesium from water. Soft drinks possess high content of phosphoric acid, this phosphoric acid from the soft drink functions the same in the human body. It removes calcium and magnesium ions from bone and this will lead to osteoporosis. In osteoporosis, osteoblastic activity increases, consequent increase in the activity of alkaline phosphatase. Intake of cola and other carbonated drinks is associated with decrease in vitamin D_3 which contributes for bone demineralization.[2]

Overall the major ill effect of cold drink consumption is disturbance in bone metabolism. Proceeding on this track present study is aimed to find out the alteration in the serum levels of calcium, phosphorous, magnesium, vitamin D3, bone density and activity of alkaline phosphatase in medical and dental students, who regularly consume soft drinks. Additionally, our aim is extended to utilize our results for sensitizing and awakening awareness in these youngsters at our institute and consequently all youth, about the adverse effects of the soft drinks on their health.

2. Materials and Methods

2.1. Place of work

Research work was carried out in the department of Biochemistry, Bharati Vidyapeeth (Deemed to be University), Medical College and Hospital, Sangli.

2.2. Duration

2015-2016.

Study Group – We divided the students in two groups. **Group A** – Students who consume 200 ml or less than 200 ml of soft drink in a week. **Group B -** Students consuming more than 200 ml of aerated (soft) drink per day. Again B group is subdivided into B1 and B2. **B1** – those who consume regular soft drink and **B2**- those who consume diet soft drink.

2.3. Inclusion criteria

Voluntary participation in the present study.

2.4. Exclusion criteria

Students with any type of previous history of Bone disorder.

2.5. Study design

Cross sectional study.

2.6. Study population

Medical and Dental students who consume soft drinks.

2.7. Data collection procedures and instruments used

After the permission from higher authorities and ethical committee; with prior information and written consent, blood samples of all students were collected with all aseptic precautions. These samples were analyzed for the –

1. Determination of serum calcium, phosphorous, magnesium and alkaline phosphatase, using the fully auto analyzer methods.
2. Bone densities were measured using Bone densitometer instrument.
3. Serum Vitamin D3 was measured using Chemiluminiscence method.
4. Questionnaire was filled by all participating students, for obtaining dietary information.

3. Results

There is no significant difference in all parameters from Both group of students. Only significant decrease in Vit D conc in group B than group A.

Group A – Students who consume 200ml or less amount of soft drink per week

Group B - Students who consume 200ml or more amount of soft drink per day.

There is no significant difference in all parameters from both groups of students. Only significant decrease in Vitamin D concentration, in group B1 than group A.

Group A – Students who consume 200ml or less than this amount of soft drink per week

Group B1 - Students who consume regular soft drinks. (Natural sweetener)

There is a significant decrease in the levels of bone density, calcium, phosphorous, vitamin D and increase in the activity of alkaline phosphatase in Group B2 than group A.

Group A – Students who consume 200ml or less than this amount of soft drink per week

Group B2 - Students who consume diet soft drinks.(Artificial sweetener)

There is a significant decrease in the levels of bone density, calcium, phosphorous, Vitamin D and increase in the activity of alkaline phosphatase in group B2 than group B1.

Group B1 - Students who consume ‘regular’ soft drinks

Group B2 - Students who consume ‘diet’ soft drinks.

4. Discussion

Human body is in a constant state of bone remolding. It is a process which maintains bone strength and ion homeostasis by replacing detached parts of old bone with

Table 1: Bone parameters in students group A & group B

Group	Number of students-'n'	Bone density Mean ± S.D.	Calcium in mg/dl Mean ± SD.	Phosphorous in mg/dl Mean ± S.D.	Magnesium in mg/dl Mean ± S.D.	Alkaline Phosphatase activity in IU Mean ± S.D	Vit. D ngm /ml Mean ± S.D
Group A	40	94.24 ± 115.01	9.42 ± 0.48	2.43 ± 0.22	3.32 ± 0.33	91.98 ± 410.58	31.31 ± 50.87
Group B	190	93.84 ± 89.26	9.39 ± 0.37	2.43 ± 0.22	3.28 ± 0.34	92.81 ± 422.52	30.27 ± 28.18
p value		0.40781	0.397015	0.484243	0.337458	0.406447	0.051241*

*- P value is significant. P < 0.05

Table 2: Bone parameters in students group A & group B1

Group	Number of students-'n'	Bone density Mean ± S.D.	Calcium in mg/dl Mean ± S.D.	Phosphorous in mg/dl Mean ± S.D.	Magnesium in mg/dl Mean ± S.D.	Alkaline Phosphatase activity in IU Mean ± S.D	Vit. D ngm /ml Mean ± S.D
Group A	40	94.24 ± 115.01	9.42 ± 0.48	2.43 ± 0.22	3.32 ± 0.33	91.98 ± 410.58	31.31 ± 50.87
Group B1	137	93.97 ± 115.55	9.45 ± 0.39	2.46 ± 0.20	3.32 ± 0.33	94.30 ± 452.24	30.01 ± 48.11
p value		0.192814	0.397201	0.328313	0.495284	0.269181	0.040365*

*- P value is significant. P < 0.05

Table 3: Bone parameters in students group A & group B2

Group	Number of students-'n'	Bone density Mean ± S.D.	Calcium in mg/dl Mean ± S.D.	Phosphorous in mg/dl Mean ± S.D.	Magnesium in mg/dl Mean ± S.D.	Alkaline Phosphatase activity in IU Mean ± S.D	Vit. D ngm /ml Mean ± S.D
Group A	40	94.24 ± 115.01	9.42 ± 0.48	2.43 ± 0.22	3.32 ± 0.33	91.98 ± 410.58	31.31 ± 50.87
Group B2	21	88.06 ±98.79	9.15 ±0.24	2.15 ±0.42	3.14 ±0.35	96.32 ±372.63	28.42 ±68.01
p value		0.012817*	0.05638*	0.027802*	0.120556	0.044778*	0..031237*

*- P value is significant. P < 0.05

Table 4: Bone parameters in students group B1 & group B2

Group	Number of students-'n'	Bone density Mean ± S.D.	Calcium in mg/dl Mean ± S.D.	Phosphorous in mg/dl Mean ± S.D.	Magnesium in mg/dl Mean ± S.D.	Alkaline Phosphatase activity in IU Mean ± S.D	Vit. D ngm/ml Mean ± S.D
Group B1	137	93.97 ± 115.55	9.45 ± 0.39	2.46 ± 0.20	3.32 ± 0.33	94.30 ± 452.24	30.91 ± 48.11
Group B2	21	88.06 ±98.79	9.15 ±0.24	2.15 ±0.42	3.14 ±0.35	96.32 ±372.63	28.42 ±68.01
p value		0.012213*	0.018151*	0.002691*	0.120556	0.016744*	0.015775*

*- Pvalue is significant. P < 0.05

newly synthesized packets of proteinaceous matrix. Bone is resorbed by osteoclast and is deposited by osteoblasts, in a process called as ossification. Bone metabolism is carefully coordinated by the strong and vital relationship between osteoclasts, osteoblasts, and an array of hormonal and regulatory influences. The relative level of these signaling molecules indicates whether healthy, balanced bone metabolism ensues.[8]

Adolescence is a critical period for bone mass accumulation and boosting peak bone mass geared to prohibit development of osteoporosis in later life.[9]

Whiting and et al. stated that nowadays milk consumption is replaced by increased consumption of soft drinks. This is a current trend in adolescent age group.[7] Carbonated soft drinks contain enormous deleterious substances. Aside from this fact that they have no nutritional value, these drinks can expedite to deep rooted health problems, increased health care costs for society and diverse social problems.[3]

Increased consumption of soft drink the most important factor, significant for girls because they are prone to osteoporosis in future.[10]

In context to this, in our study we noted that, there is no significant difference in all the biochemical bone markers except vitamin D, between the students who consume 200 ml or less amount of soft drink per week (group A) and those who regularly consume soft drink (group B). (Table 1).

Table 2 indicates there is also no significant difference in all the biochemical bone markers between the group A and group B1; except vitamin D which is significantly decreased in groupB1 (those who drink 'regular' soft drink) than that of A.

This may be explained as follows, the students from medical and dental college reside mostly in the hostel located inside the college campus. Provision of healthy diet with sufficient amount of calcium, in the form of milk, milk products like curd, butter milk, cheese paneer and nonvegeterian food is a routine diet plan of hostel mess. The dietary calcium may be capable to compensate the loss of calcium by soft drink consumption.

Table 3 showed the comparison of all the biochemical bone markers between the students from group A and B2 (those who drink 'diet' soft drink). There is significant decrease in the bone density ($p< 0.01$), calcium ($p< 0.05$) and phosphorous ($p<0.002$) and Vitamin D ($p< 0.03$); and elevated serum alkaline phosphatase activity ($p< 0.04$); in the group of students who consume 'diet' drink (group B2) than group A. In this group there is a declining tendency in the concentration of magnesium (3.32 vs. 3.14) even though, not significant.

Table 4 indicates the comparison of all the biochemical bone markers between the students from group B1 and B2. There is significant decrease in the bone density ($p< 0.01$), calcium ($p< 0.01$) and phosphorous ($p<0.002$) and Vitamin D ($p< 0.01$); and elevated serum alkaline phosphatase activity ($p< 0.01$); in the group B2 than group B1. In this group there is a declining tendency in the concentration of magnesium (3.32 vs. 3.14) even though, not significant.

Our results for decreased bone density are aligned with the results reported by Hanna M Serag,[11] Ogor R,[12] Jean P and Murray L.[13] Reduced calcium and phosphorous levels found by us are supported by Mette Kristensen and et al.[13] and many others.[2,14] As per our results of enhanced alkaline phosphatase activity, Henna Serag has also observed same results.[11] Decreases in concentration of vitamin D recorded by us are alike of many investigators, as Amanto D and Caroline[14,15] Nassar M F and et al.[16]

Soft drinks are labeled as 'regular' or 'diet' depending on the sweetening agent used. 'Regular' soft drink contains sugar as a sweetener while 'diet' soft drink contain artificial sweetener like aspartame or sucralose and aceulfame K.[17]

Earlier studies noticed the association between the 'diet' soft drinks and the incidence of obesity, diabetes mellitus, heart diseases and many neurological disorders. As our study was focused on the effect of soft drink consumption on biochemical bone markers, we did not consider any parameter related to above mentioned disorders. Hypothesis regarding these alterations in the bone markers may be explained as below. Soft drinks are far away from soft. Phosphoric acid in the soft drinks makes them acidic in nature. The pH is 2.5 which is 10,000 more acidic than water.[18] At the same time in case of 'diet' soft drinks, the aspartame – the artificial sweetener when hydrolyzed it get converted into aspartic acid.[19] Thus the aspartic acid along with phosphoric acid aggravates the acidic environment. pH get decreased and this acid pH favours bone demineralization. Regular exposure to phosphoric acid from soft drinks leads to reduction in the secretion of HCl in the stomach for long time and it will result into impaired mineral absorption.[18] Consequently it causes loss of calcium, phosphorous and magnesium (though decrease is not significant). These changes are subsequently responsible for paving the way towards the decrease in bone density.

Along with all these changes in the bone marker levels, the activity of alkaline phosphatase increased significantly which may be due to the imbalance in the bone remodeling process and if this continues, it may definitely lead to tendency for bone fracture in future.

As the phosphoric acid added by soft drinks and aspartic acid produced by hydrolysis of aspartame changes the pH to acidic; and at acidic pH the activity of 1alpha hydroxylase may get inhibited. Inhibition of this enzyme declines the conversion of 25OH cholecalciferol to 1, 25 dihydroxycholecalciferol which is vitamin D. This may be the reason for declined levels of vitamin D in all groups B, B1, B2.

When there is less availability of vitamin D, it is difficult to compensate the alterations in the bone markers, caused by soft drink consumption. Continuous consumption of not only diet drink but also of 'regular' soft drink may result into the significant changes in all these parameters. These changes certainly lead to develop bone fracture tendency in early stage of life. Thus along with phosphoric acid aspartame is the culprit for the deleterious effects of 'diet' drinks.

5. Conclusion

Consumption of soft drink when accompanied with healthy diet with sufficient calcium containing food, the chances of bone loss may be less; otherwise it has a potential for bone loss. Extending this fact when 'diet' soft drinks are consumed instead of regular soft drinks, the decrease in the pH due to phosphoric acid and aspartame; may lead to bone demineralization resulting into loss of calcium, phosphorous, vitamin D and increase in the activity of alkaline phosphatase and ends into decreased bone density. Inhibition of 1alpha hydroxylase may get inhibited due to acid pH caused by phosphoric acid from soft drinks. These changes may lead to develop bone fracture tendency in the

future life.

6. Social Message

We as a responsible parent and advocates of healthy life style know that the consumption of soft drink is definitely connected to multiple pathologies. Exorbitant intake of the carbonated beverages leads to drop off in the consumption of milk. This situation has significant impact on the health of girls and women, because they are more susceptible to develop osteoporosis in future. If soft drink intake spikes with the speed as on today, it will make boys also prone to develop bone fracture tendency in future.

Today middle class youth is spending more on the soft drinks that lack nutritive values (which are present in milk, buttermilk, sharbat, coconut water, fresh fruit juice), just to satisfy the false sense of being modern parallel to western societies. This leads to increased health care costs for society and diverse social problems. Youth is the future of every country. Hence there should be effective measures from both sides Government as well as parents.

It requires a serious speculation to avert the immense intake of soft drinks otherwise not only India but the whole world will have to pay an extortionate cost for a low cost or truly speaking costless soft drinks.

7. Limitations

We had small sample size and studied without follow up at intervals. Such type of study requires long term follow up with large number of sample size. In future we are planning for such a study.

8. Conflicts of Interest

We declare no conflict of interest.

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