ORIGINAL ARTICLE

Effects of Carbonated Drinks on Bone Health of Young Adults: a study conducted amongst students of Health University

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ABSTRACT

Background: The concerns with altered metabolic status including the increasing incidence of deteriorating bone health and musculoskeletal pain are being reported frequently throughout the world. Bone health is most commonly associated with lower levels of vitamin D. However, the recent data reports an influential role of carbonated beverage consumption on bone health of its consumers.
Aim: To find the association of carbonated drink consumption on bone health.
Methodology: The survey based study was conducted amongst the students of Health University of Karachi, Pakistan. A questionnaire was structured to evaluate the frequency and preferences of carbonated drink consumption. The consumers were also questioned about their metabolic health, life style, dietary habits, socioeconomic status and Vitamin D and calcium levels. Data was analyzed using SPSS version.
Results: The study reports a positive association of musculoskeletal pain with carbonated drink intake. Males have a higher preference for carbonated beverages as compared to females. In the study participants, a weaker association between carbonated drinks and BMI was reported.
Conclusion: The findings of the present study claim that consumption of carbonated beverages induces a negative effect on the bone health of the consumers and an effort needs to be made to increase awareness regarding the damages induced by this dietary practice.
Keywords: BMI, Bone health, Carbonated Drinks, Dietary choices, Musculoskeletal pain

INTRODUCTION

Bone is a crucial body organ that provides structural support and mobility[1]. Strength and flexibility of the bones are mainly conferred by minerals including calcium and phosphorous obtained from diet and deposit as crystals of hydroxyapatite ($Ca_{10}[PO_4]_6[OH]_2$) in the protein matrix made up of collagen[1]. Bones contain the highest proportion of body calcium (approximately 99%)[2]. Human bones are subjected to a constant change over the whole course of lifespan; a process termed as bone remodeling /mineralization. This process necessitates the resorption of old or damaged bone trailed by the deposition of new bone material. Because of incessant mineralization of bones, a sufficient resource of nutrients is desirable for osteoblastic phase of bone remodeling[3].

Dietary factors have a direct impact on bone mineral density and include inorganic minerals, vitamins and macronutrients, such as protein and fatty acids. For healthy strong bones appropriate intake of calcium and vitamin D is obligatory. Depending upon the age, recommended dietary allowance (RDA) of calcium set by World Health Organization (WHO) varies from 1000mg/day to 1500mg/day[4]. Milk, cheese and other dairy products, green leafy vegetables, soya beans, bread made with fortified flour are few calcium rich foods. Bioavailability of calcium chiefly depends on three main mechanisms; intestinal absorption, renal absorption and bone turnover. Calcium resorption and desorption is regulated by interaction of hormones (parathyroid hormone (PTH), vitamin D and calcitonin) with calcium ion in maintenance of bone mineral density (BMD) (Khan and Sharma 2020). Decreased calcium level in serum induces activation of PTH, which induces the calcium resorption in bones by increasing reabsorption of calcium in kidney[2]. Increased PTH increases vitamin D secretion in kidneys which increases calcium absorption from gastrointestinal tract (GIT) and increase bone resorption. For the maintenances of calcium balance, 1000mg of dietary calcium intake is necessary[2]. Approximately 30-35% (~350mg) of ingested calcium is absorbed via small intestine with other 200mg net absorption from GIT and pancreatic secretions. Unhealthy eating habits and processed food intake without enough calcium, phosphorus and vitamin D resulting in low mineral density of skeletal frame leading to brittle bone and related diseases such as rickets and osteoporosis[5-8]. The imbalance in calcium hemostasis may lead to Hypocalcaemia or Hypercalcemia, which may lead to osteomalacia, chronic bone pain, skeletal or abdominal muscle cramps/spasms, pathologic fractures, irritability, etc[9,10].

Though advancements and increasing trend in consuming processed food and beverages have brought ease and satisfaction in individual's lifestyle, yet such beverages have been reported to be associated with many

Received on 14-07-2020
Accepted on 02-12-2020

health related problems particularly with bone health[6]. Carbonated drinks are one of the types of artificially flavored sugary drinks which effervescence with small satisfying carbon dioxide gas bubbles[11,12]. Carbonated drinks include cola and fruit flavored drinks, carbonated water, energy drinks and soda. Generic composition of carbonated drinks includes colorants, carbohydrates, artificial sweeteners, acids, volatile compounds, phenolic compounds, terpenoids & steroids, nitrogen compounds, minerals, vitamins, caffeine, carbon dioxide and preservatives[13]. Mostly all nutrients present in carbonated drinks exceed the limits of the certain nutrients required by human body.

Consumption of carbonated drinks reported to disturbs the biochemical homeostasis of human body[8,11]. Caffeine present in such drinks is a potent diuretic, psychoactive compound and known to be associated with neurological problems[14]. Carbonic acid, phosphoric acids and citric acid present in carbonated drinks alter blood pH and produce excess amount of bicarbonates which subsequently lead to bone damage[11,15]. High phosphorus and insufficient calcium contents in the beverage encourage osteoplastic activity resulting in a disruption of bone growth resulting in weak bones.

Consumption of carbonated drinks is reported to be associated with diabetes, chronic kidney diseases, cancer, dental caries, liver diseases and osteoporosis[16]. In experimental animals, consumption of carbonated drinks has been reported to link with several chronic diseases[17,18]. Adverse effects of carbonated drinks have also been assessed on human. Several epidemiological and experimental studies reported significant decrease in the bone mineral density and increased susceptibility of fractures and gout among those subjects who consumed carbonated drinks[7,8,6,19-21]. Based on current literature search, by far, no study on evaluating the association of carbonated soft drinks with diet and bone health study has been published in Pakistan. Current research aimed to find effects of carbonated drinks on bone health of young university students in Karachi, Pakistan. This research will help in filling the study gap found in Eastern Asian adult population for the consumption pattern of carbonated drink and its effect on their bone health.

METHODOLOGY

The cross-sectional observational study was carried out at Dow University of Health Sciences (DUHS), Karachi, Pakistan during the period from April' 2019 to September' 2019. Approval of study protocol and ethics was obtained from Institutional Review Board, DUHS (IRB # irb-1340/DUHS/Approval/2019).

A self-administered questionnaire comprises of questions related to the socio-demographic status, Life style, carbonated drink consumption, bone health condition and dietary pattern were used in this study. Relevant questions in each section of the survey form were extracted from pertinent reported literature[22-24]. For assessment of bone health, question regarding physical activity, muscular cramps, levels of joint pain and fractures were asked[5,23]. To assess the dietary trend, dietary assessment methods using closed-ended surveys including food frequency questionnaires and Recall methods was followed[25]. Questions were adjusted after consultation with orthopedics and dietitian and validated through statistician. Study[2]participants from different institutes of DUHS were randomly selected.

The sample size was calculated using Open-Epi version-3 software based on the results of our own pilot study which demonstrated an affected bone health in 14.3% of carbonated drink consumers. Estimation of sample size was done at 95% confidence interval and 5% margin of error. Self-reporting healthy individuals were included as a part of study that did not self-report any terminal or fatal disease and were not on any drug or supplements to augment the bone health. Those individuals who were suffering from chronic illness were not included in the study. An informed consent form from enrolled participants was signed before filling the questionnaire.

Data collected through field survey was entered and analyzed in SPSS version 23. Calcium content of food frequency was calculated and analyzed in Microsoft word Excel and SPSS version 23 using Food Composition Table Pakistan, 2001 [26]. Graphs and tables were made using Microsoft Excel 2016. Sunlight exposure, milk consumption, dietary calcium intake, Vitamin D deficiency, calcium deficiency and musculoskeletal pain were the variables of interest included in the questionnaire for the analysis of bone health in relation to carbonated drink. Frequency and percentage will be computed for qualitative variables. Mean ±SD will be calculated for quantitative variables. Chi-square test, Fisher exact test and independent sample t-test was applied for analysis of categorical data and continuous data respectively. Univariate and multivariate logistic regression analysis were performed to determine the independent factors associated with bone health among carbonated drink consumers, including covariates mentioned in table 4. Odds ratios with 95% CI are reported in results. A value of $p<0.05$ was considered significant.

RESULTS

A total of 200 participants were taken and demographic characteristics of these were observed. The age range of participants was from 18-30 years with mean of 22.45 ±3.143. There were more female participants (n=108) in comparison to male participants (n=92). The BMI of participants were categorized. Of individuals 46% were of normal weight, 18.5% were categorized as overweight whereas 18% and 17.5% were stratified as under-weight and obese respectively. Majority of the subjects (64%) were belonging to the ethnic group of Urdu speaking. 92% of the study participants were reported as unmarried. Non-smokers were reported to be 92.5%. Of 200 subjects, 77.5% were self-reported to belongs to the family with an income >50,000 PKR. Of participants, 80% were under graduate students whereas only 20% were postgraduate students. Amongst study subjects 185 (92.5%) were found to be carbonated drink consumers that lies in the age group of 21≤25 years. The detail frequency distribution of demographic variables is presented in Table 1.

Characteristics of the carbonated drink consumers with respect to gender were analyzed with its associated

factors and bone heath. A significant relationship has been observed between age (p-value=0.04) and ethnicity (p-value=0.03). The prevalence of non-smokers was higher among the carbonated drink consumers for both genders with significant p-value=0.001. Order of preference for carbonated drink consumption was observed as Cola>White drink>Orange>Not specified>fruit flavored. Frequency of carbonated drink intake with respect to gender was significantly associated with ethnicity (p-value=0.030). The carbonated drink consumption according to gender was assessed which was significantly associated with preferred pack size (p-value=0.034). The preferred pack size of carbonated drink was 250 ml which was higher 78.8% in females and 65.1% in males. However, the masses of them (61% male; 72.2% female) consume <750 ml of carbonated drink per week (p-value=0.034). Participants who consumed carbonated drink with respect to gender were significantly associated with active exercise (*p*=0.002), mean egg intake per day (*p*=0.021), mean milk intake per day (p-value 0.049) vitamin D deficiency (*p*=0.013) and calcium deficiency (*p*=<0.001). Both Vitamin D deficiency and calcium deficiency were found more frequent in female as compared to the male carbonated drink consumers. Occurrence of fracture and musculoskeletal pain were used as indicators of bone health. Incidence of fracture was not found in our study with carbonated drink consumption among both genders. However musculoskeletal pain was significantly associated with carbonated drink consumption in both genders (74.4% male; 89.9% female) with a P value of 0.005. The assessment of carbonated drink consumption in males and females with different factors are shown in Table 2.

Characteristics of the carbonated drink consumers with respect to musculoskeletal pain were analyzed with its associated factors and bone heath. No association was found between mean age of carbonated drink consumers and musculoskeletal pain, a significant relation between gender and musculoskeletal pain (p-value 0.006) was observed. Musculoskeletal pain among carbonated drink consumers was significantly associated with total family income (*p*=0.030). The trend for musculoskeletal pain was highest among the carbonated drink consumers of normal BMI (p-value 0.046). The sunlight exposure also found significantly associated with musculoskeletal pain among carbonated drink consumers with p-value 0.015. An association between musculoskeletal pain and years of consumption of carbonated drink was also observed significant (p-value 0.018). The association carbonated drink consumers having musculoskeletal pain with different factors are represented in Table 3.

Univariate and multivariate logistic regression was performed on carbonated drink consumers for the estimation of relative association of factor with gender and musculoskeletal pain. The univariate analysis showed a trend toward significance of carbonated drink consumers among gender with mean age (OR, 0.908; p= 0.042), ethnicity (OR, 0.497; p= 0.026), smoking habit (OR, 0.116; p= 0.005), active exercise (OR, 0.323; p= 0.005), mean egg intake/day (OR, 0.644; p= 0.024), mean milk intake glass/day (OR, 0.738; p= 0.054), vitamin D deficiency (OR, 2.890; p=0.012), calcium deficiency (OR, 8.859; p= <0.001), frequency of carbonated drink (OR,0.521, ; p=0.032), preferred pack size (OR,0.821,; p=0.054), carbonated drink intake /week (OR,1.043, ; p=0.041), musculoskeletal pain (OR,3.059; p= 0.007), leg cramps(OR, 2.014; p= 0.026), backache (OR, 2.794; p= 0.001) and heel pain (OR, 2.780; p= 0.001). The multivariate analysis showed that there was significant difference were observed in smoking habit (OR, 0.092; p= 0.042), active exercise (OR, 0.182; p= 0.007), calcium deficiency (OR, 12.426; p= 0.001), frequency of carbonated drink intake (OR, 0.441; p= 0.073), preferred pack size (OR, 0.129; p= 0.019) and heel pain (OR, 2.399; p= 0.059). The univariate analysis of carbonated consumers' musculoskeletal pain with factors showed a trend towards gender (OR, 3.059; p= 0.007), total family income/month (OR, 0.209; p= 0.038), BMI (OR,2.111; p=0.059), sunlight exposure (OR,1.034; p=0.029) and carbonated drink consumption in years (OR,0.806; p=0.076). The multivariate regression result for carbonated drink consumers' musculoskeletal pain showed trend toward gender (OR, 2.935; p=0.035), BMI (OR,3.324; p=0.033)

Table 1: Demographic data of study participants (n=200)

Demographic variables	**n (%)**
Age	
Mean ±SD	22.45 ±3.14
Age groups	
≤20 years	66 (33.0)
21-25 years	95 (47.5)
26-30 years	39 (19.5)
Gender	
Male	92 (46)
Female	108 (54)
Ethnicity	
Urdu speaking	128 (64)
Other (Punjabi, Pashto, Sindhi, Balochi, Saraiki)	72 (36)
Marital status	
Single	184 (92)
Married	12 (6)
Other	4 (2)
Total Family income in PKR	
< 50,000	43 (21.5)
>50,000	155 (77.5)
Education Level	
Under graduate	160 (80)
Post graduate	40 (20)
BMI (Kg/m^2) groups	
Underweight <18.5	36 (18)
Normal 18.5–22.9	92 (46)
Overweight 23–24.9	37 (18.5)
Obese ≥25	35 (17.5)
Smoking Habit	
No	185 (92.5)
Yes	15 (7.5)
Carbonated drink intake (CDI)	
Yes	185 (92.5)
No	15 (7.5)

Table 2: Descriptive characteristics of carbonated drink consumers.

Characteristics	**Carbonated drink consumers (n=185)**		**P-value**
	Gender		
	Male	**Female**	
Demographic			
Age (in years)	**Mean ±SD**	**Mean ±SD**	
	22.99 ±3.543	22.03±2.575	0.040*
	n (%)	**n (%)**	
Age groups			
≤20 years	25 (29.1)	36 (36.4)	0.313
21-25 years	40 (46.5)	47 (47.5)	
26-30 years	21 (24.4)	16 (16.2)	
Ethnicity			
Urdu speaking	49 (57)	72 (72.7)	0.030*

Other (Punjabi, Pashto, Sindhi, Balochi, Saraiki)	37 (43)	27 (27.3)	
Marital status			
Single	77 (89.5)	93 (93.9)	0.143
Married	8 (9.3)	3 (3)	
Other	1 (1.2)	3 (3)	
Total family income/month (in thousand)			
<50000	14 (16.3)	25 (25.3)	0.139
>50000	72 (83.7)	74 (74.7)	
Education status			
Undergraduate	67 (77.9)	81 (81.8)	0.507
Post graduate	19 (22.1)	18 (18.2)	
Body Mass index (kg/m²) groups			
Underweight (<18.5)	16 (18.6)	17 (17.2)	0.353
Normal (18.5–22.9)	37 (43)	47 (47.5)	
Over weight (23–24.9)	13 (15.1)	21 (21.2)	
Obese (≥25)	20 (23.3)	14 (14.1)	
Smoking Habit			
No	73 (84.9)	97 (98)	0.001*
Yes	13 (15.1)	2 (2)	
Carbonated drink consumption			
Frequency of carbonated drink intake			
Rare	33 (38.4)	56 (56.6)	0.030*
Frequent	43 (50)	38 (38.4)	
Regular	10 (11.6)	5 (5.1)	
Consumption of carbonated drinks in years			
1-<5 years	7 (8.1)	3 (3)	0.250
5-<10 years	25 (29.1)	41 (41.4)	
10-<15 years	34 (39.5)	35 (35.4)	
15-<20 years	16 (18.6)	18 (18.2)	
>20 years	4 (4.7)	2 (2)	
Preference for carbonated drink			
Orange	11 (12.8)	15 (15.2)	0.899
Fruit flavoured	9 (10.5)	7 (7.1)	
White	19 (22.1)	23 (23.2)	
Cola	30 (34.9)	37 (37.4)	
Not specific	17 (19.8)	17 (17.2)	
Preferred pack size			
250ml	56 (65.1)	78 (78.8)	0.034*
345ml	12 (14)	4 (4)	
500ml	14 (16.3)	16 (16.2)	
>500ml	4 (4.7)	1 (1)	
Carbonated drink intake /week			
≤750 ml/week	53 (61.6)	72 (72.7)	0.034*
>750-≤1500 ml/week	21 (24.4)	10 (10.1)	
>1500 ml/week	12 (14)	17 (17.2)	
>7 packs	12 (61.6)	17 (17.2)	
Life style			
Sunlight exposure			
<15 minutes	12 (14)	20 (20.2)	0.307
30 minutes	16 (18.6)	21 (21.2)	
45 minutes	13 (15.1)	8 (8.1)	
60 minutes	13 (15.1)	9 (9.1)	
>60 minutes	32 (37.2)	41 (41.4)	
Brisk walking/day			
≤ 30 minutes	70 (81.4)	81 (81.8)	0.941
> 30 minutes	16 (18.6)	18 (18.2)	
Active exercise/day			
≤ 30 minutes	62 (72.1)	88 (88.9)	0.004*
> 30 minutes	24 (27.9)	11 (11.1)	
Egg intake/day			
Mean ±SD	2 ±0.894	1.73 ±0.697	0.021*
Milk intake/day			
Mean ±SD	0.94 ±1.044	0.66 ±0.917	0.049*
Diagnosed Vitamin D deficiency			
No	77 (89.5)	74 (74.7)	0.013*
Yes	9 (10.5)	25 (25.3)	
Diagnosed Calcium deficiency			
No	81 (94.2)	64 (64.6)	<0.001*
Yes	5 (5.8)	35 (35.4)	
Dietary Calcium intake			
≤1000 mg/day	35 (40.7)	37 (37.4)	0.644
>1000 mg/day	51 (59.3)	62 (62.6)	
Bone health status			
Ever had fracture/s			
No	69 (80.2)	83 (83.8)	0.523
Yes	17 (19.8)	16 (16.2)	
Musculoskeletal pain			
No	22 (25.6)	10 (10.1)	0.005*
Yes	64 (74.4)	89 (89.9)	
ramps			
No	37 (43)	27 (27.3)	0.025*
Yes	49 (57)	72 (72.7)	
ache			
No	44 (51.2)	27 (27.3)	0.001*
Yes	42 (48.8)	72 (72.7)	
pain			
No	57 (66.3)	41 (41.4)	0.001*
Yes	29 (33.7)	58 (58.6)	
in fingers			
No	61 (70.9)	60 (60.6)	0.141
Yes	25 (29.1)	39 (39.4)	
em in knee bending			
No	61 (70.9)	60 (60.6)	0.141
Yes	25 (29.1)	39 (39.4)	

*p-value calculated by using Chi-square and Fisher's exact test

Table 3: Distribution of Musculoskeletal pain among carbonated drink consumers.

Characteristics	**Carbonated drink consumers (n=185)**		**P-value**
	Musculoskeletal Pain		
	No	**Yes**	
Demographic	**Mean ±SD**	**Mean ±SD**	
Age in years	22.91 ±3.753	22.39 ±3.046	0.4
	n (%)	**n (%)**	
Age groups			
≤20 years	10 (16.4)	51 (83.6)	0.950
21-25 years	15 (17.2)	72 (82.8)	
26-30 years	7 (18.9)	30 (81.1)	
Gender			
Male	22 (25.6)	64 (74.4)	0.006*
Female	10 (10.1)	89 (89.9)	
Ethnicity			
Urdu speaking	21 (17.4)	100 (82.6)	1.000
other (Punjabi, Pashto, Sindhi, Balochi, Saraiki)	11 (17.2)	53 (82.8)	
Marital status			
Single	27 (15.9)	143 (84.1)	0.136
Married	3 (27.3)	8 (72.7)	
Other	2 (50.0)	2 (50.0)	
Total family income/month (in thousand)			
<50000	2 (5.10)	37 (94.9)	0.030*
>50000	30 (20.5)	116 (79.5)	
Education status			
Undergraduate	26 (17.6)	122 (82.4)	0.846
Post graduate	6 (16.2)	31 (83.8)	
Body Mass index (kg/m²)			
Underweight (<18.5)	6 (18.2)	27 (81.8)	0.046*
Normal (18.5–22.9)	8 (9.50)	76 (90.5)	
Over weight (23–24.9)	8 (23.5)	26 (76.5)	
Obese (≥25)	10 (29.4)	24 (70.6)	
Smoking Habit			
No	27 (15.9)	143 (84.1)	0.087
Yes	5 (33.3)	10 (66.7)	
Carbonated drink consumption			
Frequency of carbonated drink intake			
Rare	17 (19.1)	72 (80.9)	0.5
Frequent	14 (17.3)	67 (82.7)	
Regular	1 (6.7)	14 (93.3)	
Consumption of carbonated drinks in years			
1-<5 years	1 (10)	9 (90)	0.018*
5-<10 years	8 (12.1)	58 (87.9)	
10-<15 years	13 (18.8)	56 (81.2)	

15-<20 years	6 (17.6)	28 (82.4)	
>20 years	4 (66.7)	2 (33.3)	
Preference for carbonated drink			
Orange	7 (26.9)	19 (73.1)	0.272
Fruit flavored	2 (12.5)	14 (87.5)	
White	8 (19)	34 (81)	
Cola	7 (10.4)	60 (89.6)	
Not specific	8 (23.5)	26 (76.5)	
Preferred pack size			
250ml	23 (17.2)	111 (82.8)	0.345
345ml	5 (31.3)	11 (68.8)	
500ml	3 (10)	27 (90)	
>500ml	1 (20)	4 (80)	
Carbonated drink intake /week			
≤750 ml/ week	21 (16.8)	104 (83.2)	0.867
>750-≤1500ml/week	5 (16.1)	26 (83.9)	
>1500 ml/week	6 (20.7)	23 (79.3)	
Life style			
Sunlight exposure			
<15 minutes	3 (9.40)	29 (90.6)	0.015*
30 minutes	7 (18.9)	30 (81.1)	
45 minutes	9 (42.9)	12 (57.1)	
60 minutes	2 (9.10)	20 (90.9)	
>60 minutes	11 (15.1)	62 (84.9)	
Brisk walking/day			
≤ 30 minutes	27 (17.9)	124 (82.1)	0.658
> 30 minutes	5 (14.7)	29 (85.3)	
Active exercise/day			
≤ 30 minutes	25 (16.7)	125 (83.3)	0.639
> 30 minutes	7 (20.0)	28 (80.0)	
Egg intake/day			
Mean ±SD	1.88±0.707	1.85±0.825	0.872
Milk intake/day			
Mean ±SD	1.09±1.146	0.73±0.941	0.054
Diagnosed Vitamin D deficiency			
No	28 (18.5)	123 (81.5)	0.345
Yes	4 (11.8)	30 (88.2)	
Diagnosed Calcium deficiency			
No	29 (20)	116 (80)	0.064
Yes	3 (7.5)	37 (92.5)	
Dietary Calcium intake			
≤1000 mg/day	10 (13.9)	62 (86.1)	0.328
>1000 mg/day	22 (19.5)	91 (80.5)	

*p-value calculated by using Chi-square and Fisher's exact test

Table 4: Logistic Regression Analysis of carbonated drink consumers

Variables in equation	**Unadjusted**				**Adjusted**			
	OR	**95% C.I.**		***p*-value**	**OR[b]**	**95% C.I.**		**P value**
		Lower	**Upper**			**Lower**	**Upper**	
Carbonated drink consumers on the basis of their gender								
Mean age	0.908	0.827	0.997	0.042	0.926	0.814	1.054	0.247
Ethnicity								
Urdu speaking	1	1	1	0.026	1	1	1	0.127
Others (Punjabi, Pashto, Sindhi, Balochi, Saraiki)(1)	0.497	0.269	0.918		0.481	0.188	1.231	
Smoking habit								
No	1	1	1	0.005	1	1	1	0.042
Yes	0.116	0.025	0.529		0.092	0.009	0.917	
Active exercise								
≤30 minutes	1	1	1	0.005	1	1	1	0.007
<30 minutes	0.323	0.147	0.707		0.182	0.053	0.626	
Mean intake of egg(s)/day	0.644	0.439	0.945	0.024	0.414	0.16	1.073	0.07
Egg intake per day								
1 egg/day	1	1	1	0.027	1	1	1	0.392
2 eggs/day	1.085	0.567	2.073	0.806	1.168	0.321	4.247	0.813
3 eggs/day	0.192	0.064	0.579	0.003	1.015	0.103	9.996	0.99
4 eggs/day	0.73	0.044	12.192	0.826	76.286	0.366	15882.19	0.112
5 eggs/day	0.365	0.031	4.233	0.42				
Mean intake of glass of milk/day	0.738	0.541	1.006	0.054	2.02	0.896	4.555	0.09
Glass milk intake/day								
0 glass/day	1	1	1	0.197	1	1	1	0.078
1 glass/day	0.719	0.384	1.347	0.303	0.38	0.119	1.21	0.102
2 glasses/day	0.129	0.027	0.628	0.011	0.131	0.01	1.767	0.126
3 glasses/day	0.647	0.151	2.768	0.557	0.093	0.004	1.958	0.127
4 glasses/day	0.324	0.028	3.712	0.365	12.455	0.142	1091.743	0.269
5 glasses/day	0.647	0.039	10.707	0.761	1	1	1	
Vitamin D deficiency								
No	1	1	1	0.012	1	1	1	0.753
Yes	2.890	1.265	6.602			0.195	3.263	
Calcium Deficiency								
No	1	1	1	<0.001	1	1	1	0.001
Yes	8.859	3.283	23.908		12.426	2.644	58.39	
Frequency of carbonated drink intake								
Rare	1	1	1	0.032	1	1	1	0.18
Frequent	0.521	0.282	0.961	0.037	0.441	0.18	1.079	0.073
Regular	0.295	0.093	0.937	0.038	0.347	0.044	2.715	0.313
Preferred pack size								
250 ml	1	1	1	0.054	1	1	1	0.133
345 ml	0.239	0.073	0.781	0.018	0.126	0.022	0.711	0.019
500 ml	0.821	0.37	1.817	0.626	0.749	0.232	2.423	0.63
>500 ml	0.179	0.02	1.649	0.129	0.591	0.03	11.786	0.73
Carbonated drink pack consumed /week								
<3 pack /week	1	1	1	0.041	1	1	1	0.447
5-7 pack /week	0.351	0.152	0.806	0.014	0.499	0.15	1.656	0.256
>7 pack /week	1.043	0.459	2.367	0.920	1.226	0.326	4.61	0.763
Carbonated drink intake /week								
≤750 ml/week	1	1	1	0.041	1	1	1	0.447

>750-≤1500 ml/week	0.351	0.351	0.806	0.014	0.499	0.15	1.656	0.256
>1500 ml/week	1.043	0.459	2.367	0.920	1.226	0.326	4.61	0.763
Musculoskeletal pain								
No	1	1	1	0.007	1	1	1	0.776
Yes	3.059	1.356	6.902		0.788	0.153	4.062	
Leg cramps								
No	1	1	1	0.026	1	1	1	0.617
Yes	2.014	1.089	3.723		1.334	0.431	4.131	
Backache								
No	1	1	1	0.001	1	1	1	0.102
Yes	2.794	1.515	5.151		2.411	0.839	6.929	
Heel pain								
No	1	1	1	0.001	1	1	1	0.059
Yes	2.780	1.526	5.065		2.399	0.966	5.956	
Carbonated drink consumers on the basis of their bone health (Musculoskeletal pain)								
Gender								
Male	1	1	1	0.007	1	1	1	0.035
Female	3.059	1.356	6.902		2.935	1.081	7.968	
Total family income/month (in thousands)								
<50000				0.038				0.171
>50000	0.209	0.048	0.917		0.311	0.058	1.657	
BMI								
Underweight (<18.5)				0.059				0.033
Normal (18.5–22.9)	2.111	0.671	6.64	0.201	3.324	0.852	12.964	0.084
Over weight (23–24.9)	0.722	0.22	2.368	0.591	0.498	0.123	2.016	0.328
Obese (≥25)	0.533	0.169	1.689	0.285	0.586	0.146	2.36	0.452
Sunlight exposure								
<15 minutes	**1**	1	1	0.029	1	1	1	0.065
30 minutes	0.443	0.104	1.882	0.27	0.414	0.078	2.215	0.303
45 minutes	0.138	0.32	0.6	0.008	0.225	0.042	1.203	0.081
60 minutes	1.034	0.158	6.764	0.972	5.844	0.497	68.651	0.16
>60 minutes	0.583	0.151	2.251	0.434	0.643	0.142	2.908	0.567
Mean glass intake of milk/day	0.721	0.512	1.015	0.061	0.612	0.394	0.95	0.029
Consumption of carbonated drinks in years								
1-<5 years	0.373	0.16	0.869	0.022	0	0	.	0.999
5-<10 years	1	1	1	0.076	1	1	1	0.092
10-<15 years	0.806	0.09	7.228	0.847	0.497	0.042	5.911	0.58
15-<20 years	0.479	0.056	4.118	0.502	0.416	0.036	4.855	0.484
>20 years	0.519	0.055	4.901	0.567	1.93E+08	0	.	0.999

* p-value calculated by using Univariate and multivariate logistic regression. The O.R are adjusted for age, ethnicity, smoking habit, active exercise, egg intake/day, milk intake/day, calcium deficiency, vitamin D deficiency, frequency of carbonated drink intake, preferred pack size, carbonated drink pack consumed/week, carbonated drink intake/week, musculoskeletal pain, leg cramps, backache, heel pain, BMI, sunlight exposure, mean intake of glass of milk/day, consumption of carbonated drink in years.

DISCUSSION

Modern dietary intake particularly processed food, and carbonated drinks have been associated varied metabolic status of consumers including BMI and bone health [8]. The growing popularity and easy access has promoted the higher consumption of carbonated beverages which leads higher risk of deteriorating bone health[27]. The high consumption of carbonated beverages has not only affected children, adolescents and young adults but also adults and elderly[28].

In the current study we have observed association of carbonated drink consumption on multiple factors such as life style, socioeconomic status and dietary pattern. The study further accounts for the impact of carbonated drink consumption responsible for bone health deterioration. For this purpose, a questionnaire was designed to assess the effect of carbonated drink consumption on bone health. Our study indicated that carbonated drink consumption was significantly higher in males as compared to males. The data is in accordance to observations reported earlier in certain other populations such as Arabs, American and British[29]. Although the reasons are not very clear but the positive association of carbonated drinks in males is generally attributed to more outgoing and social life style prevalent in males as compared to females. The data may also be supported by the fact that the females are comparatively more diet conscious and aware regarding the health hazards of artificial sugar consumption[30].

During the study, a significant association was also made between the carbonated drink consumers and non-smokers indicating the consumption of carbonated drinks as an alternate to smoking. Considering the carbonated drink consumption of carbonated drinks is still more socially acceptable as compared to smoking in societies such as Pakistan[31]. Certain population based studies have published regarding the varying lifestyles in different ethnic groups and western influenced fast food diet with increasing consumption of carbonated drinks being more prevalent in urban and chic ethnic groups[29,32]. Similar observation was made in our study where Urdu speaking ethnic group has a higher inclination towards carbonated drink consumption as compared to rest of ethnic groups questioned during study.

Habitual dietary and life style factors are often associated patterns. Increasing carbonated drink consumption is also associated with poor dietary choices including low protein and dairy based diets along with less exercise[29,30,32]. This further directs a positive association of carbonated drink consumption with increased BMI. A contrast was observed in our study where carbonated drink consumers were involved in active exercise had

significantly more protein and diet intake. Modern diet and excess consumption of carbonated drink is very commonly associated with increased caloric intake progressing towards poorly regulated fat accumulation and increased BMI. In the present study, most of the carbonated drink consumers reported the significant intake of dairy and protein portions and have been involved in frequent exercise. This might justify the healthy BMI range of our study subjects. Similar observations have been previously reported by Vartanian et al which indicated a weaker relationship between the uptake of carbonated drink and increasing BMI[30].

Carbonated drink consumption have gradually become a staple in Pakistani dietary intake, particularly in subjects with higher socioeconomic status[19]. Primary literature has reported an increasing trend of carbonated drink consumption in individuals of all financial background. The study conducted by Abdullah et al. has reported that individuals with lower socioeconomic status are associated with poor dietary practices including western based food patterns and consumption of carbonated drinks in Asian and Australian populations[32]. In contrast to that, the data reported by Data and Hussain highlighted that individuals from almost all financial backgrounds bear a large share of carbonated drink consumption and most of the Pakistani population is indulged in the intake of carbonated drinks irrespective of their financial backgrounds individuals. They further identified that malpractice of carbonated drink consumption has become a staple in influential household. This is not only has public health concerns but also pose an increasing financial burden on a general household and bear a large share of economy overall[19]. Though carbonated drink consumption is not acceptable irrespective of socioeconomic status, it has a larger impact in lower socioeconomic groups as they tend to replace the healthier portions of food which imposes an additional health risk on the consumers.

In our study we observed the supporting evidence to Vartanian et al, the individuals who had been consuming carbonated drinks for longer complained more about bone health issues such as frequent pains[30]. In the current study population, young adults of both genders were observed to be suffering from musculoskeletal pain. However, our data suggests a higher prevalence for musculoskeletal pain in females than in males. Our results further demonstrated that females reported higher incidence of leg cramps, backache and heel pain than in males. One of the possible explanations could be the lack of exercise was more frequently recorded in females as compared to males. Similar findings have been reported previously as well which reported positive association of bone health and carbonated drink among females[7,30]. During the study, it was observed that the individuals who consumed less then recommended portions of milk and egg suffered from vitamin D and calcium deficiency resulting in increasing incidence of musculoskeletal pain. Vitamin D and calcium deficiency is well proven to affect the bone and muscular health and their optimal levels are affected by diet and adequate exposure to sunlight. In Pakistan the prevalence of vitamin deficiency in females is much higher as compared to males and could be the possible reason of higher incidence of musculoskeletal pain in females[33,34]. Studies further support the evidence that increased carbonated drink consumption leads to vitamin D and calcium deficiency[35].

CONCLUSION

Consumption of carbonated drink is well associated with increased caloric intake due to extra sugar included; however, its effect on bone health should not be neglected. Considering the increasing trend of carbonated beverages in Pakistani house hold, there is a need to establish an understanding in young generation of Karachi, Pakistan. The present study reports the hazards of carbonated drinks in young adults and its effect on bone health, emphasizing dietary habits, insufficient sunlight exposure and Lack of activity.

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