Soft Drinks Consumption and the Risk of Nonalcoholic Fatty Liver Disease

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Abstract

Introduction: The increased consumption of sugar-sweetened beverages (SSBs) has been implicated in the increased incidence of obesity and metabolic syndrome. Little of the research on sugar-sweetened beverage intake has examined the consumption patterns of sugared beverages by college students, despite the vulnerabilities of this population to weight gain. The current study sought to characterize sugar-sweetened beverage intake of undergraduate students who belong to high socio-economic strata and to study its correlation with presence of non-alcoholic fatty liver disease.

Material and Methods: In a cross-sectional, a self-reported questionnaire based study about soft drink consumption (≥2/day, 1/day, <1/day). That included undergraduate medical students. Anthropometry and blood pressure were recorded and fasting glucose, insulin and lipid profile and abdominal ultrasonography for the presence of fatty liver was assessed.

Results: A total of 242 students were studied. The students in group 1 (≥2/day) had significantly higher BMI, waist circumference and diastolic blood pressure than students of other groups. They also had higher triglycerides, fasting insulin, HOMA-IR and significantly lower levels of HDL-cholesterol. Overall (40%) students had metabolic syndrome in group 1 compared to 8% and 3% in other groups while presence of NAFLD was observed in 75%, 16% and 4% in three groups respectively. Duration of soft drink consumption had positive correlation with presence of NAFLD.

Conclusion: Substantial consumption of soft drinks is leading to increased obesity and cardio-metabolic risk factors in young adults. Artificially sweetened diet soft drinks have been posed as a healthier alternative due to their lack of calories but they do not guarantee protection against non-alcoholic fatty liver disease.

Editorial Viewpoint

• With changing food habits there is more consumption of sweetened beverages in the country.
• In this study tries to correlate intake of beverages in UG students belonging to high socio-economic strata and presence of fatty liver.
• It finds an increased obesity and cardiometabolic risk in young adults with consumption of soft drinks.

Introduction

The increased consumption of sugar-sweetened beverages (SSBs) over the past two decades has been implicated in the increased incidence of obesity and metabolic syndrome, a group of conditions associated with insulin resistance, including hypertension, dyslipidemia, central adiposity, and impaired glucose metabolism.

Non-alcoholic fatty liver disease (NAFLD) recognized as hepatic manifestation of metabolic syndrome, is a common clinicopathological condition characterized by significant lipid deposition in the hepatocytes of the liver parenchyma and persistent abnormalities in liver enzyme. The rising prevalence of NAFLD is related to the epidemic of obesity.

NAFLD is a significant health problem affecting 20%-30% of the adult population.¹ It can progress to nonalcoholic steatohepatitis. This form of liver injury carries a 20%-50% risk for progressive fibrosis, 30% risk for cirrhosis, and 5% risk for hepatocellular carcinoma.²-⁴ Although the mechanisms underlying disease progression are not well defined—insulin resistance and obesity-related inflammation are thought to

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Soft drink consumption questionnaire

Name Age Gender Class
Type of beverage- Alcoholic (amount/type) Nonalcoholic
Soft drink consumption
Regular Diet Fruit
Amount/day <1 drink/day 1 drink/day ≥2 drinks/day
Diet-Veg/Nonveg
Fast Food consumption
Intake of vegetables/fruits
Physical activity (no exercise)/30 minutes daily walk/30 minutes brisk walk/gym or jogging
Family History-

The rising incidence of obesity in today’s generation is associated with many health complications including NAFLD.5

The association of soft drink consumption with obesity and higher insulin resistance has been attributed to multiple factors, including greater caloric intake, the high fructose corn syrup content, less satiety and compensation.

The negative impact of consuming sugar-sweetened beverages on weight and other health outcomes has been increasingly recognized; therefore, many people have turned to high-intensity sweeteners like aspartame, sucralose, and saccharin as a way to reduce the risk of these consequences. However, accumulating evidence suggests that frequent consumers of these sugar substitutes may also be at increased risk of excessive weight gain, metabolic syndrome, type 2 diabetes and cardiovascular disease.6

Little of the research on sugar-sweetened beverage intake has examined the consumption patterns of sugared beverages by college students, despite the vulnerabilities of this population to weight gain. The current study sought to characterize sugar-sweetened beverage intake of undergraduate students who belong to high socio-economic strata according to modified Kuppuswami scale and to study its correlation with presence of non-alcoholic fatty liver disease.7

Subjects and Methods

In a cross sectional study, from April to July 2015, four hundred undergraduate students studying in Era’s Lucknow Medical College Lucknow, were given a self reporting questionnaire about soft drink consumption practice over a minimum period of last six months. Out of 400 students, 156 were excluded as 88 were simultaneous consumers of alcohol containing beverages and 70 students submitted incomplete information.

We enrolled 242 students in our study who were soft drink consumers and divided them in three groups according to the amount of consumption of soft drink (≥2/day, 1/day, <1/day). One drink was containing approx 250 ml of soft drink. The study was approved by the Institutional ethical committee and informed consent was obtained from every subject.

Anthropometry and blood pressure were recorded and fasting glucose, insulin, liver function tests and lipid profile was assessed. All the study participants were later subjected for abdominal ultrasonography for the presence of fatty liver. NAFLD is a diagnosis of exclusion, so its workup needs to exclude other causes such as significant alcohol consumption (defined as ≥30 g/d of ethanol for men and 20 g/d of ethanol for women), hepatitis B and/or C infection, drug abuse, autoimmune liver disease, haemochromatosis and Wilson’s disease.

Serum liver enzymes Aspartate aminotransferase (AST), Alanine aminotransferase (ALT), Gamma-glutamyl transferase (GGT) Alkaline phosphatase (ALP) were estimated, and normal kit ranges were: ALT: 10–40 international units per liter (IU/L), AST: 10–35 IU/L, GGT: 5–30 IU/L, ALP: 80–150 IU/L.

Five point ultrasonographic criteria of diagnosis of fatty liver disease recommended by Dasharty8 was used to diagnose NAFLD: (1) Increased hepatic brightness or hyperechogenicity (2) posterior attenuation of the right lobe (3) increased contrast between the right kidney and liver (HRC), (4) loss of visualization of right diaphragm and (5) diminished visibility of the intrahepatic vessels.

In our study, conventional B-mode liver ultrasound was performed with a convex 3.5 MHz probe, by the qualified radiologist who was unaware of the aims of the study, degree of soft drink consumption and laboratory values. All the subjects were subjected for ultrasonography only one time during the study.

The metabolic syndrome was defined according to International Diabetes Federation (IDF) criteria.9 Metabolic syndrome by IDF may be defined as Central obesity (defined as waist circumference ≥94 cm (male), ≥80 cm (female)) and any two of the following:

1. TG >150 mg/dl (1.7 mmol/L)
2. HDL-C <40 mg/dl (male), <50 mg/dl (female)
3. Blood pressure ≥130/85 mmHg
4. Fasting plasma glucose >100 mg/dl (5.6 mmol/L).

Insulin resistance was measured by Homeostasis model assessment (HOMA) method and was calculated by the formula: Fasting serum insulin (microunits/ml) x fasting serum glucose (milli moles per liters)/22.5.10

All the laboratory parameters and abdominal ultrasonography were performed once and no repeat observations were made.

Statistical Analysis

All Statistical analysis was done by using the Statistical package for social sciences (SPSS 15.0 version)
with p<0.05 taken as statistically significant. Quantitative data were expressed as mean± standard deviation while categorical data were expressed as percentages; to compare two samples, an unpaired Student t test was used, whereas comparisons among groups were performed by means of 1-way analysis of variance. The value of Pearson’s linear correlation coefficient was determined to study correlation between duration of soft drink consumption and presence of NAFLD.

### Results

A total of 242 students who completed the self-reported questionnaire were studied. It was observed that maximum consumption was of carbonated drinks (65%) such as Coke and Pepsi (sugar content 10.6 gm/100 ml equates 40 kcal/100 ml, followed by Sprite, Fanta (sugar content 6.6 gm/100 ml and Diet Coke (30%) which contained aspartane with no calories. A significant number of participants consumed fruit juices that also had high sugar content (5-8gm/100ml that equals 20-30 kcal/100ml).

Table 1 shows the clinical characteristics of the students in three groups according to the amount of soft drink consumption. Male preponderance was observed in group 1 who had history of maximum (≥2 soft drinks/day) soft drink consumption.

The students in group 1 had significantly higher BMI, waist circumference and diastolic blood pressure than students of group 3 who had minimum consumption. They also had higher triglycerides, fasting insulin, HOMA-IR and significantly lower levels of HDL-cholesterol. No significant difference was apparent in group 2 and 3. Serum amino transferases (AST and ALT) were not significantly different between the study groups. Serum ALT was greater than upper normal limit in 76/242 participants.

Over all 40% students had metabolic syndromes in group 1 compared to 8% and 3% in other groups as depicted in Table 2.

In the present study, we found 75% of students had presence of NAFLD in group 1, while 16% in group 2 and 4% in group 3 (p=0.001).

Our study included only those subjects who had persistent soft drink consumption at least for 6 months or more than 6 months. We found that duration of consumption of soft drinks was longer and had positive correlation (r=0.36) with presence of NAFLD. The mean duration of consumption among subjects with NAFLD was 26±8.5 months and 10±3.2 months, p=0.02 in subjects without NAFLD.

It was revealed by the questionnaire that fast food consumption and amount of exercise was not significantly different in high and low consumers.

### Discussion

The problem of obesity has escalated dramatically among adolescents and young adults in recent times. Intake of sugar-sweetened beverages has been implicated as a likely contributing factor to the growing obesity rates among children and adolescents. Dietary behaviour among individuals consuming soft drinks also may account in part for the clustering of metabolic risk factors in these people. Individuals with greater intake of soft drinks also have a dietary pattern characterized by greater intake of calories and saturated and trans fats, lower consumption of fibre and dairy products, and a sedentary life. The high sweetness of diet or regular soft drinks may lead to conditioning for a greater preference for intake of sweetened items, artificial sweeteners may increase desires for sweetness and more energy-dense foods. Second, overconsumption of other foods/beverages may also occur in conjunction with diet beverage consumption owing to overestimation of the number of calories saved by substituting diet beverages for sugar-sweetened beverages.

Among the adolescents and young adults enrolled in college in the United States approximately 35% are overweight or obese.11 On the basis of the 2009–2010 NHANES data, approximately half of US adults consumed one or more sugar sweetened beverages (SSB) on a given day and almost 7% of their total daily energy intake came from SSBs.12 Adolescents consume 20% of their total energy intake from added sweeteners, the majority of which are consumed in sodas and fruit drinks.13,14

Our study revealed that duration and quantity of soft drink consumption was significantly greater in subjects who had NAFLD, although serum aminotransferase levels were not different in participants of three groups. Validated standards are not used to establish upper
normal limits for ALT and aspartate aminotransferase (AST) mostly. Instead, laboratories use locally defined reference populations to establish their own reference intervals for these tests.  

Soft drink consumption leads to weight gain by virtue of their high added sugar content, low satiety potential and incomplete compensatory reduction in energy intake at subsequent meals after consumption of liquid calories, leading to positive energy balance. In addition to weight gain, higher consumption of sugar-sweetened beverages is associated with development of metabolic syndrome and type 2 diabetes.

During the past decades mounting concerns over deleterious health impacts of sugar consumption have led to promotion and increased intake of artificial sweeteners. It is a general pattern of both greater socioeconomic advantage and health-promotion behaviour.

In our study also we were surprised to see that in group 1 who had highest soft drink consumption and metabolic syndrome along with NAFLD, 30% soft drinks were actually diet drinks.

In the present study, both regular and diet soft drinks appeared to pose similar metabolic hazards, which suggests that other factors may be operational. Consumption of liquids is associated with a lesser degree of dietary compensation (the adjustment in energy intake made in subsequent meals in response to food intake).

Assy et al demonstrated that increased ingestion of soft drinks was found to be linked to NAFLD independent of metabolic syndrome. They studied the association between soft drink consumption and the presence of fatty liver in NAFLD patients who do not have classic risk factors. They observed that 80% of patients (25 of 31) consumed an excessive amount of soft drink beverages (more than 50 g/day of added sugar) for 36 months, compared with 20% in healthy controls. Similarly, Abid et al also found that 80% of patients with NAFLD had excessive intake of soft drink beverages (>500 ml/day) compared to 17% of healthy controls (p<0.001). The NAFLD group consumed five times more carbohydrates from soft drinks compared to healthy controls (40% vs. 8%, p<0.001).

Larger consumption of added nutritive sweeteners such as high fructose corn syrup (the primary sweetener in soft drinks) leads to increased insulin resistance and an increase in triglyceride levels. Fructose leads to glycosylation of tissue proteins, intracellular accumulation of sorbitol and oxidative stress. The caramel content of both regular and diet drinks may be a potential source of advanced glycation end products, which may promote insulin resistance and can be proinflammatory and can be implicated in pathogenesis of NAFLD.

Individuals who consume an excessive amount of soft drinks tend to lead a sedentary lifestyle and eat a higher calorie rich food that includes more fructose. Because both regular and diet soft drink consumption in our study resulted in an increased risk of fatty liver, factors other than calories and sugar content likely contribute to the development of fatty liver. These factors include the consumption of fructose, aspartame, caramel and other covariants.

Aspartame is absorbed from the intestine and metabolized by the liver to form phenylalanine, aspartic acid and methanol. This process causes mitochondrial dysfunction and energy depletion, which may contribute to accumulation of fat. Also, regarding obesity and aspartame, formaldehyde converted from the free methyl alcohol accumulates in the cells and damages mitochondrial DNA, with most toxicity effects occurring in the liver.

Increased awareness about the health hazards of over consumption of sugar sweetened beverages lead to preference for diet drink. Several prospective studies have been conducted to examine associations of diet drink intake with chronic diseases, including coronary heart disease (CHD), chronic kidney disease, and cardiometabolic syndrome and its individual components. In the National Health Survey consuming ≥2 servings of diet soft drinks per day was associated with an increased risk of coronary artery disease and chronic kidney disease in comparison with consuming, <1 serving of diet soft drinks per month over 11 to 12 years of follow-up. Middle aged men and women consuming≥1 servings of diet soft drinks per day had 30% higher risk of developing metabolic syndrome over 9 years of follow-up. Similar results were also observed for the components of metabolic syndrome. In the Northern Manhattan Study of,2,500 multiethnic adults with 10 years of follow-up and a cardiovascular event incidence of; 2%, daily diet soft drink intake was associated with an increased risk of events.

There are several limitations to this study. First, the findings may not be extrapolated to general population because of the selection bias associated with the use of a convenience sample from a medical college where students belonged to higher socio-economic strata further sample size was small in our study. The subjects of all three groups had history of fast food consumption with minimum exercise which might have affected and contributed to development of metabolic syndrome and NAFLD.

Being a cross-sectional study, cause–effect relationship could not be proved between soft drink consumption and NAFLD. The subjectivity of self reported questionnaire and use of ultrasonography for detection of fatty livers...
Table 2: Biochemical parameters of students of three groups according to soft drink consumption

<table>
<thead>
<tr>
<th>Variable</th>
<th>≥2 soft drinks/day (n=40)</th>
<th>1 soft drink/day (n=97)</th>
<th>&lt;1 soft drink/day (n=105)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triglyceride (mg/dl)</td>
<td>156±58.6</td>
<td>130±18</td>
<td>112±26</td>
<td>0.001</td>
</tr>
<tr>
<td>HDL-Cholesterol (mg/dl)</td>
<td>40±7.6</td>
<td>44±4.6</td>
<td>51.43±8.6</td>
<td>0.01</td>
</tr>
<tr>
<td>LDL Cholesterol (mg/dl)</td>
<td>85±10</td>
<td>88±7</td>
<td>90±12</td>
<td>0.8</td>
</tr>
<tr>
<td>Alanine aminotransferase (IU/L)</td>
<td>42±8</td>
<td>36±5</td>
<td>36±2</td>
<td>0.23</td>
</tr>
<tr>
<td>Aspartate aminotransferase (IU/L)</td>
<td>38±8.6</td>
<td>40±6</td>
<td>36±5.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Fasting blood glucose (mg/dl)</td>
<td>108±25</td>
<td>102±16</td>
<td>100±12</td>
<td>0.05</td>
</tr>
<tr>
<td>Fasting insulin (mu/ml)</td>
<td>6.4±2.3</td>
<td>3.5±1.6</td>
<td>2.8±1.8</td>
<td>0.03</td>
</tr>
<tr>
<td>HOMA-IR</td>
<td>4.8±2.1</td>
<td>2.6±1.7</td>
<td>1.63±0.92</td>
<td>0.01</td>
</tr>
<tr>
<td>Metabolic syndrome (%)</td>
<td>16 (40%)</td>
<td>8 (8%)</td>
<td>4 (3%)</td>
<td>0.001</td>
</tr>
<tr>
<td>Presence of NAFLD</td>
<td>30 (75%)</td>
<td>15 (16%)</td>
<td>4 (4%)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Data is expressed in mean±SD or n(%)