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Time course effect of selected carbonated soft drinks on human fasting blood glucose level

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ABSTRACT

Background: Soft drinks are non-alcoholic beverages that contain high amount of reducing sugar, and their excessive or chronic intake has been associated with increased risk of diabetes in children and adults.

Objective: The time course change in blood sugar level following intake of different brands of soft drinks in adolescents was evaluated in this study.

Methods: Forty female and male sex matched students of age from 18 to 25 years old who agreed to informed consent were requested to fast for 8 hours overnight and randomized into eight groups. Seven of these groups were respectively served 50 centilitres (cL) of Pepsi®, Mountain Dew®, Coca Cola®, Schweppes®, La Casera®, Teem®, and 7up® while the last group was served the same volume of drinking water and used as control. Socio-demographic information of the participants, fasting blood glucose (BG) level, and BG level at 30 and 60 minutes after soft drinks consumption were recorded into questionnaire provided for each participant. Total sugar content in the soft drinks was determined spectrophotometrically by phenol-sulphuric method. BG level of the participants at various intervals was estimated using Accu-Check Active Glucometer.

Results: The total sugar content (g/10 cL) of the soft drinks ranges from 9.53 ± 0.00 in Teem to 25.49 ± 0.03 in Mountain dew. There were marked rise in BG level in the participants that consumed soft drinks, having peak BG level reached at 30 minutes after intake of soft drinks compared to the participant in control group that drank water. The peak BG level at 30 minutes ranges from 123.30 ± 6.70 in participants that were given Schweppes® to 103.00 ± 16.46 in participants that received Mountain dew®. The bioavailability of BG level in each group is in decreasing order Teem® > 7up® > Coke® > Schweppes® > Pepsi® > La Casera® > Mountain dew®, respectively.

Conclusion: Pre-prandial consumption of soft drinks produced an average of 38% increase in BG level within 30 minutes which decreases afterward in adolescents. This observation suggests that sugar derived from soft drinks at pre-prandial consumption are rapidly absorbed and utilized in normal adolescents.

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Blood glucose; adolescent; pre-prandial; total carbohydrate; soft drink

Introduction

Soft drink is the common name given to sugar sweetened classes of non-alcoholic beverages that are consumed cooled or chilled [1]. They often contain carbonated water, sweetener, and natural or artificial flavors [2]. Soft drinks may also contain caffeine, colorings, preservatives, and some other ingredients [3]. Following the development of soft drinks centuries ago, they have become a public health concern because of the devastating effects of excess sugar on human health. Chronic consumption of soft drinks has been associated with risk of overweight, inflammation, immune system dys-function, diabetes, and cardio-metabolic

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diseases [4]. Increased blood sugar level as a result of soft drink consumption has been shown to acutely increase insulin secretion, thermogenesis, and lipogenesis [5].

In Australia, tertiary institutions have been reported to be heavy consumers of soft drinks [6]. Surveys across the globe also indicated that travelling, work rate, addiction, and weather condition can influence rate of consumption of soft drinks among individuals and in communities. In Nigeria, there are different types of soft drinks which are sugar sweetened carbonated drinks like in other countries. These soft drinks after consumption are expected to increase blood sugar as absorption proceeds with time and decreases afterward as clearance and tissues utilization of sugar (metabolism) commences. Over the years, the negative impacts of simple sugars from soft drink intake have been popular and appear to be the main culprit in hyperglycemia and its complications. More so, different brands of soft drinks are believed to contain different amounts of sugar. In this study, we assessed the time course effect of some selected carbonated soft drinks on blood sugar level among adolescents between ages 18–25 years old.

Materials and Methods

Study area and location

This study was carried out in the Department of Biochemistry, Lead City University (LCU), Ibadan, Nigeria.

Study design and population

This study is on the time course effect of soft drinks on fasting blood glucose (FBG) level in adolescents. Forty adolescents (age 18–25) 25 years, weight range of 55–61 kg, and height range of 5.0–5.6 feet were drawn from 200 to 400 level students of the University. The participants were requested to fast for 8 hours overnight and randomized into eight groups. Seven of these groups were respectively received 50cL each of Pepsi®, Mountain Dew®, Coca Cola®, Schweppes®, La Casera®, Teem®, and 7up® while the last group was served same volume of drinking water (control).

Blood glucose level determination

Blood samples were collected aseptically using lancet needle. The BG level was measured using Accu-Check Active Glucometer with test strips. The study population were drawn from 200 and 400 level female students of the University within the ages of 18 and 25 years, weight range of 55–61 Kg, and height range of 5 feet 4 inches to 5 feet 6 inches. Candidates with non-diabetic and no history of cardiovascular or neurological disorder were used for the study and informed consents were officially obtained from the participants. Blood samples were collected aseptically using lancet needle. The BG level was measured using Accu-Check Glucometer with test strips.

Data collection procedure

A questionnaire was designed for participants' data collection. Information recorded in the questionnaire are initials, age, sex, address, weight, height, medication history, FBG level, and BG level at 30 minutes and 60 minutes after drinking 50 cL of soft drinks.

Inclusion criteria and exclusion criteria

Adolescents of any gender, fasted overnight, non-diabetic, and no history of cardiovascular or neurological disorder were used for the study. Any respondent who ate or drink within the study period, or who chose to discontinue from the study were excluded.

Determination of total sugar content

The total sugar content of the soft drinks was determined by phenol-sulphuric assay described by Birch and Mwangelwa [7]. To 1 ml of diluted sample, 1 ml of phenol reagent (5%) and 5 ml sulphuric acid (96%) was added. The sample is incubated for 30 minutes and absorbance of each sample was recorded at 420 nm. The concentration of unknown sample was calculated with reference to standard curve made by using glucose.

Area under curve (AUC) and bioavailability determination

Area under curve (AUC) was determined using GraphPad Prism. Bioavailability was derived from AUC based on assumption that the clearance in all participants is constant.

Statistical analysis

All analyses were performed using GraphPad Prism 6.4. Total sugar contents of the soft drinks were expressed as mean ± standard deviation of triplicate determination. The BG levels of each group at

Table 1. Total sugar concentration (g/10 cL) in soft drinks.

Samples	Total carbohydrate /10 cL*	Estimated amount/50 cL**
7up®	12.77 ± 0.74	63.85
Coke®	14.47 ± 1.05	72.35
La Casera®	20.69 ± 0.25	103.45
Mountain Dew®	25.49 ± 0.69	127.45
Pepsi®	16.10 ± 0.25	80.50
Schweppes®	16.15 ± 0.50	80.75
Teem®	9.53 ± 0.77	47.65

*Results are mean ± standard deviation (n = 3). **Estimated amount per 50 cL was determined by multiplying total carbohydrate by 5.

interval were expressed as mean ± standard deviation of participants in the group.

Results

Table 1 presents the total carbohydrate content of the different soft drinks. The carbohydrate content (g/10 cL) ranges from 9.3 ± 0.00 in Teem® to 25.49 ± 0.03 in Mountain Dew®.

The FBG (mg/dL) among participants ranged from 83.33 ± 2.65 in participants that received drinking water (DW) to 87.67 ± 0.58 in those that received La Casera. At baseline, there was no significant change in FBG level of the participants that were served soft drinks compared to control, however, the peak level of BG, which was significantly higher than BG level in those served drinking water, was observed in 30 minutes among those that were served soft drinks. The participants that were served Schweppes®, 7up®, Mountain Dew®, Pepsi®, La Casera®, Teem®, and Coke® show 56.03%, 45.00%, 43.06%, 32.52%, 31.17%, 31.61%, and 25.76% rise in the BG level, respectively (Table 2). The bioavailability of glucose among the participants is in decreasing order Teem®>7up®>Coke®>Schweppes®>Pepsi®>La Casera®>Mountain dew® (Table 3).

Discussion

Excessive intake of soft drinks has been associated with increased risk of diabetes and obesity in children and adults [8–11]. This is because soft drinks contain high amount of reducing sugars especially fructose and glucose [12,13]. The result of present study shows that soft drinks contain substantial amounts of sugar which is relatively close in value to the stated content of sugar in the labels of the drinks used in the study.

Soft drink consumption was noted to increase the BG level of the consumers. Interestingly, drinks like Schweppes® and 7up® which were found to contain relatively lesser amount of sugar produced higher percentage rise in BG level, with participants on Mountain dew®, Pepsi®, and La Casera® also demonstrating moderately high percentage rise in BG level in 30 minutes. The peak BG level obtained at 30 minutes does not relatively produced a direct proportional relationship with overall bioavailability of blood sugar in all group, except in group that was served Schweppes®. For instance, relatively low bioavailability of BG was observed in the group that was served Mountain dew®. For instance, relatively low bioavailability of BG was observed in participants that were served Mountain dew®. This, however, does not exonerate drinks such as Teem®, Pepsi®, and Coke® which caused relatively lower rise in BG level from the chronic damaging effects of simple sugars as they demonstrated relatively high bioavailability.

It is important to note that increased BG level reached the peak all groups at 30 minutes after soft drinks consumption, and apparently lowered at 60 minutes. The observed short period of increased BG level justified reducing sugars in these soft drinks are actively absorbed into blood stream. Simple sugars such as galactose, glucose, and fructose are relatively absorbed through the ileum of

Table 2. Blood glucose levels (BG, mg/dL) with time among candidates taking different soft drinks.

Drinks	Peak time minutes	FBG	BG at 30 minutes	BG at 60 minutes	% Δ in BG level at peak
DW	—	83.33 ± 2.65	63.33 ± 0.02	63.20 ± 1.10	-24.00
7up®	30.0 ± 0.00	80.00 ± 1.07	116.00 ± 4.58*	77.00 ± 3.70*	45.00
Coke®	30.0 ± 0.00	86.67 ± 2.08	109.00 ± 11.53*	90.00 ± 9.25*	25.76
La Casera®	30.0 ± 0.00	87.67 ± 0.58	115.00 ± 13.00*	76.33 ± 8.90*	31.17
Mountain Dew®	30.0 ± 0.00	72.00 ± 9.85	103.00 ± 16.46*	99.67 ± 13.10*	43.06
Pepsi®	30.0 ± 0.00	82.00 ± 4.58	108.67 ± 8.96*	89.67 ± 3.40*	32.52
Schweppes®	30.0 ± 0.00	79.00 ± 2.00	123.30 ± 6.70*	108.00 ± 4.50*	56.08
Teem®	30.0 ± 0.00	83.33 ± 2.52	109.67 ± 1.58*	70.33 ± 2.80*	31.61

Results are mean ± standard deviation (n = 5). DW = drinking water (control), *Values were significantly different with time using one way analysis of variance at p = 0.05.

Table 3. Bioavailability of BG in participants receiving different soft drinks.

Soft Drink	AUCx	Bioavailability* (g min/l)
7up®	5,835.84	91.39
Coke®	5,920.26	81.83
La Casera®	5,910.43	57.13
Mountain Dew®	5,665.99	44.46
Pepsi®	5,835.76	72.49
Schweppes®	6,505.23	80.56
Teem®	5,595.01	117.42

AUCx = area under curve for glucose concentration with time
*derived from AUCx based on assumption that the clearance of sugar in all participants is the same.

the intestine into the blood by active transport. Interestingly, sharp reduction in BG level within 30 minutes after reaching the peak can be linked with several factors like sugar distribution into the tissues, tissues utilization, clearance, and individual differences (metabolomics). More importantly, efficient glucose homeostasis which is strongly associated with effective insulin secretion and action is an important factor. In addition, sweet taste which is characteristics of these soft drinks has been linked with increased insulin release [14] in which the immediate effect is to lower BG level. Besides the aforementioned factors, fasting state at which the students were before taking the soft drinks may also contribute to a sharp reduction in the level of BG as regular fasting increases insulin sensitivity.

Bioavailability refers to extents and rate at which nutrients, active metabolites, or drugs enter systematic circulation and are distributed to respective tissues where they are utilized [15]. The bioavailability of a metabolite is often governed by its dose and rate of clearance. We had anticipated that the greater the sugar contents of the soft drinks the higher the level of sugar available in the circulation, however, in this finding, the sugar content of each soft drinks did not correspond to the level of sugar in circulation. For instance, drinks such as Teem® and 7up® with relatively low sugar contents demonstrated relatively high blood sugar bioavailability.

Factors such as industrial type of sugar used to process the soft drinks, use of sweetener, and some other content (excipients) which may interfere with absorption and bioavailability of glucose in circulation requires some serious concern. Notwithstanding, some soft drinks contain caffeine, as acute administration of caffeine has been shown to impair glucose metabolism by decreasing insulin sensitivity in healthy humans via downstream secretion of plasma epinephrine level [16], however, the bioavailability of glucose in the participants that received caffeinated and non-caffeinated soft drinks used in this study was not distinguishable.

Conclusion

In conclusion, data obtained in this study revealed the effect of soft drink consumption on BG level with time. Pre-prandial soft drink consumption causes average increase in BG level by 38% within 30 minutes, and fell afterward. This observation suggests that sugar derived from soft drinks at pre-prandial consumption is rapidly absorbed and utilized in adolescents. Further investigation is, however, required on chronic consumers of soft drinks among adolescents.

Conflict of Interest

The authors declare no conflict of interest with regard to this study.

Ethical approval

This study was approved by the LCU Ethical Review Board and all participants were given consent forms prior to the study, the consent forms were translated to local language (Yoruba) and participants that agreed and signed the consent form were recruited for the study. The right for any participant to withdraw was preserved throughout the study.

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