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Effect of Carbonated Beverages on Salivary pH and Dental Caries in a Sample of Egyptian Children "A cross-sectional study"

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Aim: Investigation of the correlation between the intake of carbonated beverages, salivary pH and dental caries.
Materials and methods: One hundred and thirty-nine Egyptian children aged 4-6 years were selected for this study. A questionnaire was designed and validated in Arabic language to collect information from subjects about frequency of intake of carbonated beverages including packed fruit juices, and sweetened milk. Caries occurrence was further assessed by dmf index. Salivary pH was tested for each child. Statistical analysis was carried out using One-Sample Kolmogrovo-smirnov. For parametric distribution, Pearson Correlations was used. For nonparametric distribution, Spearman's Correlations was used.
Results: A weak correlation was detected between the frequency of drinking carbonated beverages and salivary pH (r=0.023). A weak correlation between the frequency of drinking carbonated beverages and dmf index (r= 0.024). A non-significant correlation (r=0.127) was also found between the dmf index and salivary pH of the selected children.
Conclusion: Excessive drinking of carbonated beverages and salivary pH were not of a direct influence on the increase of caries occurrence among selected children.

Keywords: Saliva pH, dmf, Sweetened beverages, Primary teeth, Nutrition.

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Introduction

Tooth decay is considered a chief public health matter and a wide spreading chronic oral complaint. It has a multifactorial nature where; dental caries is known to result from the interaction between three prime factors. Each factor alone cannot initiate the carious process, yet for the disease to occur the combination of the bacteria, host, media (dental plaque) need to present in conjunction with other factors such as: salivary flow rate, salivary buffering capacity, salivary pH, anatomy of teeth etc. Oral cavity is exposed to concurrent phases of demineralization followed by remineralization. For caries to occur, there has to be an imbalance towards the demineralization phase augmented by the presence of pathological factors that outweigh the protective factors.[1] This imbalance over a period of time that varies from one individual to the other favors the initiation of the disease.

Effect of saliva on oral health and minimizing the caries experience is highly notable. Saliva encompasses different physical and mechanical properties to aid in minimizing the caries occurrence. Primarily, in respect to its mechanical cleansing capability, it decreases the accumulation of plaque. Secondary, it increases the resistance of enamel to acid attacks through its mineral content. Thirdly, it buffers and neutralizes the acids released by caries producing organisms. Fourthly, through its bacterial killing action.[2]

Nowadays, children are exposed to different types of beverages and processed food. It is advocated that the excessive consumption of carbonated soft drinks especially by young children is considered a major risk indicator for development of dental caries for primary dentition and should be diminished.[3]

Carbonated beverages market is considered one of the largest markets that occupy the largest percentage of sales global wise. Unfortunately, our children represent a big sector on the consumer chart for such beverages. This increase in consumption has been correlated to multifactors. A principal factor is that these beverages and their vending machines are widely available with ready access to everyone.[4]

Carbonated drinks are thought to cause massive destruction for the enamel of the tooth structure owing to its general low pH. Nevertheless, the presence of such relatively acidic beverages in the oral cavity for long periods of time can erode the enamel of teeth. Moreover, the sugar content as a favorable media for the caries producing bacteria present in the dental plaque to act on and generate organic acids subsequently causing demineralization of hard tooth structure and thus dental caries. Not only carbonated beverages can have this drastic effect also, packed sweetened juices might have the same effect upon regular consumption. [5]

In accordance to this, the WHO currently recommends the reduction of intake of sugars to less than 10% of total energy intake for both adults and children. WHO also advises a further reduction of the intake of free sugars to 5% less of total energy intake whenever applicable.[6]

Due to the scarce research and the recommendation in 2022 to conduct more research in moderate to low-income countries,[7] this study was formulated to assess the effect of salivary pH and frequency of drinking carbonated beverages on the oral condition and caries experience in children. The hypothesis was that the salivary pH and frequent intake of carbonated beverages had an effect on the caries experience.

Materials and methods

Sample Selection:

A total number of 139 children were selected for this study. Sample size calculation was performed using Epicalc

program version 1.02 with a power of 80 % and alpha=0.05. The calculation was on a number of children with dmf index equal 10 of those reporting pH (5,2) and pH (6,8) based on the study by Fudali-Walczak M[8] in 2015.

Selected subjects conformed to the following eligibility criteria; inclusion criteria: Subjects age ranged from 4–6 years of age, healthy, medically free and their parents agreed to sign the written consent. The dietary habits, socioeconomic level as well as the oral hygiene and lifestyle were nearly comparable among the selected subjects to minimize the impact of such factors on the study outcome. The exclusion criteria included; children whose parents refused to sign the informed consent and who were on any medication during or 15 days before the study.

Ethical consideration

The research protocol was accepted prior to the conduction of the study by the Ethical Committee of Faculty of Dentistry, Ain Shams University (FDAS-Rec IR011744) and it follows the "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE) statement. The informed consent was signed by all participating children's parents, explaining the objective of the study, clarifying all steps and confirming the confidentiality of all subjects' data. The subjects had the right to refuse participating in the study without any penalty or loss of benefit. Verbal assent was obtained from all subjects.

Assessment of caries experience using dmf Index:

Caries experience for all subjects was carried at tooth level by means of dmf index, where an intraoral examination was performed using a dental mirror, explorer and air spray under normal dental unit halogen light (Ri-Magic, Rudolf Riester GmbH, Jungingen, Germany). The dmf index was calculated for each child according to the WHO standards.[9,10] The overall caries burden was then calculated for the whole sample.

Salivary pH testing:

To conduct salivary pH testing, all subjects were given clear instructions not to eat or drink for one hour before the test. The selected child was asked to spit in a calibrated test-tube through a collecting funnel. Both items were previously sterilized. A digital pH meter (SIGMA pH meter: model number 131) calibrated with buffers of pH 4 and 7 was used to measure the salivary pH immediately after collection of sample. The electrode was immersed into the test-tube containing the collected saliva followed by pH interpretation that was conducted 10 minutes from the collection time of the sample.[8]

Frequency of intake of carbonated beverages:

A printed questionnaire was designed and validated in Arabic language to assess the intake of carbonated beverages. The questionnaire was first designed and face-validity was established. Three professionals tested the questionnaire for reliability and content validity. Finally, data collection was performed using the modified questionnaire, where the number of intakes of carbonated beverages was scored against a scale from 1 to 5 representing "seldom" to "several times per day" respectively.

Statistical analysis:

Statistical analysis was carried out using SPSS (SPSS Inc, Chicago, IL, 2001). One-Sample Kolmogrovo-smirnov evaluated the normality distribution parameters first. For parametric distribution, Pearson Correlations was used. For nonparametric distribution, Spearman's Correlations was used.

Results

The present cross-sectional study included 139 children, 78 boys (56%) and 61 girls (44%). Results showed that 52.5% of the participants had healthy saliva. A percentage of 46.8% of participants had moderate saliva and only 0.7% had acidic saliva. Results of the rate of consumption of carbonated beverages is shown in (Table 1) where almost 16% of the participants consumed carbonated beverages several times per day. 21% of the participants took them once per day. 24% of the participants mentioned having them several times per week. 15% consumed them once a week. While 22 % of the participants stated that they seldom drink them. There was no statistically significant difference between the rate of intake of carbonated beverages and salivary pH (r=0.023). Also, no statistically significant difference between the frequency of intake of carbonated beverages and dmf index (r= 0.024) was noted nor between the dmf index and salivary pH of the participants (r=0.127). (Table 2).

Table 1: Percentage of rate of intake of carbonated beverages among the selected subjects.

Score	Number of patients	Percentage %
1	31	22.3%
2	21	15.1%
3	34	24.5%
4	30	21.6%
5	23	16.5%
Total	139	100%

Discussion

Caries of primary teeth was rated as one of the most prevalent conditions, affecting millions of children around the world according to the 2015 Global Burden of Disease Study.[11,12] Primary teeth decay is still affecting and in fact uprising in some developing countries owing to the nutritional changes affecting the current generation. In spite, all the efforts made to overcome such disease, there is still growing evidence that there is a relation between the rate of intake of sugary substances and caries experience. Abbass et al[13] in 2019 reported that 74% of the Egyptian children had dental caries.

There are several indices that can measure the dental caries experience among which and the most commonly used to its easiness and its ability to measure the caries prevalence in a community is the dmft/DMFT index. This index records teeth that are decayed, filled due to caries and missed due to caries.[9]

Table 2: Spearman Rank Correlation coefficient between the different tested variables.

N = 139		Salivary pH	Carbonated Beverages intake
Carbonated Beverages intake	rs	-0.023	
	p value	0.791	
dmf	rs	0.024	0.127
	p value	0.778	0.136

*Significance, p-value of ≤0.05

Results of this study declared a non-significant relationship amongst the frequency of intake of carbonated beverages and dmf score. This came in accordance to Burt BA et al[14] who conducted a systematic review in 20021 to assess the relation between sugar intake and caries risk in 134 selected articles, the results of which showed that only two articles discovered a strong correlation amongst sugar consumption and caries development, while sixteen other articles discovered a moderate correlation, and eighteen articles discovered weak-to-no correlation. This was attributed to the fluoride exposure that may influence caries risk even with high sugar consumption. A negative correlation was also found by Chi L et al[15] between self-reported measures of carbonated beverages and dental caries using hair biomarkers. On the contrary, Eichenberger-Gilmore et al[16] found that the

frequent consumption various sugar sweetened beverages increases the risk for dental caries in primary teeth. In the latest systemic review in 2023 by Large et al[7] it has been affirmed that the consumption of unhealthy food and beverages in children below 10 years aids in the increased risk of dental caries. Nevertheless, Pitchika et al[17] detected an association between carbonated beverages and caries experience in 10 years old children, yet this association was diminished at the older age group (15 years). This diminution was suggested to be due to imprecise reporting of the intake of such beverages by adolescents, professional fluoride protection or even home use of fluoridates toothpastes.

Findings of the present study indicated a weak correlation as well between salivary pH and dmf. This came in agreement with Cunha-Cruz et al[18] who found that there is no correlation between the dmf and salivary pH. Besides, Animireddy D. et al[2] reported that among children who were caries free, with minimal or even with early childhood caries, there was a generalized decrease in the salivary pH, salivary flow rate, and buffering capacity with higher viscosity of saliva. This revealed that the interaction between the different physicochemical properties of saliva including salivary flow rate, pH, buffering capacity as well as the salivary viscosity, had an effect on caries activity in children. This was demonstrated by Prabhakar et al[19] study where samples of un-stimulated saliva in caries active children showed a light reduction in salivary pH, buffering capacity and flow rate. Yet, salivary proteins, calcium and anti-oxidants were increased.

The weak correlation between salivary pH and frequency of carbonated drinks intake revealed in this study was augmented by Hans R. et al[20, 21] study that found a correlation between various beverages tested and their cariogenic and erosive potential where the tested fluids in the latter study demonstrated a drop in salivary pH just after their consumption. Yet, the time consumed for the pH to return to the non-critical pH was relatively short time. This might explain the results of the current study that couldn't detect a significant correlation between the salivary pH and consumption of carbonated beverages. This assumption was expressed based on several studies among which is Tenuta LM et al[4] who assessed the duration required for the salivary pH to return to baseline after exposure to both orange juice and a cola-based soft drink. A mini pH electrode was used. Salivary pH began to return to the baseline value at 30 s after expectoration of the cola-based soft drink and at 90 s after expectoration of the orange juice. Goel I.[22] also suggested a decline in the salivary pH after consumption of both a carbonated drink & fruit juice. However, after 20 minutes, the pH commenced to rise and a constant rise was seen after 30 minutes. Agrawal et al[23] found same results where the buffering capacity of the saliva nullified the pH drop caused by intake of carbonated beverages in only 30 minutes. A comparison between the intakes of cold carbonated drinks and packed fruit juices revealed a higher drop in the salivary pH after consumption of carbonated beverages in comparison to packed fruit juices.[24] Accordingly, in most communities if not all, it is recommended to lessen the amounts of carbonated and carbonated beverages to minimize impact on oral health.[25] The inability to homogenize the oral hygiene, eating habits and salivary components [26] between participants could be considered from the limitations of this study.

Conclusion

Consumption of carbonated beverages, salivary pH couldn't be considered as sole risk factors for development of caries in children. Based on the limitations of this study, further studies

on bigger samples and different geological areas are indicated with high quality dietary assessment.

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