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ORIGINAL RESEARCH

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Dental Plaque pH Variation with Regular Soft Drink, Diet Soft Drink and High Energy Drink: An *in vivo* Study

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ABSTRACT

Background: A high incidence of dental caries and dental erosion associated with frequent consumption of soft drinks has been reported. The purpose of this study was to evaluate the pH response of dental plaque to a regular, diet and high energy drink.

Methodology: Twenty subjects were recruited for this study. All subjects were between the ages of 20 and 25 and had at least four restored tooth surfaces present. The subjects were asked to refrain from brushing for 48 hours prior to the study. At baseline, plaque pH was measured from four separate locations using harvesting method. Subjects were asked to swish with 15 ml of the respective soft drink for 1 minute. Plaque pH was measured at the four designated tooth sites at 5, 10 and 20 minutes intervals. Subjects then repeated the experiment using the other two soft drinks.

Results: pH was minimum for regular soft drink (2.65 ± 0.026) followed by high energy drink (3.39 ± 0.026) and diet soft drink (3.78 ± 0.006). The maximum drop in plaque pH was seen with regular soft drink followed by high energy drink and diet soft drink.

Conclusion: Regular soft drink possesses a greater acid challenge potential on enamel than diet and high energy soft drinks. However, in this clinical trial, the pH associated with either soft drink did not reach the critical pH which is expected for enamel demineralization and dissolution.

Keywords: Dental plaque pH, Regular soft drink, Diet soft drink, High energy drink.

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INTRODUCTION

Soft drinks are nonalcoholic, flavored, carbonated beverage, usually commercially prepared and sold in bottles or cans.[1] Especially in younger age-groups, there has been a shift away from traditional eating habits toward increasing reliance on snack foods, ‘ fast foods’ and convenience foods accompanied by a range of sweetened or naturally sweet soft drinks.[2]

Excessive use of the drinks has been attacked on two main dental grounds: (1) That as almost all of them are fruit-based or carbonated or both, they may be acidic enough to damage (erode) surfaces of the teeth not covered by dental plaque, (2) that those which contain fermentable carbohydrates (i.e. generally speaking, sugars) may serve as a source of substrate diffusing into the dental plaque, from which microorganisms inhabiting the plaque can generate the acid that brings about the destructive process of dental caries, initially in the subsurface of the enamel beneath the plaque.[2,3] A high incidence of dental caries associated with frequent consumption of soft drinks has been reported.[3]

To reduce the caloric intake associated with soft drinks, artificial sweeteners have been added to them to form the so called ‘diet’ soft drinks. Artificial sweeteners, such as those found in diet soft drinks, are not metabolized by most of the oral bacteria. Nevertheless, both regular and diet soft drinks contain phosphoric acid and citric acid.[4]

Sports drinks are typically formulated to: (1) Prevent dehydration, (2) supply carbohydrates to augment available energy, (3) provide electrolytes to replace losses due to perspiration, (4) conform to requirements imposed by regulatory authorities and probably the most important and (5) be highly palatable.[5] The regular and frequent use of sports supplement drinks by sportsmen and women can potentially lead to increased caries experience (dental decay) and to dental erosion.[6]

The relative cariogenicity of foodstuffs including solid foods and beverages has been studied using enamel surface topography,[7] microhardness of the enamel[8] and plaque pH. Measurements of the pH of dental plaque after eating foods have been widely used for estimating the cariogenic potential of foods since typical changes in dental plaque pH, known as the Stephan response, occur after consuming sugar-containing foodstuffs.[9,10] This study evaluated the effects of a carbonated soft drink, a diet soft drink and a high energy drink on plaque pH in young adults.

METHODOLOGY

Twenty healthy subjects were recruited for this study. Subjects were between 20 and 25 years of age and had at least four restored tooth surfaces present. There were no active caries in any of the subjects. Eligible participants were given an information summary to read, then the study was verbally explained. Those interested in participation signed an informed consent form which was reviewed and approved by the ethical committee of the institution.

Subjects were instructed to stop brushing their teeth 48 hours prior to the dental appointment so that adequate plaque accumulation could occur. Previous clinical trials have demonstrated this time interval acceptable for plaque accumulation.[11,12] All appointments took place in the morning. Subjects were asked to refrain from eating and drinking (except water) until after their dental visit that day. Upon subject arrival, compliance with nonbrushing and refraining from eating and drinking was confirmed. A baseline pH was measured at four sites, (mesial of tooth no. 3, distal of no. 10, mesial of no. 19 and distal of no. 26).

Plaque pH was measured by the 'harvesting method' that involves removing small samples of plaque from representative teeth and the measurement of plaque pH on an electrode outside the mouth. This method is said to be suited for the ranking of foodstuffs according to their acidogenicity.[13]

Subjects were asked to swish with 20 ml of the regular soft drink for 1 minute. Plaque pH was again measured at the selected sites at 5, 10 and 20 minutes. This aspect of time has been shown to be adequate for plaque pH to be buffered significantly.[11,12] The patient then rinsed with deionized water and was allowed to rest during a 20 minutes 'washout' period. The pH was again measured at the selected sites and the subject rinsed with 20 ml of the diet soft drink for 1 minute. Plaque pH was measured at the selected sites at 5, 10 and 20 minutes. The same procedure was then followed for the high energy drink.

STATISTICAL ANALYSIS

Mean and standard deviation for the plaque pH was calculated. One way ANOVA was used for multiple group comparison. Correlation of pH of the beverages with the drop in plaque pH was calculated using Pearson correlation analysis. p values < 0.05 were considered statistically significant.

RESULTS

Table 1 shows the mean and standard deviation of pH of the drinks tested in the study and the mean plaque pH 5, 10 and 20 minutes after swishing with the respective drink. pH was minimum for Coca Cola (2.65 ± 0.026) followed by Red Bull (3.39 ± 0.026) and Diet Coke (3.78 ± 0.006). The maximum drop in pH was seen with Coca Cola followed by Red Bull and Diet Coke.

Graph 1 shows the pH values at baseline, 5, 10 and 20 minutes after swishing with each of the drinks.

Graph 2 shows correlation between pH of beverages and the plaque pH 5 minutes after swishing with the drinks.

Statistically significant, positive correlation was found between pH of beverages and the plaque pH 5 minutes after swishing with the drinks.

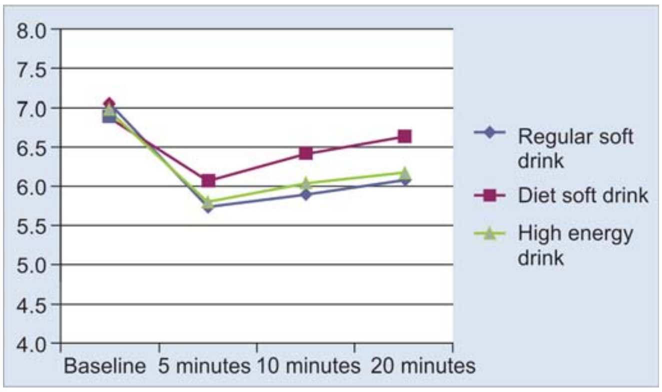
However, in this clinical trial, the pH associated with neither beverage reached the critical pH which is expected for enamel demineralization and dissolution.

DISCUSSION

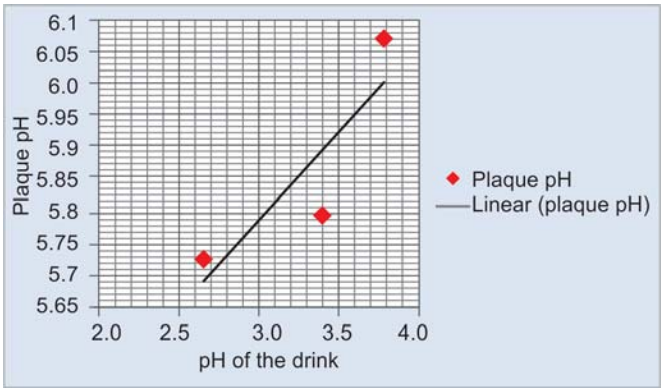
Measurement of plaque pH values and their changes after consuming foodstuffs or beverages can be used to estimate the acidogenic potential of foods or beverages and to evaluate an individual's caries susceptibility.[3] The acidogenic potential of foodstuffs is an important factor in the pathogenesis of dental caries. However, acidogenicity of foodstuffs is not quite equivalent to their cariogenicity. The term cariogenicity is used deliberately because the ability of any particular foodstuff to contribute to the initiation of caries is determined not only by its acidogenicity but also by many other factors, such as modifying factors in foods,[14]

Table 1: The mean and standard deviation of pH of the drinks tested in the study and the mean plaque pH 5, 10 and 20 minutes after swishing with the respective drink

Drink	*pH*	*Plaque pH*		
		5 minutes	10 minutes	20 minutes
Regular soft drink	2.65 ± 0.026	5.726 ± 0.287	5.8920 ± 0.258	6.08 ± 0.273
High energy drink	3.39 ± 0.026	5.795 ± 0.293	6.0350 ± 0.325	6.16 ± 0.317
Diet soft drink	3.78 ± 0.006	6.0720 ± 0.485	6.4230 ± 0.444	6.64 ± 0.415



Graph 1: The pH values at baseline, 5, 10 and 20 minutes after swishing with each of the drinks



Graph 2: Correlation between pH of beverages and the plaque pH 5 minutes after swishing with the drink

sugar content, how often the food is eaten,[15,16] eating sequence and food interactions.[17]

The postchallenge response of plaque pH to the test drinks produced a similar pattern to that of the Stephan curve. These findings were similar to a study conducted in Taiwan in 2001 by Guay-Fen Huang et al.[3] The values of the minimum pH after consuming carbonate, sport, and lactate drinks were higher in our study than those obtained by Meurman et al,[18] although the respective pH values of the drinks were almost identical with theirs. This might have been due to the effect of previous diet and of different measured sites.[19] Another reason is that the subjects in our study were healthy dental students. Apparently, their oral health characteristics were better than that of the average person.[3]

Sport drink contains 7.5% sugar and is usually not recognized as a cariogenic beverage since it does not taste as sweet as other sugar-containing beverages. Since sport drink is consumed continuously during exercise, there is prolonged and frequent contact of the drink with the teeth. Subsequently, erosive dental lesions have been reported among athletes and other physically active people.[18]

The test soft drinks in this study had a low pH between 2.6 and 3.8. Consumption of acidic products may cause erosion of the teeth. However, food pH affected acid provoking potential and also influenced food clearance by salivary flow, which has an indirect effect on plaque pH. In our study, the ranking order of the pH drops after consuming beverages was consistent with that of the beverage pH values. These findings are consistent with studies conducted by Guay-Fen Huang et al[3] and Roos EH et al.[4]

Phosphoric and citric acid are common ingredients found in either regular, diet or high energy soft drinks. It was demonstrated that diet soft drinks caused less of a decrease in plaque pH when compared to regular soft drinks and high energy drinks at 5, 10 and 20 minutes following consumption. Similar results have been reported by Roos EH et al[4] in 2002.

Dental caries are the outcome of complicated interactions among food, bacteria, the teeth and saliva, but the reaction is not simplistic. It is unlikely that any one test, such as dental plaque pH measurement, would suffice for estimating the cariogenic potential of a foodstuff. The frequency of acidogenic episodes is more important than the degree of acidogenicity during one episode. In spite of all these factors, the deleterious effects of the soft drinks on teeth cannot be ignored.

CONCLUSION

The consumption of a regular soft drink caused a significantly greater decrease in plaque pH at 5, 10 and 20 minutes time intervals when compared to the consumption of a diet soft drink and high energy drink. However, the pH with either regular or diet soft drinks did not reach the critical pH which is expected for enamel demineralization and dissolution.

RECOMMENDATIONS

Although the erosion and caries processes are as different as their histological appearance, the two conditions occurring concurrently could be deleterious to dental hard tissues. As dental professionals, we need to educate our patients about the consequences of soft drink consumption and provide suggestions to minimize the risk. Public should be made aware about hazardous effects of beverages on teeth.

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