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Original Article

Influence of Soft Drink Intake on the Salivary pH of Schoolchildren

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Abstract

Objective: To evaluate the influence of Coca-Cola® consumption on the salivary pH of 12-year old children. **Material and Methods:** The convenience sample was composed of forty-five 12-year old students of both genders from public schools of Itatiba, state of São Paulo, Brazil. Salivary pH was measured with pH colorimetric tape indicator (Merck). The reading of the colorimetric method was made by an experienced evaluator under uniform lighting conditions. The colorimetric tape was positioned in the back of the student's tongue, which remained with the mouth shut for 30 Seconds. For control, the first measurement (T_0) was performed before the intake of the soft drink (baseline pH). Subsequently, students were instructed to slowly drink 100 ml of Coca-Cola® using a plastic disposable cup. Immediately after ingestion, the pH was measured again with the colorimetric tape (t_1). The oral pH values were also measured 5 minutes (t_2), 10 minutes (t_3) and 15 minutes (t_4) after the soft drink intake, keeping the tape positioning always the same in all measurements. The statistical SAS software was used for data analysis. Comparisons of oral pH values at different times were performed by the Tukey-Kramer test adopting 5% significance level. **Results:** Immediately after soft drink intake, the salivary pH significantly decreased (pH = 6.26) ($p < 0.05$) compared to baseline (pH = 7.23) ($p < 0.05$). Fifteen minutes after ingestion, although an increase in the pH was observed (pH = 6.64), it had not yet returned to baseline (T_0) ($p < 0.05$). **Conclusion:** Coca-Cola® intake caused a significant reduction in salivary pH, without, however, reaching critical pH for enamel demineralization.

Keywords: Saliva; Hydrogen ion Concentration; Soft Drinks; Erosion.

Introduction

Erosive tooth wear was for many years a condition of little interest for clinical dental practice and public health [1]. However, with the epidemiological reduction in caries prevalence observed in recent decades, dental elements are kept for a longer period in the oral cavity, making them more susceptible to the development of other types of injuries, such as tooth erosion [2].

Epidemiological studies have pointed an increasing trend in the prevalence of erosion among different age groups in different countries [3,4]. In Brazil, studies on the prevalence of this disease have aroused the interest of researchers because this condition has become increasingly common in clinical practice [5].

Erosion is described as the localized, pathological and progressive loss of tooth structure caused by a chemical process not involving bacterial action, in which the mineral tissue is chemically removed from the tooth surface by acids or chelating substances [6,7].

The acids responsible for dental erosion can come from extrinsic or intrinsic sources [8]. Intrinsic sources are chronic vomiting and gastroesophageal reflux that persist for a long period [9] and affect mainly the palatal and incisal areas of dental elements [10]. Those of extrinsic origin come from the environment (acid pH of swimming pools), chronic use of medications (ascorbic acid, acetylsalicylic acid) and diet (unruly consumption of acidic foods and drinks) [9].

When in contact with saliva, the acids present in erosive foods dissociate, releasing hydrogen ions (H +), consequently decreasing the pH of the oral environment to values below the critical pH for enamel (5.5) and dentine dissolution (6.5) [1]. With pH reduction, the solubility of enamel apatite increases dramatically. Simple calculations show that a pH drop within the pH range from seven to four gives rise to a seven-fold increase in hydroxyapatite solubility [7].

The solubility of apatite is affected by pH as the hydroxyl concentration is inversely proportional to the hydrogen concentration and concentration of ionic phosphate complex depends on the solution pH [7]. The medium becomes then undersaturated with respect to calcium and phosphate ions that comprise the crystals of carbonated apatite, hydroxyapatite and fluorapatite, causing mineral dissolution of the tooth structure [1]. When saliva is undersaturated with respect to hydroxyapatite, it may still remain supersaturated with respect to fluorapatite. However, in pH≤4, saliva becomes undersaturated with respect to both HAP and FAP, thus losing its mineralizing capacity [6].

Therefore, the consumption of acidic foods can cause significant reduction in the hardness of both enamel and dentin, and although saliva has the ability to remineralize enamel and dentin, its effect is limiting and inversely proportional to the acidic food intake frequency [6]. Furthermore, the remineralization process is not immediate since the reestablishment of the enamel surface hardness by saliva occurs after 2 hours from the acid attack [11]. It could then be inferred that the pH value is one of the most important factors to be considered in the liquid diet regarding tooth erosion [7].

Soft drinks are among the liquid foods most widely ingested by children and adolescents in Brazil [12]. Studies have shown that regular soft drinks are the second beverage most widely

consumed during the meal by adolescents (28.6%) [13]. Another important finding was that as the age of the children increased, the consumption of carbonated drinks, including soft drinks, increased while milk intake decreased significantly [14].

This study aimed to evaluate the effect of Coca-Cola® consumption on the oral pH of 12-year-old schoolchildren.

Material and Methods

This study was approved by the Ethics Research Committee of the Faculty of Dentistry and São Leopoldo Mandic Research Center according to the principles of resolution 466/2012 of the National Health Council - Ministry of Health (Protocol No. 450368/2013).

This research was developed in the city of Itatiba, metropolitan region of Campinas, state of São Paulo, southeastern Brazil. The city is located at northwest of the state capital, about eighty kilometers away. Its estimated population is 113,284 inhabitants and Municipal Human Development Index (MHDI) of 0.778 and Education MHDI is 0.708 [15].

According to the literature [16], the sample size required for this type of study would be 31 students, but this work decided to use a larger sample as a guarantee of the maintenance of minimum sample after applying the exclusion criteria.

Study participants were all students aged 12 years of both genders, regularly enrolled in a public school of Itatiba, Brazil, that, by free will, agreed to participate in this research, returning for this the Informed Consent Form signed by parents, thus obtaining a non-probabilistic sample for convenience of 52 children.

Based on predetermined exclusion criteria (physical limitation that prevented the examination, medication user and baseline salivary pH), seven children were excluded by presenting initial salivary pH (detected only after the first measurement) below 6.8 [17], resulting a total sample of 45 students (n = 45), 26 females and 19 males.

Soft drink Coca-Cola® (Jundiaí, São Paulo, Brazil) was selected for this study because in previous studies it presented (1,2) the lowest pH among all soft drinks evaluated. The pH of 4 bottles of Coca-Cola® (Jundiaí, São Paulo, Brazil) used in the study was measured with the colorimetric tape and the value found for all was pH = 2.0.

Salivary pH was measured with Merck® colorimetric tape indicator (Darmstadt, Germany), in which salivary pH is determined by the colorimetric method, using a scale designed for reading. A single experienced evaluator made the reading of the colorimetric method under uniform lighting conditions. All evaluations were performed on the same day in the morning and afternoon shifts.

For the first measurement (t_0) with children sitting, the pH indicator tape was positioned in the back of the student's tongue, which remained with the mouth shut for 30 Seconds. After this time, the strips were removed from the oral cavity and through the colorimetric method, the salivary baseline pH of each child was obtained. Then, students were instructed to slowly drink 100 ml of soft drink Coca-Cola® (Jundiaí, São Paulo, Brazil), using a disposable plastic cup. Immediately after

ingestion, the pH was measured again using the colorimetric tape (t_1). The oral pH values were also measured at intervals of 5 (t_2), 10 (t_3) and 15 (t_4) minutes after soft drink ingestion. The colorimetric tape position is always the same for all measurements [16].

After exploratory analysis that indicated that data met the assumptions of a parametric analysis, methodology of mixed models for repeated measures was applied. The SAS (Statistical Analysis System) statistical software was used for data analysis. Comparisons of oral pH values in different time periods were performed by Tukey-Kramer test considering 5% of significance level.

Results

As can be seen in Table 1, the salivary pH value decreased significantly ($p < 0.05$) immediately after soft drink intake. After 15 minutes of ingestion, there was a significant increase in pH (6.64) ($p < 0.05$), being on average greater than the value observed at t_1 and t_2, but still lower than baseline (t_0).

Table 1. Mean (standard deviation) of salivary pH according to the time of ingestion.

Time	pH
t_0 - **Before soft drink intake**	7.23 (0.64) a
t_1 - **Immediately after soft drink intake**	6.26 (1.00) c
t_2 - **5 min after soft drink intake**	6.29 (0.89) c
t_3 - **10 min after soft drink intake**	6.34 (0.88) bc
t_4 - **15 min after soft drink intake**	6.64 (0.76) b

*Means followed by different letters (lowercase in the vertical) are significantly different (p = 0.05).

Discussion

Studies on the prevalence of dental erosion have aroused the interest of researchers worldwide [3] because its prevalence in the population is increasing and also to the close relationship of this disease with the lifestyle of patients [18].

In recent years, the total amount and frequency of consumption of acidic foods and beverages increased as a result of changes in lifestyle. In 2007, the annual worldwide consumption of soft drinks reached 552 billion liters, which is equivalent to a little less than 83 liters per person per year. In the United States, the average was 212 liters per person per year in 2009 [19].

Increased dental erosion has been associated with increased consumption of soft drinks [20]. *In vitro* studies have demonstrated an association between the presence of dental erosion and consumption of acidic beverages [21,19].

To analyze the erosive capacity of liquid foods, in addition to pH, other factors such as the type of acid present and the degree of ion dissociation of this acid should be considered [20]. In this study, only the pH value was taken into account due to the easy measurement in field and because pH represents alone the best way to evaluate the erosive potential of acidic drinks [22].

Studies that compared the pH of Coca-Cola® with other soft drinks indicated Coca-Cola® as having the lowest pH [23]. In different studies that analyzed Coca-Cola®, the value of its pH

presented variations between 1.78 and 2.70 [6, 23, 21, 19]. The results of this study corroborate the studies of these authors, in which the pH found for Coca-Cola® was 2.0.

In this study, children were asked to drink Coca-Cola® slowly. This form of drink intake, keeping it longer in contact with teeth is relevant, since maintaining liquid acids in the mouth before swallowing them is seen as a risk factor for erosion [24], as there is a positive relationship between mineral tooth loss and exposure time of the dental element to acidic drinks [25].

Although the pH of the soft drink used in this study was 2.0 and despite the significant decline in salivary pH after soft drink intake, in none of the time periods analyzed, salivary pH achieved values that are associated with enamel demineralization (≤ 5.5) [1].

The choice of the pH measurement method, by colorimetric tape was due to its practicality and feasibility in field studies. Despite being a subjective evaluation, the reading was performed by an experienced researcher and the technique seems to be similar to the use of potentiometer to measure salivary pH [26].

Although the positioning of the tape on the back of the tongue [16] can represent a study limitation, as the values measured at this location are higher than those found if the measurement was performed in the saliva [17], the results of this study confirm the significant reduction in the pH of the oral environment after ingestion of this soft drink, which may lead to losses in the mineral balance of the dental structure immediately after consumption.

Another important variable in the erosive potential of soft drinks is their buffering capacity [27], since the greater their buffering capacity, the longer the saliva will take to neutralize acids and thus more apatite is dissolved prior to salivary pH establish its normal value [19]. In this study, 5 and 10 minutes after soft drink intake, the pH had already reached values of 6.29 and 6.34, respectively, but values had not returned to normal. Even 15 minutes after soft drink intake, the salivary pH of 6.64 was still below the pH value initially measured (pH = 7.23). These results corroborate those of another study that measured the changes in salivary pH in children after industrial grape juice intake and found that 15 minutes after intake, salivary pH value had not reached normal values [16].

The presence of calcium, phosphate and fluoride in beverages can counteract mineral dissolution caused by acid foods [28]. However, the agents present in diet that cause erosion, such as Coca Cola®, are highly undersaturated with respect to calcium, phosphate and fluoride when compared to hydroxyapatite and fluorapatite [29].

The frequency of acidic drink consumption must also be taken into consideration. The frequent consumption of acidic drinks can increase the erosive effect of the drink on the enamel, becoming important to evaluate the history of consumption of these drinks in erosive lesions [21]. An *in situ* study showed that daily intake of Coca-Cola® caused significant losses in the surface structure of both enamel and dentin, which are not reversed by the saliva action and were proportional to the intake frequency [6].

In this study, participants ingested slowly and at once 100 ml of soft drink. Even though the amount and frequency of soft drink consumption is reduced, immediate reduction in the pH value was confirmed and throughout the study, return to baseline was not identified.

The acid pH presented by industrialized soft drinks such as Coca-Cola® does not determine by itself the development of erosive lesions in teeth, but is a factor that must be highlighted by the consumption frequency for determining the individual risk of the patient of developing this type of injury [30]. Thus, the patient's education on the causes and prevention of dental erosion is essential to prevent their onset and progression.

Conclusion

Soft drink Coca Cola® was responsible for significantly lowering of salivary pH; however, under the conditions of this study, this drop did not reach the critical pH for enamel demineralization.

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