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ORIGINAL ARTICLE

Relationship between erosive tooth wear and beverage consumption among a group of schoolchildren in Mexico City

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Abstract

Objective To assess the association between erosive tooth wear (ETW) and consumption of different kinds of beverages in a group of schoolchildren 11–14 years old in Mexico City.

Methods Cross-sectional study in a sample of students ($n = 512$) in Mexico City. The Basic Erosive Wear Examination (BEWE) was used to quantify ETW. Beverage consumption (BC) was determined using a frequency questionnaire; beverages included pure water, natural fruit juices, milk, hot beverages, and soft drinks. Ordinal logistic regression model was used to evaluate the association between the presence of ETW and BC.

Results In total, 45.7% of the schoolchildren showed an initial loss of surface texture (BEWE = 1) and 18.2% a distinct defect involving loss of dental tissue (BEWE ≥ 2) in at least one tooth. For each glass (350 ml) of milk/week, the odds of not having erosive wear (BEWE = 0) versus having an initial loss of surface texture (BEWE = 1) or of having an initial loss of surface texture versus the presence of a defect involving the loss of dental tissue (BEWE ≥ 2) decreased 4% (OR = 0.96, 95% CI 0.93–0.99, $p =$ 0.008); for each portion of sweet carbonated beverage consumed (350 ml), the odds increased 3% (OR = 1.03, 95% CI 1.001–1.07, $p = 0.046$).

Conclusion The intake of milk and milk-based products could be a dietary means of helping prevent ETW, especially if their consumption could replace sweet carbonated drink consumption.

Clinical relevance Knowing the impact of beverage consumption on ETW helps to provide suitable recommendations for the prevention and control of ETW in order to promote tooth longevity.

Keywords Erosive tooth wear · Tooth erosion · Sweet carbonated beverages · Prevention and control

Introduction

Erosive tooth wear (ETW) is defined as a chemical-mechanical process resulting in a cumulative loss of hard dental tissue that is not caused by bacteria; it is a multifactorial process where diet, saliva, dental hygiene, and some aspects of general health play different roles. One of the most important sources of chemical attack comes from acids from the diet. Some studies carried out on European populations have shown that the greater the quantity of erosive products consumed per day, the greater the risk of ETW [1, 2].

It has been demonstrated in in vitro studies that sweet carbonated drinks, sports beverages, and fruit juices cause a loss of hardness of the enamel, presumably because they contain at least one of the following acids: carbonic acid, phosphoric acid, malic acid, and citric acid [3]. Owing to their low pH, these acids weaken the link between calcium and the

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phosphate mineral composition of the enamel and dentin, and this leads to mineral loss [4]. Epidemiologic studies have shown that the intake of acidic beverages, such as carbonated drinks, fruit juices, and sports drinks, is an important factor associated with the presence of ETW. This is very important considering that the intake of these drinks has increased considerably among teenagers and young adults [5–7].

On the other hand, a relationship between the presence of less ETW and higher milk consumption has been observed [7, 8]. This relationship is most likely due to the high amount of calcium present in milk products. These minerals protect the dental surface against hydroxyapatite demineralization [9, 10]. Additionally, their lipids and proteins can adhere to the tooth surface, working as a protective barrier against acids [11].

Nowadays, among teenagers in Mexico, a variety of soft drinks (sugared and artificially sweetened, carbonated and non-carbonated, energy drinks, sports drinks, and other sugared or artificially sweetened beverages) are very popular [12–14]. In a study carried out over 13 countries, Mexico was among the four countries with the highest intake of soft drinks, with an intake of approximately of 470 ± 469.5 ml/day; furthermore, milk and milk-based product intake was also significant in Mexico, with an intake of approximately 333.5 ± 284 ml/day [15].

To study the relationship between the intake of these soft drinks (naturally or artificially flavored) and the role of milk products as factors that may help prevent ETW is important, particularly in people who consume a large number of potentially erosive beverages.

Additionally, other factors have been associated with the presence of ETW: the brushing of teeth previously eroded by acid attack [16, 17], vitamin C in chewable tablet consumption [3, 18], and constant regurgitation (e.g., gastroesophageal reflux and bulimia) [1, 19]. By contrast, saliva is considered the most important biological factor in the prevention of ETW because it counteracts the erosive effect of acid products and increases the rate of re-mineralization of eroded dental enamel by restoring calcium, phosphate, and fluoride levels [20].

The aim of the investigation was to assess the association between ETW and the consumption of different kinds of beverages in a group of schoolchildren aged 11–14 years in Mexico City.

Methods

Study group

A cross-sectional study was conducted in a convenience sample of schoolchildren 11 to 14 years old from two public schools located in a municipality in the north of Mexico City in 2015. A total of 1443 schoolchildren attended the selected schools. The Dentistry School's Committee on Ethics and Investigation at the Autonomous National University of Mexico approved the protocol of the investigation (CIE/01/27/1015). Once the nature of the study was explained and each student was asked for their consent, their parents or guardians were also asked for their informed written consent and signed an informed consent letter.

The calculation of the sample size was performed based on the prevalence of ETW (29.5%), given that the subjects were unexposed (low or zero consumption of sweet carbonated drinks) based on the results of a previous investigation [21]. With a power of 0.80 and an odds ratio equal to 1.80, the required sample size was 477; assuming a 20% non-response rate, 574 schoolchildren were invited to participate. Of the 574 invited, 35 did not accept (non-response rate = 7.3%) and the final sample size was 537.

Variables

The dependent variable was the presence of ETW. The presence and severity of this condition were assessed utilizing the Basic Erosive Wear Examination (BEWE), which has four codes [1]:

0 No surface loss
1 Initial loss of surface texture
2 Distinct defect, hard tissue loss < 50% of the surface area
3 Distinct defect, hard tissue loss ≥ 50% of the surface area

These criteria were used for each surface (vestibular, palatal/lingual, and occlusal/incisal) of all teeth, excluding dental surfaces that were more than 50% restored. Each participant was assigned to a group according to the maximum code found for any tooth, forming three categories:

- *No erosive wear* (BEWE = 0): all surfaces had code "0"
- *Initial loss of surface texture* (BEWE = 1): at least one surface had a code "1" as the maximum
- *Distinct defect involving the loss of dental hard tissue* (BEWE ≥ 2): at least one surface had a code "2" or "3".

The consumption of beverages was an independent variable. The beverages included in this study were pure water (tap water/bottled water), natural fruit juices (pure or with water), milk, hot beverages (coffee or infusions), and soft drinks (sweet carbonated drinks, fruit-based drinks, and sports and energy drinks).

Other variables were included such as demographic information (sex and age), habits related to the consumption of drinks (keeping drinks in the mouth before swallowing them or the consumption of sweet carbonated drinks or fruit juice fruit before going to bed), the consumption of some food (citrus fruits, yogurt, caramels, and chewing gum), dental hygiene (presence of debris and time between the moment they eat/drink and the moment they brush their teeth), the consumption of vitamin C chewable tablets, gastroesophageal reflux, frequent vomiting, and saliva characteristics (flow rate, pH, and buffer capacity).

Data collection methods

The presence of ETW was determined through a clinical examination by an examiner (A. E. G. A. P.) previously standardized by an expert (A. L.), obtaining a kappa coefficient of 0.93. The dental exam was performed with the participant sitting in front of an artificial light using a probe (PCP11), a dental mirror (#5), and gauze to dry the dental surfaces.

Information about drink and food intake was obtained using a standardized questionnaire about the frequency of consumption over the last seven days, and the information was obtained through an interview. In order to estimate the portions the subjects were consuming per week, the schoolchildren were asked to remember the days and number of portions of drink and food they consumed, confirming that the amount consumed over those days was the same that they were consuming habitually [22, 23]. Illustrations were shown to the participants to assess the portions consumed. The portions were established using a 350 ml glass of drink, 100 g of citrus fruits, 150 g of yogurt, a 7 g piece of caramel, and a 3 g piece of chewing gum.

Information of habits related to the consumption of drinks, tooth brushing, consumption of vitamin C chewable tablets, gastroesophageal reflux, and frequent vomiting was gathered through a standardized self-reported questionnaire; questions and possible answers are shown in Table 1.

A visual inspection for the presence of debris, defined as the soft foreign matter on the surface of the teeth, consisting of mucin, bacteria, and food, and varying in color from grayish white to green or orange, was conducted, rating clinically all vestibular and palatal/lingual surfaces using the Oral Hygiene Index (OHI) [24]. The presence of debris was defined as the percentage of surfaces covered 2/3 or more with debris; the examination was conducted by the same examiner (A. E. G. A. P.) who was standardized by an expert, obtaining a kappa coefficient of 0.89.

Measurement of the properties of saliva

The properties of the saliva that were analyzed were the flow rate of stimulated saliva (milliliters per minute), pH of stimulated saliva (≥ 7/< 7), and saliva buffer capacity (high/medium/low). Saliva collection was performed in the morning between 8:00 and 10:00 am; the participants were asked not to consume any food or drink and not to brush their teeth or wash their mouth at least one hour before collecting the salivary sample.

Table 1 Questions asked of a group of schoolchildren aged 11 to 14, north of Mexico City

Variable	Question	Answer
(1) Keeping drinks inside the mouth	Do you usually keep/rinse your mouth with sweet carbonated drinks or juices?	No/yes
(2) Drinking acidic drinks before going to bed	How often do you drink sweet carbonated drinks or juices before sleeping or right before going to bed?	Never/sometimes/frequently
(3) Time between the moment they ate/drank and the moment they brushed their teeth	How long after eating any food or drinking any beverage do you brush your teeth?	> 1 h/15 min–1 h/< 15 min
(4) Vitamin C chewable tablets	How often do you consume vitamin C chewable tablets?	Never/sometimes/frequently
(5) Gastroesophageal reflux	Do you suffer from gastroesophageal reflux?	No/yes
(6) Vomiting frequently	Do you often vomit (at least once a week)?	No/yes

In order to obtain this information, the following procedure was followed:

1. Stimulated saliva flow rate: each student was handed a standardized piece of chewing gum (without flavor) to stimulate saliva production. After 30 s, the participant was asked to swallow the generated saliva; from that moment, the saliva was collected every minute for 5 min and was weighed in an electronic balance (Series YS™; Ohaus Corporation), assuming 1 mg = 1 ml.
2. The pH of saliva: in order to evaluate the stimulated saliva pH, a potentiometer with an electrode (Starter ST2100™; Ohaus Corporation) was introduced into the stimulated saliva sample to make the measurement.
3. Buffer capacity: it was determined with a test strip from the Saliva-Check Buffer™ kit (GC America Inc.). A drop of saliva was applied over the three fields of the test strip; after 2 min of reaction, the buffer capacity was determined according to the change of color of each of the three fields. The possible results are high, medium, and low.

Statistics analysis

The information was analyzed using Stata v. 12 [25]. A descriptive analysis was performed using summary measures, including centralization and dispersion measures for the description of the quantitative data (age, drink and food consumption, presence of debris, and saliva flow rate) and frequencies for categorical data (sex, presence of ETW, time between the moment subjects ate/drank and the moment they brushed their teeth, consumption of vitamin C chewable tablets, gastroesophageal reflux, frequent vomiting, saliva pH, and saliva buffer capacity).

For the regression models, BEWE scores were categorized in three groups: one with *no erosive wear* (BEWE = 0), an *initial loss of surface texture* (BEWE = 1), and a *distinct defect involving the loss of dental tissue* (BEWE ≥ 2) were compared using the independent variables. It was found that the quantitative variables were not normally distributed; therefore, a non-parametric analysis was performed using the Wilcoxon rank test to compare weekly consumed portions of drinks and food. A Chi-squared test was utilized for the categorical variables. In the multivariate analysis, ordinal logistic regression was used. The assumption of parallel regression was validated through the test of proportionality of odds across response categories of the ETW. The variables included in the model were those with a level of significance of $p < 0.35$ in the bivariate analysis and those that were considered important because of their biologic plausibility. Finally, possible interactions were analyzed. The statistical significance was set at $p < 0.05$.

Results

The mean age of the 512 participants was 12.18 ± 0.56 years old; 7% were 11, 68.9% were 12, 22.7% were 13, and 1.4% were 14. A total of 51.6% were women. The mean number of teeth examined per participant was 25.78 ± 3.16 (median = 27); in 238 (46.5%) schoolchildren, 28 teeth were examined. The smallest number of permanent teeth that could be examined was 13. In the study group, the prevalence of ETW was 63.9%. 234 subjects (45.7%) presented an *initial loss of surface texture* (BEWE = 1), 90 (17.6%) presented a *defect involving the loss of dental tissue < 50%* (BEWE ≥ 2), and 3 (0.6%) presented *loss of hard tissue ≥ 50%* on at least one of the examined surfaces. The mean number of teeth with ETW was 3.37 ± 2.18 (median = 3) in cases identified as positive for ETW. The most frequently affected teeth in the category of initial loss of surface texture (BEWE = 1) were upper central incisors on their palatine surfaces and incisal edges. In the category of defect *involving the loss of hard tissue* (BEWE ≥ 2), inferior molars (occlusal surface) were the most affected teeth. Fig. 1 depicts the distribution ETW according to the type of tooth.

Older children had a higher prevalence of erosive defects. Among 13- and 14-year-old schoolchildren, in both categories, defects involving loss of tissue (25.2%) and initial loss of surface texture (50.4%) occurred more frequently than in 12-year-old schoolchildren (15.6%/44.7%) and 11-year-old schoolchildren (19.4%/38.9%) ($Chi^2 = 11.93$; $p = 0.018$). No differences in ETW were observed by sex ($Chi^2 = 2.63$, $p = 0.268$).

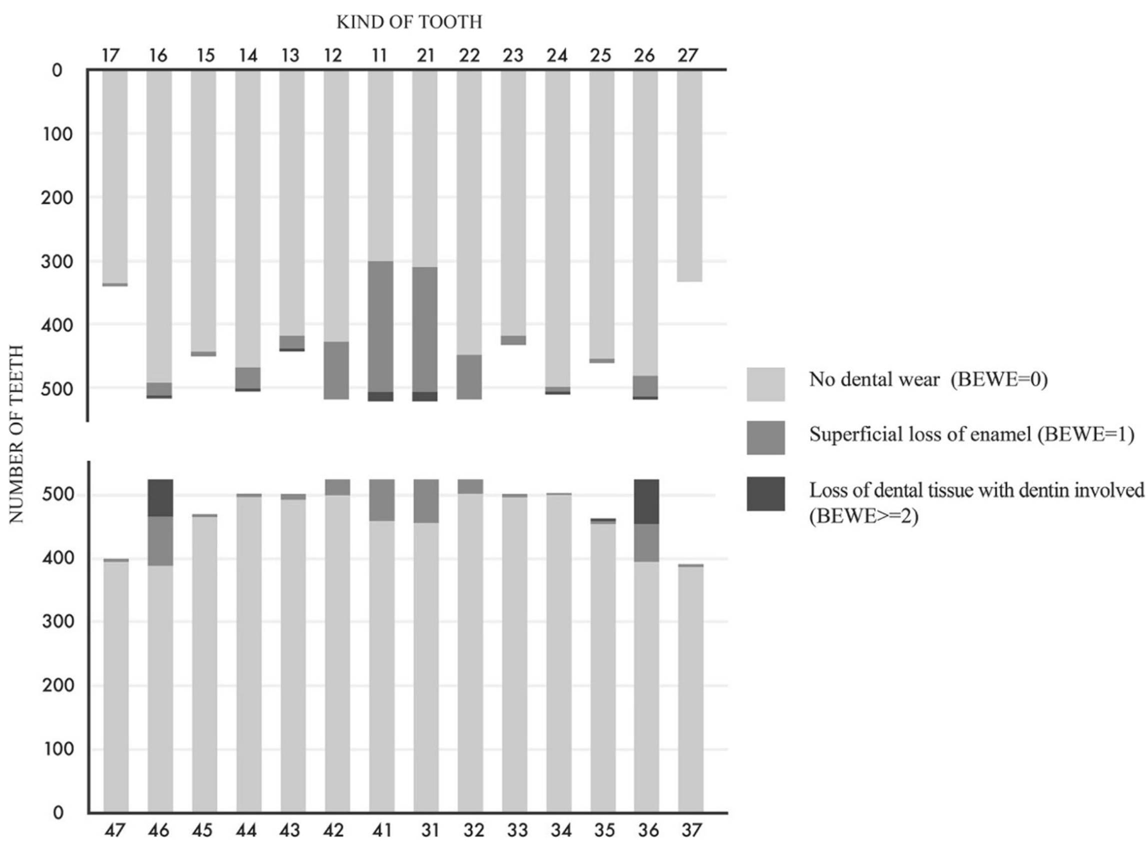

Fig. 1 Distribution of erosive tooth wear by kind of tooth in a group of students aged 11 to 14, Mexico City

In general, the beverages that were consumed the most frequently by the students were pure water, water mixed with fruit juice, and milk with 17.1 ± 11.23 (median = 14), 6.82 ± 7.59 (median = 4), and 6.66 ± 5.56 (median = 7) weekly portions, respectively. The most frequently consumed soft drinks were sweet carbonated drinks and fruit-based drinks (with artificial flavor or natural fruit), with a total consumption of 3.92 ± 5.0 (median = 2) and 2.42 ± 3.55 (median = 1) portions per week, respectively.

Type of beverages and ETW

The milk consumption was higher in those who presented absence of ETW. Those without ETW (BEWE = 0) had a mean consumption of 7.64 ± 5.95 (median = 7) portions, compared with schoolchildren exhibiting an initial loss of surface texture (BEWE = 1) who had a mean of 6.11 ± 5.33 (median = 5.5) portions and those exhibiting a defect involving more loss of dental tissue (BEWE ≥ 2) who had 6.13 ± 5.11 (median = 7) weekly portions ($Chi^2 = 9.33$, $p = 0.009$).

Table 2 presents the weekly mean consumption of beverages according to the presence of ETW. No differences in the presence of ETW were found with respect to the consumption of pure water, water mixed with fruit juices, sweet carbonated drinks, natural fruit-based drinks (or with artificial flavors), sports drinks, coffee, orange juice, infusions, energy drinks, citrus fruits, yogurt, caramels, and chewing gum ($p > 0.05$).

Table 3 shows the distribution of schoolchildren with respect to ETW status and according to habits related to the consumption of drinks, dental hygiene, vomiting, gastroesophageal reflux, vitamin C chewable tablet consumption, and salivary characteristics. An association was found between salivary pH and ETW, the percentage of subjects free of ETW (BEWE = 0) was higher among those who had a pH ≥ 7.0 (38.1%) compared to those with a pH < 7.0 (24.3%) ($Chi^2 = 7.1$, $p = 0.029$).

No statistically significant associations were found between ETW and keeping drinks inside the mouth, consuming acid drinks before going to bed, the percentage of

Table 2 Portions of drinks (glass of 350 ml) and food taken weekly according to the level of erosive tooth wear, north of Mexico City

Drink or food	Mean ± s.d. median of total portions	Median ± s.d. median of portions according to the presence of ETW			Chi^2 of the Wilcoxon rank test	*p*
		BEWE = 0 *n* = 185	BEWE = 1 *n* = 234	BEWE ≥ 2 *n* = 93		
Pure water	17.10 ± 11.23 14	17.74 ± 11.38 20	16.52 ± 11.27 14	17.30 ± 10.88 18	1.23	0.542
Water mixed with fruit juices	6.82 ± 7.59 4	6.87 ± 8.03 4	6.94 ± 7.56 4	6.39 ± 6.8 4	0.19	0.910
Milk	6.66 ± 5.56 7	7.64 ± 5.95 7	6.11 ± 5.33 5.5	6.13 ± 5.11 7	9.33	0.009
Sweet carbonated drinks	3.92 ± 5.00 2	3.17 ± 3.72 2	4.26 ± 5.28 2	4.55 ± 6.22 2	3.63	0.162
Natural fruit-based drinks or with artificial flavors	2.42 ± 3.55 1	2.77 ± 4.26 1	2.12 (2.82) 1	2.46 ± 3.66 1	2.07	0.355
Sports drinks	1.10 ± 3.14 0	0.61 ± 1.67 0	1.42 ± 3.49 0	1.25 ± 4.18 0	4.55	0.102
Coffee	1.08 ± 1.92 0	1.15 ± 2.12 0	1.00 ± 1.67 0	1.14 ± 2.08 0	0.06	0.969
Orange juice	1.02 ± 2.71 0	0.83 ± 2.10 0	1.21 ± 3.33 0	0.92 ± 1.94 0	1.03	0.597
Infusions	0.88 ± 1.83 0	0.87 ± 1.66 0	0.83 ± 1.92 0	1.05 ± 1.92 0	1.70	0.427
Energetic drinks	0.29 ± 1.33 0	0.19 ± 0.85 0	0.42 ± 1.78 0	0.19 ± 0.56 0	3.26	0.196
Citrus fruits (portion of 100 g)	7.11 ± 9.44 4	7.07 ± 10.00 3.3	7.09 ± 8.92 4.1	7.25 ± 9.64 4	0.54	0.762
Yogurt (portion of 150 g)	2.03 ± 2.87 1	1.85 ± 2.47 1	2.19 ± 3.14 1	1.99 ± 2.89 1	0.69	0.709
Caramels (portion of 3 g)	5.96 ± 8.14 3	5.52 ± 7.12 3	6.25 ± 9.11 3	6.12 ± 7.48 4	0.83	0.661
Chewing gum (portion of 3 g)	2.69 ± 5.34 1	2.48 ± 4.57 1	2.62 ± 5.42 0	3.30 ± 6.45 1	2.38	0.304

BEWE = 0, no erosive wear; BEWE = 1, initial loss of surface texture; and BEWE ≥ 2, distinct defect involving the loss of dental tissue

Table 3 Distribution of the schoolchildren with respect to ETW according to habits associated with the consumption of drinks, dental hygiene, vomiting, gastroesophageal reflux, Vitamin C chewable tablet consumption, and saliva characteristics in a group of 11- to 14-year-old schoolchildren, north of Mexico City.

Variable	Total	Frequency according to ETW (%)			Chi^2	*p*
		BEWE = 0 *n* = 185 (36.1)	BEWE = 1 *n* = 234 (45.7)	BEWE ≥ 2 *n* = 93 (18.2)		
Keep/Rinse drinks in the mouth						
No	471 (100)	169 (35.9)	217 (46.1)	85 (18.0)	0.32	0.851
Yes	41 (100)	16 (39.0)	17 (41.5)	8 (19.5)		
Drinking acidic drinks before going to bed**						
Never	210 (100)	80 (38.1)	95 (45.2)	35 (16.7)	4.06	0.698
Sometimes	148 (100)	54 (36.5)	62 (41.9)	32 (21.6)		
Frequently	134 (100)	46 (34.3)	65 (48.5)	23 (17.2)		
Did not know	20 (100)	5 (25.0)	12 (60.0)	3 (15.0)		
Debris* (% of covered surfaces)						
Mean ± s.d.	24.11 ± 19.67	23.27 ± 19.32	25.20 ± 20.62	23.01 ± 17.91		
Median	18.75	17.02	19.64	21.43	0.86	0.649
Time spent brushing teeth**						
> 1 h	104 (100)	33 (31.7)	54 (51.9)	17 (16.4)	5.39	0.516
15 min − 1 h	104 (100)	34 (32.7)	52 (50.0)	18 (17.3)		
<15 min	246 (100)	94 (38.2)	102 (41.5)	50 (20.3)		
Did not know	58 (100)	24 (41.4)	26 (44.8)	8 (13.8)		
Vitamin C chewable tablet consumption**						
Never	253 (100)	86 (34.0)	120 (47.4)	47 (18.6)	7.19	0.251
Sometimes	128 (100)	49 (38.3)	51 (39.8)	28 (21.9)		
Frequently	75 (100)	27 (36.0)	34 (45.3)	14 (18.7)		
Did not know	56 (100)	23 (41.1)	29 (51.8)	4 (7.1)		
Gastroesophageal reflux**						
No	451 (100)	164 (36.4)	202 (44.8)	85 (18.8)	1.72	0.449
Yes	61 (100)	21 (34.4)	32 (52.5)	8 (13.1)		
Frequent vomiting**						
No	502 (100)	184 (36.7)	227 (45.2)	91 (18.1)	3.26	0.150
Yes	10 (100)	1 (10.0)	7 (70.0)	2 (20.0)		
Saliva flow rate* (ml/min)						
Mean ± s.d.	1.08 ± 0.52	1.09 ± 0.53	1.07 ± 0.50	1.10 ± 0.57		
Median	1.01	0.99	1.0	1.06	1.56	0.944
Stimulated saliva pH						
≥ 7.0	438 (100)	167 (38.1)	190 (43.4)	81 (18.5)	7.10	0.029
< 7.0	74 (100)	18 (24.3)	44 (59.5)	12 (16.2)		
Saliva buffer capacity						
High	62 (100)	26 (41.9)	27 (43.6)	9 (14.5)	5.30	0.258
Medium	314 (100)	119 (37.9)	135 (43.0)	60 (19.1)		
Low	136 (100)	40 (29.4)	72 (52.9)	24 (17.7)		

BEWE = 0, no erosive wear; BEWE = 1, initial loss of surface texture; and BEWE ≥ 2, distinct defect involving the loss of dental tissue

*For these variables, the value of Chi^2 corresponds to the Wilcoxon rank test

**For these variables, the *p* value corresponds to the Fisher test

dental surfaces with debris, the time between the moment the subjects ate/drank and the moment the subjects brushed their teeth, the consumption of vitamin C chewable tablets, gastroesophageal reflux, vomiting frequently, the saliva flow rate, and the buffer capacity of the saliva ($p > 0.05$) (Table 3).

Multivariate analyses

The ordinal logistic regression model constructed included the following variables: milk consumption, sweet carbonated drink consumption, sports drink consumption, coffee consumption, energy drink consumption, chewing gum consumption, vitamin C chewable tablet consumption, frequent vomiting, pH of stimulated saliva, and saliva buffer capacity (all adjusted according to age, sex, and number of examined teeth). The only statistically significant variables were milk and sweet carbonated drink consumption.

The results showed that a greater consumption of milk was associated with a lower prevalence of ETW. By contrast, a greater consumption of sweet carbonated beverages was associated with a higher prevalence of ETW. With each additional portion (glass of 350 ml) of milk consumed, the odds of not having ETW (BEWE = 0) versus having an *initial loss of surface texture* (BEWE = 1), or of having an *initial loss of surface texture* (BEWE = 1) versus having a *distinct defect involving the loss of dental tissue* (BEWE ≥ 2) were reduced by 4% (OR = 0.96; 95% CI: 0.93–0.99; $p = 0.008$). With each additional portion (350 ml) of sweet carbonated beverages consumed, the odds were increased by 3% (OR = 1.03; 95% CI: 1.001–1.07; $p = 0.046$). No statistically significant interactions were found. Table 4 presents the final model with the univariate odds ratios and multivariate odds ratios adjusted according to age, sex, and number of teeth examined.

Discussion

This paper contributes information about the prevalence and distribution of ETW and its associated factors in Mexican students. Few reports have been conducted in Latin America about this condition. The age group studied is considered to have a high risk of ETW because of their high consumption, beginning at a very young age, of drinks with a low pH and low calcium and fluoride such as sweet carbonated drinks, fruit juices, and non-carbonated soft drinks [12–14].

A high prevalence of ETW (63.9%) was found in the adolescents studied; approximately half of the cases were in the low category (45.7% exhibited superficial changes on the enamel). The drinks associated with ETW were milk, which was associated with a protective effect, and sweet carbonated drinks, which were associated with a higher prevalence of ETW.

The main limitation of this study is that it is not possible to determine causal associations owing to the cross-sectional design of the study. Another limitation is the possible memory bias in beverage consumption; however, frequency food intake questionnaires are a diet evaluation tool that are widely used in epidemiological studies [22, 26]. In addition, the dietary information was obtained regarding the previous week. It is important to obtain the information in a short period of time, since it has been observed that a period of time greater than 7 days reduces the validity of the information [27]. There is a need for longitudinal studies that could help elucidate the roles of different beverages in the initiation and progression of ETW [8, 28, 29].

Among the advantages of the study was that it included measurements of stimulated flow rate, pH, and buffer capacity, considering that saliva is one of the most significant biologic modulators of ETW [30]. However, statistically significant differences were not found with respect to the characteristics of the saliva and ETW. This has also been observed in other studies [31–33]. This lack of significant differences might be due to the fact that the flow rates in most of the participants were within the normal range [20].

There is evidence that the time between consuming food and erosive beverages and brushing teeth has no effect on the degree of ETW [34–36]. Accordingly, no association was found between dental hygiene and ETW.

The prevalence of ETW found in this study [45.7% with an initial loss of surface texture (BEWE = 1) and 18.2% with a distinct defect involving the loss of dental tissue (BEWE ≥ 2)] was higher compared with results of some other investigations using the BEWE index. In Brazil, Alves et al. [37] found a prevalence of 13.5% with an initial loss of surface texture (BEWE = 1) and 1.5% with a distinct defect involving the loss of dental tissue (BEWE ≥ 2). In Uruguay, Alvarez Loureiro et al. [38] found that 4.4% of the participants showed a distinct defect involving the loss of dental tissue (BEWE ≥ 2). In France, Muller-Bolla et al. [39] found a prevalence (BEWE > 0) of 56.8%. The higher prevalence observed in this study could be explained by the high consumption of sweet carbonated drinks that has been reported in Mexican populations, and this factor was found to be associated with the prevalence of ETW in the present study. The consumption of soft drinks with respect to the total liquid consumption is higher among Mexican adolescents (31–32%) than among adolescents in Brazil (13–15%), Uruguay (25–27%), and France (16–20%) [15].

Sweet carbonated drinks have been one of the products most frequently associated with ETW [7, 18, 21, 37] because of their low pH (most soda contains phosphoric acid and citric

Table 4 Crude and adjusted OR of the ordinal logistic regression model between erosive tooth wear and explanatory variables for the group of schoolchildren aged 11 to 14, north of Mexico City

	Univariate		Multivariate*	
	OR (95% CI)	*p*	OR (95% CI)	*p*
Milk**	0.96 (0.93–0.99)	0.008	0.96 (0.93–0.99)	0.008
Sweet carbonated drinks**	1.04 (1.01–1.07)	0.013	1.03 (1.001–1.07)	0.046

*Adjusted according to age, sex, and number of examined teeth, **reference < 350 ml acid [3]). They also usually have a low concentration of calcium and fluoride, and the combination of these factors contributes to their erosive capacity [2].

Other studies have reported a higher prevalence of ETW than that observed in the Mexican students in this study. Provatenou et al. [40] found a prevalence of 79% (BEWE > 0) in a sample of 14-year-old schoolchildren in Greece. Zhang et al. [41] found a prevalence of 73.5% with an initial loss of surface texture (BEWE = 1) in 12-year-old schoolchildren in Hong Kong. However, only 1.5% of the participants had a distinct defect involving the loss of dental tissue (BEWE ≥ 2) compared with the 18.5% found in the current study. Zhang et al. [42] in China found that 18.6% of 12-year-old schoolchildren showed a distinct defect involving the loss of dental tissue (BEWE ≥ 2), which was similar to the findings of the present investigation.

With respect to the association between ETW and milk consumption, our results are similar to those obtained in a meta-analysis published in 2015 [7] where the consumption of milk was associated with ETW. Milk has a high concentration of calcium, phosphate, and casein, which protect the dental surface against hydroxyapatite dissolution [9, 10]; moreover, its lipid and protein content adheres to the dental surface, acting as a barrier against acids that are able to reach the oral cavity through extrinsic or intrinsic sources [11]. Also, Corrêa et al. [43] found, in a group of 2–20-year-old Brazilians, that the odds of exhibiting ETW in anterior teeth were 60% lower (OR = 0.40) in those who frequently drank milk compared with those who had a lower consumption. Finally, Manaf et al. [44] found that the consumption of milk (≥ 107/< 107 ml) among students aged 19–21 in Malaysia decreased the odds of exhibiting ETW in 53% (OR = 0.47). In a recent study in Mexico, it was found that teenagers aged 14–19 had a prevalence of ETW with exposure of dentin of 9.8%, while among those who had no or low milk consumption the prevalence was 19.2%; however, this difference was only marginally statistically significant ($p = 0.09$) [21].

Recently, the European Federation of Conservative Dentistry has recommended making safer food choices as preventive management against ETW, such as beverages rich in calcium like milk [1]. The results of this study add to growing evidence that supports these recommendations.

Conclusion

More than half of the participants studied had ETW. Milk or milk-based beverage intake could represent a dietary product that could help prevent or control ETW, particularly when its consumption replaces the consumption of other drinks such as sweet carbonated drinks.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in this study were in accordance with the ethical standards of the Dentistry School's Committee on Ethics and Investigation at the Autonomous National University of Mexico and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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