

Original

Prevalence and risk factors for dental erosion among 11- to 14-year-old school children in South India

Sandeep Kumar¹), Shashidhar Acharya²), Prashant Mishra¹), Nitai Debnath³),
and Ramprasad Vasthare²)

¹)Department of Public Health Dentistry, Sri Aurobindo Institute of Medical Sciences, Indore, India

²)Department of Public Health Dentistry, Manipal College of Dental Sciences, Manipal, India

³)Department of Prosthodontics, College of Dental Sciences, Rau, India

(Received June 27, 2013; Accepted October 29, 2013)

Abstract: This cross-sectional survey was conducted to assess the prevalence and severity of dental erosion and to determine the potential risk factors for dental erosion among 11- to 14-year-old school children in South India. The total sample size for the study was 605, of which 303 school children were from private schools and 302 from public schools. A questionnaire was designed to record information about socio-demographic characteristics, oral hygiene practices, dietary habits and risk factors for dental erosion. Chi square test, bivariate analysis and Logistic regression analysis were performed to analyse the data. The children who consumed lemon several times a day (OR = 13.41, $P < 0.001$), and those who preferred carbonated drinks (OR = 2.80, $P = 0.007$) had a higher tendency to develop dental erosion. The overall prevalence of dental erosion was found to be low (8.9%). Erosion was found to be greater in posterior teeth (65.6%) than anterior teeth (34.4%). Loss of enamel only with loss of surface contour was observed in most (94.8%) of the cases. The prevalence of dental erosion was found to be low in school children. Private school children were affected more by dental erosion. Frequency of lemon consumption and consumption of carbonated drinks were identified as risk factors.

(J Oral Sci 55, 329-336, 2013)

Keywords: dental erosion; schoolchildren; risk factors; cross-sectional.

Introduction

According to Pindborg, dental erosion is “superficial loss of dental hard tissue by a chemical process that does not involve bacteria” (1). The prevalence of dental erosion is not well documented and measures of erosive tooth wear have been rarely reported (2). In addition, it is often difficult to compare the outcomes of different epidemiological studies on dental erosion due to the difference in examination standards, including scoring systems, samples and groups examined (3). Intact hard dental tissues, including enamel, dentin, and cementum, are critical for the integrity of the dentition, (4) and the loss of these tissues can have significant consequences for the patient.

Tooth erosion is classified as idiopathic, extrinsic or intrinsic, implying that, according to the case history, the acids producing tooth destruction may be of unknown, exogenous or endogenous origin (5).

Dental erosion manifests itself in various forms. Erosive tooth wear in children is a common condition. In children and adolescents (like in adults), chemical, biological and behavioural factors and their interplay are possible reasons for this condition (5). Case reports have linked erosion with abusive or unusual behavior (6). Frequent and excessive consumption of specific dietary elements such as citrus fruits, lemon juice, orange juice, fruit squashes, cola-flavoured soft drinks and citrus flavoured drinks have all been implicated. Unusual eating, drinking and swallowing habits; for example holding an

Correspondence to Dr. Sandeep Kumar, Flat no 304, Sanskar block, Sri Aurobindo Institute of Medical Sciences, Indore, Madhya Pradesh, India

E-mail: drsandeep40@yahoo.com

doi.org/10.2334/josnusd.55.329

DN/JST.JSTAGE/josnusd/55.329

acid beverage in the mouth before swallowing, increases the contact time of an acidic substance with the teeth and thus increases the risk of erosion. It can be stated that dietary factors represent the most important external risk factor for children to develop dental erosion (7).

Prevention of dental erosion is an essential component of managing the condition and protecting the dentition against further damage. When this substance loss begins at a young age, there is a greater chance of losing tooth substance continuously over a lifetime if no adequate preventive measures are performed (8,9). Restorative therapies for erosion are another essential factor in the management of the condition. Restorations should be conservative, using adhesive materials that require minimal preparation of the teeth in order to be effectively adapted to the remaining tooth structure (<http://www.hswriting.ca/>).

Dental erosion seems to be a problem for the dental profession in this millennium. However, it is more worrying when this condition is found in an alarming proportion among children. If this condition is not controlled and stabilized, the child may suffer from severe tooth surface loss, tooth sensitivity, over closure, poor aesthetics, or even dental abscesses in the affected teeth (10). Since, there is not currently enough data to draw conclusions about the prevalence of dental erosion, more studies are needed in order to better understand the epidemiology of this destructive condition. Hence, this study was performed to assess the prevalence and severity of dental erosion among 11- to 14-year-old school children and to determine the potential risk factors for dental erosion.

Materials and Methods

This cross-sectional survey was conducted in 11- to 14-year-old school children attending public and private schools located in urban and rural areas of Udupi, Karnataka. Children within the age group of 11-14 years, who were present on the day of examination and were willing to participate, with positive parental consent, were included. Children who were medically compromised, not willing to participate and did not have parental consent were excluded from the study.

A two stage stratified cluster random sampling was done to select children from public and private schools located in rural and urban areas of Udupi, Karnataka. Schools were selected in such a manner that subjects were equally distributed in public and private schools. All the eligible children in the selected schools present on the day of examination were included in the study. Based upon the findings of the pilot study done, it was decided

to include a total sample size of 605 school children; 303 school children from private schools and 302 from public schools.

A questionnaire was designed to record information about socio-demographic characteristics, oral hygiene practices, dietary habits and risk factors for dental erosion. The questionnaire was translated into Kannada language. The validity was checked by a back-translation method, involving blind re-translation into English. The validity of translation was verified by experts in both languages.

Ethics approval was obtained from Kasturba Hospital, Manipal University and permission to examine the school children was obtained from the Principals of respective schools (IEC 86/2011). Informed consent was received from the children's parents as well as children participating in the study. The study was scheduled to be conducted in the months of December 2011 to January 2012 (2 months) and 25-30 children were to be examined per day.

After receiving permission from the school authority, the questionnaires were distributed to the school children to be filled in the classroom under the supervision of the examiner. Care was taken that no discussion took place amongst the students while filling the questionnaire. The filled proforma were returned to the examiner after 15-20 min. The proforma were checked and any incomplete forms were asked to be completed. After clinical examination, a lecture on oral health awareness was given to the children and teachers for duration of 15 min with the help of a model and toothbrush. The health talk primarily focused on oral hygiene maintenance.

The O'Sullivan Index was used for recording dental erosion among school children (11). The examination was carried out by a single trained and calibrated examiner. A mouth mirror, cotton roll and CPI probe were used for clinical examination. The tip of the probe was slid gently across the tooth surface to confirm the presence of dental erosion. The clinical examination was done under natural light. The occlusal, buccal, palatal/lingual surfaces of all teeth were checked for presence of dental erosion. To eliminate the possibility of interviewer bias, data collection, questionnaire and visual examination were always carried out by the same examiner.

Statistical analysis of the data was done using Statistical Package for Social Sciences (SPSS) version 16.5. Chi-square test was performed to check for significant difference between categorical variables. Frequency distribution analysis was performed to evaluate the prevalence of erosion. Logistic regression analysis was performed to identify the risk factors for erosion. A *P*

Table 1 Socio-demographic factors and type of diet consumed by the respondents

Questionnaire	Categories	Private schools <i>n</i> (%)	Public schools <i>n</i> (%)
Location of school	Urban	153 (50.5%)	152 (50.3%)
	Rural	150 (49.5%)	150 (49.7%)
Gender	Male	129 (42.6%)	176 (58.3%)
	Female	174 (57.4%)	126 (41.7%)
Socio-economic status	Upper	5 (1.7%)	0 (0%)
	Middle	268 (88.4%)	156 (51.7%)
	Lower	30 (9.9%)	146 (48.3%)
Type of diet	Vegetarian	43 (14.2%)	75 (24.8%)
	Mixed	260 (85.8%)	227 (75.2%)
Total		303 (100%)	302 (100%)

Table 2 Prevalence of dental erosion in whole sample and in public and private school children

Prevalence	Number of school children (%)
Prevalence of dental erosion in whole sample	54 (8.9%)
Prevalence of dental erosion in private school children	38 (6.3%)
Prevalence of dental erosion in public school children	16 (2.6%)

Table 3 Distribution of dental erosion according to surface, location, severity and amount of tooth surfaces affected out of the total number of affected teeth based on the O'Sullivan Index (*n* = 96)

	Number of teeth (%)
Based upon surface affected recorded as per O Sullivan Index	
Surface	
Labial or buccal only	2 (2.1%)
Lingual or palatal only	28 (29.2%)
Occlusal or incisal surfaces only	64 (66.7%)
Labial and incisal/occlusal	0 (0%)
Multisurfaces	2 (2.1%)
Based upon location of tooth recorded as per O Sullivan Index	
Location	
Number of posterior teeth affected by erosion	63 (65.6%)
Number of anterior teeth affected by erosion	33 (34.4%)
Based upon severity of erosion recorded as per O Sullivan Index	
Severity Code	
Code 1: Matte appearance of the enamel surface with no loss of contour	5 (5.2%)
Code 2: Loss of enamel only (loss of surface contour)	91 (94.8%)
Code 3: Loss of enamel with exposure of dentine (dentinoenamel junction visible)	0%
Code 4: Loss of enamel and dentine beyond dentinoenamel junction	0%
Code 5: Loss of enamel and dentine with exposure of the pulp	0%
Code 6: Unable to assess (e.g. tooth crowned or large restoration)	0%
Based upon amount of tooth surface affected recorded as per O Sullivan Index	
Amount of tooth surface	
Code +: More than half of the tooth surface affected	65 (67.7%)
Code -: Less than half of tooth surface affected	31(32.3%)

value ≤ 0.05 was considered to indicate statistical significance.

Results

The total sample comprised 605 school children, out of which 305 children belonged to the urban area and 300 to the rural area. The differences in gender, socioeconomic

status and type of diet consumed were found to be statistically significant between the groups (Table 1).

Out of total 605 children screened, dental erosion was found in 54 children (8.9%) of which 38 children (6.3%) belonged to private schools and 16 (2.6%) belonged to public schools (Table 2).

Out of the total surfaces affected (96), labial surfaces/

Table 4 Bivariate analysis for the whole sample with erosion as dependent variable

Factors	Categories	Erosion present <i>n</i> (%)	Erosion absent <i>n</i> (%)	<i>P</i> value
Location	Urban	29 (9.5%)	276 (90.5%)	0.612
	Rural	25 (8.3%)	275 (91.7%)	
Type of school	Private	38 (12.5%)	265 (87.5%)	0.002*
	Public	16 (5.3%)	286 (94.7%)	
Socio economic status	Upper class	2 (40%)	3 (60%)	0.004*
	Middle class	44 (10.4%)	380 (89.6%)	
	Lower class	8 (4.5%)	168 (95.5%)	
Gender	Male	28 (9.2%)	277 (90.8%)	0.825
	Female	26 (8.7%)	274 (91.3%)	
Diet	Vegetarian	8 (6.8%)	110 (93.2%)	0.362
	Mixed	46 (9.4%)	441 (90.6%)	
Brushing frequency	Once/day	22 (7.5%)	272 (92.5%)	0.001*
	Twice/day	30 (9.7%)	278 (90.3%)	
	More than twice/day	2 (66.7%)	1 (33.3%)	
Brushing method	Toothbrush	54 (9%)	545 (91%)	0.441
	Finger	0 (0%)	6 (100%)	
Brushing material	Paste	54 (8.9%)	550 (91.1%)	0.911
	Others	0 (0%)	1 (100%)	
Frequency of fruits consumption	Several times a day	10 (15.6%)	54 (84.4%)	0.052
	Every day	16 (10%)	144 (90%)	
	Several times a week	18 (9.0%)	182 (91%)	
	Once a week	10 (9.3%)	97 (90.7%)	
	Several times a month	0 (0%)	73 (100%)	
	Seldom/Never	0 (0%)	1 (100%)	
Frequency of biscuits consumption	Several times a day	8 (20.5%)	31 (79.5%)	0.141
	Every day	8 (8%)	92 (92%)	
	Several times a week	17 (9%)	171 (91%)	
	Once a week	13 (7.5%)	160 (92.5%)	
	Several times a month	6 (6.5%)	86 (93.5%)	
	Seldom/Never	2 (15.4%)	11 (84.6%)	
Frequency of lemon consumption	Several times a day	17 (42.5%)	23 (57.5%)	<0.001**
	Every day	4 (8.9%)	41 (91.1%)	
	Several times a week	15 (10.8%)	124 (89.2%)	
	Once a week	13 (9.1%)	130 (90.9%)	
	Several times a month	4 (2%)	195 (98%)	
	Seldom/Never	1 (2.6%)	38 (97.4%)	
Frequency of jam consumption	Several times a day	1 (7.7%)	12 (92.3%)	0.464
	Every day	2 (12.5%)	14 (87.5%)	
	Several times a week	10 (12.7%)	69 (87.3%)	
	Once a week	14 (10.1%)	124 (89.9%)	
	Several times a month	20 (9.2%)	198 (90.8%)	
	Seldom/Never	7 (5%)	134 (95%)	
Frequency of sweets consumption	Several times a day	7 (19.4%)	29 (80.6%)	0.001*
	Every day	15 (19.2%)	63 (80.8%)	
	Several times a week	13 (8.4%)	142 (91.6%)	
	Once a week	8 (6.7%)	111 (93.3%)	
	Several times a month	8 (6.5%)	116 (93.5%)	
	Seldom/Never	3 (3.2%)	90 (96.8%)	
Type of soft drinks preferred	Carbonated	43 (13.7%)	270 (86.3%)	<0.001**
	Non-carbonated	11 (3.8%)	281 (96.2%)	
Method of consumption	Straw	12 (6.3%)	180 (93.8%)	0.021*
	Direct swallow	28 (13.3%)	182 (86.7%)	
	Both ways	14 (6.9%)	189 (93.1)	
Snacks consumption with soft drinks	Yes	21 (10.4%)	180 (89.6%)	0.354
	No	33 (8.2%)	371 (91.8%)	
Time of consumption of soft drinks	In morning before meal	6 (7.9%)	70 (92.1%)	0.897
	With meals	8 (7.7%)	96 (92.3%)	
	In between meals	27 (9%)	272 (91%)	
	At night before sleeping	13 (10.3%)	113 (89.7%)	
Medical diseases	Yes	12 (10%)	108 (90%)	0.650
	No	42 (8.7%)	442 (91.3%)	
Medicine consumption	Yes	6 (10.9%)	49 (89.1%)	0.588
	No	48 (8.7%)	502 (91.3%)	
Vit C consumption	Yes	9 (10.2%)	79 (89.8%)	0.643
	No	45 (8.7%)	472 (91.3%)	
Sports	Swimming	0 (0%)	4 (100%)	0.530
	Others	54 (9%)	547 (91%)	

*CHI-SQ test

**P* < 0.05 is statistically significant

Table 5 Results of Logistic regression analysis

Factor	Categories	Adjusted odds ratio	95% Confidence Interval	P value
Type of school	Private	1.32	0.62-2.81	0.468
	Public	1.00		
Socio economic status	Upper class	8.87	0.67-116.69	0.141
	Middle class	2.14	0.85-5.39	
	Lower class	1.00		
Brushing frequency	Once/day	1.000		0.384
	Twice/day	1.33	0.70-2.52	
	More than twice/day	6.57	0.28-152.74	
Frequency of lemon consumption	Several times a day	13.41	1.54-116.72	<0.001**
	Every day	2.34	0.23-23.70	
	Several times a week	3.19	0.39-26.47	
	Once a week	3.37	0.40-28.23	
	Several times a month	0.66	0.07-6.22	
	Seldom/Never	1		
Frequency of sweets consumption	Several times a day	4.40	0.97-20.01	0.226
	Every day	3.07	0.78-12.08	
	Several times a week	1.57	0.40-6.12	
	Once a week	1.39	0.33-5.92	
	Several times a month	2.41	0.57-10.14	
	Seldom/Never	1.00		
Type of soft drinks preferred	Carbonated	2.80	1.32-5.94	0.007*
	Non-carbonated	1.00		
Method of consumption	Straw	1.00		0.606
	Direct swallow	1.48	0.66-3.32	
	Both ways	1.16	0.48-2.77	

*Logistic regression analysis

* $P < 0.05$ is statistically significant

buccal surfaces of the tooth were found to be affected in 2.1% (2), only lingual/palatal surfaces were affected in 29.2% (28), only occlusal or incisal surfaces were affected in 66.7% (64) and multiple surfaces of the teeth were affected in 2.1% (2). Erosion was found to be greater in posterior teeth (65.6%) than anterior teeth (34.4%). Loss of enamel only with loss of surface contour was observed in most (94.8%) of the cases, whereas matte appearance of the enamel surface with no loss of contour was seen in 5.2% of cases. In 67.7% (65) of the affected teeth (96), dental erosion was seen involving "more than half" of the teeth surface (Table 3).

A bivariate analysis was performed for the whole sample with erosion as dependent variable. Erosion was found to be significantly associated with type of school, socioeconomic status, brushing frequency, frequency of consumption of lemon and cola drinks, frequency of consumption of sweets, type of soft drinks preferred and method of consumption (Table 4).

Since erosion is a multifactorial disease, logistic regression analysis was performed to identify the factors that were significantly associated with the development of dental erosion. The factors that were significant after bivariate analysis, were then subjected to logistic regres-

sion model using *ENTER* method. The children who consumed lemon several times a day had a significantly higher tendency (OR = 13.41, $P < 0.001$) to develop dental erosion than children who seldom/never consumed lemon. The children who preferred carbonated drinks had a significantly higher (OR = 2.80, $P = 0.007$) tendency to develop dental erosion than children who preferred non-carbonated drinks. The type of school attended ($P = 0.468$), socioeconomic status ($P = 0.141$), brushing frequency ($P = 0.384$), frequency of sweets consumption ($P = 0.226$) and method of consumption of preferred drinks ($P = 0.606$) were found to be non-significantly associated with the development of dental erosion (Table 5).

Discussion

The objectives of the study were to assess the prevalence and severity of dental erosion among 11- to 14-year-old school children, and to determine the potential risk factors for dental erosion, through a self-administered questionnaire. The same questionnaire was used by Chu et al. (12).

Dental erosion was assessed using the O'Sullivan Index (11) as used by Peres et al. (13). However, these

authors evaluated only the 4 permanent maxillary incisors. In the present study, all teeth were examined. The assessment of all teeth, in 11- to 14-year-old children is appropriate because, at this age, the teeth have been exposed in the mouth for a considerable period of time.

In the present study, the prevalence of dental erosion was found to be low (8.9%). This was in agreement with the findings of Ferreira et al. (14), wherein they found a low prevalence of dental erosion in 11- to 14-year-old Brazilian school children. However, studies done by Manguiera et al. (15) and Deery et al. (16), have reported a very high prevalence up to 60% of dental erosion affecting the school children in US and UK, respectively. Diet has been considered the main etiological factor in development of erosion lesions. However, low prevalence of dental erosion in the present study indicates that the children had less exposure to fizzy and erosive drinks than in other countries such as USA and UK (16).

Out of the total number of teeth affected by erosion ($n = 96$), nearly 2/3rd were found to be affecting occlusal or incisal surfaces only, and a relatively lower percentage was found to affect the multiple surfaces of tooth, which was similar to the findings of Ganss et al. (17) and Bard-ley et al. (18).

The erosion was found to be greater in posterior teeth (65.6%) than anterior teeth (34.4%), similar to the findings of Ganss et al. (17), who reported that mandibular first molars were most affected by dental erosion among adolescents.

Regarding the severity of dental erosion, "loss of enamel 'only' with loss of surface contour" was observed in most (94.8%) of the cases, followed by "the matte appearance of the enamel surface with no loss of contour" in 5.2% of cases, which was similar to findings obtained by Talebi et al. (19).

In nearly 2/3rd of cases, more than half of the tooth's surface was affected, similar to the findings of Peres et al. (13) and Wang et al. (10), who observed that nearly 60% of the affected teeth had more than half of their surfaces affected.

A bivariate analysis was performed to identify the indicators for dental erosion. The school children studying in private schools had a significantly higher prevalence of dental erosion compared to public school children, which was similar to the findings of Manguiera et al. (15) and Talebi et al. (19). However, when logistic regression analysis was performed, no significant association was found between the type of schools attended and development of dental erosion.

The prevalence of erosion was found to be significantly higher in school children who belonged to upper

or middle class, which agreed with the findings of Nunn (20), and Manguiera et al. (15). However, when logistic regression analysis was performed no significant association was found between socioeconomic status and the development of dental erosion.

Erosion seemed to increase with the increase in brushing frequency. It was found to be significantly higher in school children who brushed twice or more daily. Milosevic (21) also found a positive association between frequency of tooth brushing and development of dental erosion.

The use of toothpowder was found to increase the rate of erosion because of the abrasive nature of the particles. Rios et al. (22) stated that even some kinds of toothpastes accelerate tooth wear due to the removal of superficial enamel layer. Ponduri et al. (23) reported that non-fluoride toothpaste could increase dentine loss compared with drinks alone. On the contrary; fluoride and re-mineralizing toothpastes (containing NaF, calcium, phosphate, and fluoride ions) are effective in inhibiting enamel erosion. The fluoride concentration around 1,100 ppm in dentifrices helps to reduce dentin wear caused by erosion, but the protection for dentin does not increase with increasing fluoride concentration (24). Re-mineralizing toothpaste is more effective in decalcified enamel (25). It could improve tooth-surface smoothness and gloss with regular use (26). However, in the present study, none of the school children in private and public schools reported the use of toothpowder to maintain oral hygiene. Hence, the role of toothpowder in development of erosion lesions could not be evaluated. No significant association was found between use of different brushing materials and development of erosion lesions.

Erosion has been found to be significantly associated with frequency of lemon and cola consumption. Johansson et al. (27) did a comparison study and found a positive association between erosion and soft-drink consumption. The present study showed that children who regularly consumed soft drinks had a higher tendency to develop dental erosion than children who did not. Because of the acidity and high sugar content of cola drinks, their corrosive potential is probably related to both the volume and the frequency of intake (27).

Hamasha et al. (28), in his study in Jordanian school children aged 12-14 years found that frequent consumption of lemon was an important risk indicator for dental erosion. Various studies have identified consumption of lemon drinks as an important risk indicator for development of dental erosion due to its acidic contents (citric acid) (10,12). The findings of the present study were also

in agreement with the findings of previous studies and frequent consumption of lemon drinks was found to be an important risk factor for dental erosion.

Erosion was found to be significantly associated with the frequency of sweet consumption. Studies have shown that the consumption of sweet food and fermentable carbohydrates lower the pH, thereby facilitating the dissolution of enamel (29).

Erosion was found to be significantly associated with carbonated drinks consumption. The school children who consumed carbonated drinks had higher tendency to develop dental erosion when compared to children who preferred non-carbonated drinks. Moazzez et al. (30) did a comparison study and found a positive association between reported consumption of carbonated drinks and dental erosion which was similar to the findings of Al-Dlaigan et al. (31). Carbonated drinks have lower pH than fruit juices (32). The buffering capacities are in the following order: fruit juices, fruit-based carbonated drinks, non-fruit-based carbonated drinks (33). Besides causing erosion on tooth surfaces, carbonated drinks could reduce surface hardness of enamel, dentin, microfilled composite, and resin-modified glass ionomer cements (34).

Results of logistic regression analysis showed that the factors lemon and cola consumption, and consumption of carbonated drinks, were the strongest predictors for development of dental erosion.

Dental erosion is commonly seen in children and adults in all regions of the world. Although the prevalence of dental erosion was low in school children, the various risk factors identified like frequency of lemon consumption and consumption of carbonated drinks in large volume over a prolonged period may cause severe loss of dental hard tissues that would adversely affect aesthetics and oral function. Private school children were more affected by dental erosion. Erosion was found to be more on occlusal and incisal surfaces resulting in loss of surface contour of tooth. Appropriate steps should be taken for early intervention, as it is the key to effective prevention of erosive tooth wear.

Acknowledgments

The authors would like to express their gratitude to the Principals and school children of various private and public schools located in Udupi, South Karnataka for their cooperation and active participation in the study.

References

1. ten Cate JM, Imfeld T (1996) Dental erosion, summary. *Eur J Oral Sci* 104, 241-244.

2. Lussi A (2006) Erosive tooth wear – a multifactorial condition of growing concern and increasing knowledge. *Monogr Oral Sci* 20, 1-8.
3. Jaeggi T, Lussi A (2006) Prevalence, incidence and distribution of erosion. *Monogr Oral Sci* 20, 44-65.
4. Hellwig E, Lussi A (2006) Oral hygiene products and acidic medicines. *Monogr Oral Sci* 20, 112-118.
5. Gupta M, Pandit IK, Srivastava N, Gugnani N (2009) Dental erosion in children. *J Oral Health Comm Dent* 3, 56-61.
6. Zero DT, Lussi A (2006) Dental erosion. *Monogr Oral Sci* 20, 100-105.
7. Scheutzel P (1996) Etiology of dental erosion – intrinsic factors. *Eur J Oral Sci* 104, 178-190.
8. Taylor G, Taylor S, Abrams R, Mueller W (1992) Dental erosion associated with asymptomatic gastroesophageal reflux. *ASDC J Dent Child* 59, 182-185.
9. Dodds AP, King D (1997) Gastroesophageal reflux and dental erosion: case report. *Pediatr Dent* 19, 409-412.
10. Wang P, Lin HC, Chen JH, Liang HY (2010) The prevalence of dental erosion and associated risk factors in 12-13-year old school children in Southern China. *BMC Public Health* 10, 478.
11. O'Sullivan EA (2000) A new index for the measurement of erosion in children. *Eur J Paediatr Dent* 1, 69-74.
12. Chu CH, Pang KK, Lo EC (2010) Dietary behavior and knowledge of dental erosion among Chinese adults. *BMC Oral Health* 10, 13.
13. Peres KG, Armênio MF, Peres MA, Traebert J, De Lacerda JT (2005) Dental erosion in 12-year-old school children: a cross-sectional study in Southern Brazil. *Int J Paediatr Dent* 15, 249-255.
14. Vargas-Ferreira F, Praetzel JR, Ardenghi TM (2011) Prevalence of tooth erosion and associated factors in 11-14-year-old Brazilian schoolchildren. *J Public Health Dent* 71, 6-12.
15. Manguiera DF, Sampaio FC, Oliveira AF (2009) Association between socioeconomic factors and dental erosion in Brazilian schoolchildren. *J Public Health Dent* 69, 254-259.
16. Deery C, Wagner ML, Longbottom C, Simon R, Nugent ZJ (2000) The prevalence of dental erosion in a United States and a United Kingdom sample of adolescents. *Pediatr Dent* 22, 505-510.
17. Ganss C, Klimek J, Lussi A (2006) Accuracy and consistency of the visual diagnosis of exposed dentine on worn occlusal/incisal surfaces. *Caries Res* 40, 208-212.
18. Bardsley PF, Taylor S, Milosevic A (2004) Epidemiological studies of tooth wear and dental erosion in 14-year-old children in North West England. Part 1: the relationship with water fluoridation and social deprivation. *Br Dent J* 197, 413-416.
19. Talebi M, Saraf A, Ebrahimi M, Mahmodi E (2009) Dental erosion and its risk factors in 12-year-old school children in Mashhad. *Shiraz Univ Dent J* 9, Suppl, 13-18.
20. Nunn JH (1996) Prevalence of dental erosion and the implications for oral health. *Eur J Oral Sci* 104, 156-161.
21. Milosevic A (2002) Dental erosion and toothbrushing habits of school children. *Br Dent J* 192, 514-516.

22. Rios D, Honório HM, Magalhães AC, Buzalaf MA, Palma Dibb RG, Machado MA et al. (2006) Influence of toothbrushing on enamel softening and abrasive wear of eroded bovine enamel: an in situ study. *Braz Oral Res* 20, 148-154.
23. Ponduri S, Macdonald E, Addy M (2005) A study in vitro of the combined effects of soft drinks and tooth brushing with fluoride toothpaste on the wear of dentine. *Int J Dent Hyg* 3, 7-12.
24. Magalhães AC, Rios D, Moino AL, Wiegand A, Attin T, Buzalaf MA (2008) Effect of different concentrations of fluoride in dentifrices on dentin erosion subjected or not to abrasion in situ/ex vivo. *Caries Res* 42, 112-116.
25. Muñoz CA, Feller R, Haglund A, Triol CW, Winston AE (1999) Strengthening of tooth enamel by a remineralizing toothpaste after exposure to an acidic soft drink. *J Clin Dent* 10, 17-21.
26. Munoz CA, Stephens JA, Proskin HM, Ghassemi A (2004) Clinical efficacy evaluation of calcium, phosphate, and sodium bicarbonate on surface-enamel smoothness and gloss. *Compend Contin Educ Dent* 25, 32-39.
27. Johansson AK, Johansson A, Birkhed D, Omar R, Baghdadi S, Carlsson GE (1996) Dental erosion, soft-drink intake, and oral health in young Saudi men, and the development of a system for assessing erosive anterior tooth wear. *Acta Odontol Scand* 54, 369-378.
28. Hamasha AA, Zawaideh FI, Al-Hadithy RT (2013) Risk indicators associated with dental erosion among Jordanian school children aged 12-14 years of age. *Int J Paediatr Dent* doi: 10.1111/ipd.12026.
29. Gibson S, Williams S (1999) Dental caries in pre-school children: associations with social class, toothbrushing habit and consumption of sugars and sugar-containing foods. Further analysis of data from the National Diet and Nutrition Survey of children aged 1.5-4.5 years. *Caries Res* 33, 101-113.
30. Moazzez R, Smith BG, Bartlett DW (2000) Oral pH and drinking habit during ingestion of a carbonated drink in a group of adolescents with dental erosion. *J Dent* 28, 395-397.
31. Al Dlaigan YH, Shaw L, Smith A (2001) Dental erosion in a group of British 14-year-old, school children. Part I: prevalence and influence of differing socioeconomic backgrounds. *Br Dent J* 190, 145-149.
32. Bartlett DW, Coward PY (2001) Comparison of the erosive potential of gastric juice and a carbonated drink in vitro. *J Oral Rehabil* 28, 1045-1047.
33. Edwards M, Creanor SL, Foye RH, Gilmour WH (1999) Buffering capacities of soft drinks: the potential influence on dental erosion. *J Oral Rehabil* 26, 923-927.
34. Wongkhantee S, Patanapiradej V, Maneenut C, Tantbirojn D (2006) Effect of acidic food and drinks on surface hardness of enamel, dentine, and tooth-coloured filling materials. *J Dent* 34, 214-220.