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ORIGINAL ARTICLE

Dental hard tissue erosion rates and soft drinks – A gender based analysis in Chennai city, India

Annapurna Kannan, M.A. Adil Ahmed, Prabu Duraisamy *, Sunayana Manipal, Preethi Adusumillil

SRM Dental College, Bharathi Salai, Ramapuram, Chennai 600 089, India

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KEYWORDS

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Abstract *Background:* A shift in the type and quantity of beverages consumed has been noticed, especially the decrease in the intake of milk and increased consumption of soft drinks. Soft drinks have a pH level of 2 which causes the need to assess its effect on the oral cavity, especially that of dental erosion. The study was done to evaluate if dental erosion was more prevalent in any one particular gender. Also a comparison was done between carbonated and non carbonated type of soft drinks, the various amounts and frequencies of consumption, the favourite brand of soft drink and their consequent dental erosion rates were evaluated.

Materials and methods: A cross sectional descriptive study was done among 400, middle income adults, belonging to the age group of 18–25 years. They were examined between January and March in the year 2012, by a single examiner. A questionnaire was circulated previously in two zones of Chennai, India and the subjects were chosen by lottery method. Clinical approval was obtained from the Ethics Committee of the Department of Public Health Dentistry, SRM Dental College, India to conduct the dental assessment. The dental erosion rates were estimated using Smith and Knight Index.

Results: Participants who consumed beverages weekly (17.65% males) had less erosion than those who consumed it daily (61.23% males). Higher the quantity of consumption more was the Erosion Index. Higher index values were seen in those who consumed only carbonated soft drinks (35.16 of female) than those who consumed only non-carbonated soft drinks (15.93% of female). On

* Corresponding author. Tel.: +91 0 9944483919; fax: +91 044 22492429.
E-mail address: drdp76@yahoo.co.in (P. Duraisamy).

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comparison of variables between genders, the p values (0.221 for type of soft drink, 0.826 for quantity of soft drink consumed) obtained were greater than the level of significance (>0.05).
Conclusions: Erosion causes deleterious effects to the dental hard tissues. No sex predilection was seen.

1. Introduction

Continuous evolution and experimentations with food and beverages have caused a plethora of changes in our staple diet [1–2]. Contemporary changes include shift in the types and quantities of beverages consumed, the manner in which they are consumed and their role in the diet. Most notable, is the decrease in the intake of milk and increased consumption of carbonated and non-carbonated soft drinks [3–5].

Nutrient profiles of these beverages differ, and substitution of these drinks against natural dairy products, have important nutritional implications as most of these soft drinks have a pH in the ranges of 2 [6]. Less recognized, however, are the implications that changes in beverage consumption can have for oral cavity. Oral bacteria ferment carbohydrates and produce acids. The inherent acids and sugars have both acidogenic and cariogenic potential, resulting in dental caries and potential enamel erosion [7,8].

Dental erosion (erosive tooth wear) is the situation of a chronic loss of dental hard tissue that is chemically etched away from the tooth surface by acid and/or chelation without bacterial involvement [9]. These acids can be from diet through the ingestion of food and beverages, or from stomach acids when they reverse course and travel through the oesophagus to the mouth [10,11]. This leads to a significant impact on patients' oral health by creating loss of tooth structure, tooth sensitivity and changes in the appearance of teeth. The pattern of erosion is related to how frequent the dental tissue is exposed to acidic fluid. Many studies have showed a positive relationship between caries and dental erosion and the consumption of soft drinks [6,12–15].

2. Materials and method

This cross sectional descriptive study was conducted among four hundred, middle income adults [16] (287 females and 113 males) belonging to the age group 18–25 years. They were examined in Chennai between January and March in the year 2012. Dental examination using mouth mirror and dental explorer (Type III examination) was completed by a single examiner on the permanent dentition of all the participants. Clinical approval was obtained from the Ethics Committee of the Department of Public Health Dentistry, SRM Dental College, Ramapuram, Chennai, India to conduct the dental assessment. Examination for tooth wear was done using Smith and Knight's Tooth Wear Index and scores were recorded for each participant. Smith and Knight's index records wear on all four surfaces (buccal, cervical, lingual and incisal–occlusal), irrespective of the aetiology of dental erosion [17]. The scores were given based on the characteristics seen on the enamel, dentin and pulp [Table 1]. Maximum score obtained by the individual for the most eroded tooth (full tooth or any particular surface) was noted down.

Table 1 Smith and Knight tooth wear index [16].

Score	Criteria
0	No loss of enamel surface characteristics
1	Loss of enamel surface characteristics
2	Buccal, lingual, and occlusal loss of enamel, exposing dentin for less than 1/3 of the surface; incisal loss of enamel; minimal dentin exposure
3	Buccal, lingual, and occlusal loss of enamel, exposing dentin for more than 1/3 of the surface; incisal loss of enamel; substantial loss of dentin
4	Buccal, lingual, and occlusal complete loss of enamel, pulp exposure, or exposure of secondary dentin; incisal pulp exposure or exposure of secondary dentin

The participants of the study were chosen from those who responded to the questionnaires previously distributed in two zones of Chennai, prior to the oral examination. A lottery method was employed to choose 400 subjects among those who responded to the total number of 700 questionnaires circulated. The questionnaire consisted of essential demographic details and multiple choice questions regarding the subjects' preferred way of consumption of soft drink beverages, type of soft drink, average quantity and frequency of consumption of soft drink. Participants were asked to name their favourite brand of soft drink. All the answers were correlated to participants' score of Smith and Knight's Tooth Wear Index. Varied answers for the favourite brand of soft drinks were given [Table 2].

Statistical analysis

A master chart was prepared in Microsoft Excel. SPSS software version 15.0 was used for the analyses. The characteristics of the study were analysed separately based on the gender. This was followed by, comparison of the variables between genders. Chi square test was employed. 0.05 was set as the level of significance. Any significant correlation present within each variable connecting the genders was analysed.

3. Results

3.1. Consumption of soft drinks

The number of female respondents who consumed soft drinks was 279 as against 8, who did not consume it. Among the male respondents, 108 participants consumed soft drinks as against 5, who did not consume it [Table 3].

Higher Smith and Knight Index values were recorded in those who consumed soft drinks than those who did not consume them [Table 3].

$x^2 = 0.345$, $p = 0.557$ – no significant association between genders on who consumed more soft drinks [Table 3].

Table 2 Favourite soft drink brands.

Brand name	Manufacturing company	Composition
Appy fizz	Parle Agro India Pvt. Ltd., Mumbai, India	Carbonated water, sugar, acidity regulator (330, 331), class II preservative (211), added apple flavour, contains no fruit
Bovonto	Kali Aerated Water Works, Salem, Tamil Nadu, India	Carbonated water, sugar, acidity regulator (330, 331), class II preservative (211), added tangy grape flavour, contains no fruit
Coke	The Coca-Cola Company, East Godavari, Andhra Pradesh, India	Carbonated water, sugar, acidity regulator (330, 331), class II preservative (211), added natural flavouring substances, contains no fruit
Fanta	The Coca-Cola Company, East Godavari, Andra Pradesh, India	Carbonated water, sugar, acidity regulator (330), stablizers (414, 445), class II preservative (211), synthetic food colour (110), added flavours (natural & nature identical flavouring substances), contains no fruit.
Frooti	Parle Agro India Pvt. Ltd., Mumbai, India	Non carbonated water, mango pulp, sugar, citric acid, ascorbic acid, salts, colouring and flavouring agents
Limca	The Coca-Cola Company, East Godavari, Andra Pradesh, India	Carbonated water, sugar, acidity regulator (330, 331), class II preservative (211), added natural flavouring substances, contains no fruit
Maaza	The Coca-Cola Company, East Godavari, Andra Pradesh, India	Non carbonated water, mango pulp-alphonsa variety, sugar, citric acid, ascorbic acid, salts, colouring and flavouring agents
Mirinda	Pepsico, Inc., West Bengal, India	Carbonated water, sugar (13.3%), acidity regulator (330,331), class II preservative (211), colour(110), stabilisers (1450, 445), added flavours (natural substances), contains no fruit
Mountain dew	Pepsico, Inc., West Bengal, India	Carbonated water, sugar (11.7%), acidity regulator (330, 331), class II preservative (211), colour (102), stabilisers (414, 445), added flavours (natural substances), contains no fruit, contains caffeine
Nimbooz	Pepsico, Inc., West Bengal, India	Non carbonated water, sugar (10.1%), acidity regulator (330, 296), preservative (202), 5% lime juice, salt, added flavours (natural and natural identical flavouring substances)
Pepsi	Pepsico, Inc., West Bengal, India	Carbonated water, sugar(10.6%), acidity regulator (338), class II preservative (211), colour (150d), stabilisers (414, 445), added flavours (natural substances), contains no fruit, contains caffeine
Red bull	Red Bull Gmbh	Caffeine, taurine, glucuronolactone, B-group vitamins, sucrose, and glucose
Seven up	Pepsico, Inc., West Bengal, India	Carbonated water, sugar (11.2%), acidity regulator (330, 331, 296), class II preservative (211), added flavours (natural substances), contains no fruit
Slice	Pepsico, Inc., West Bengal, India	Non carbonated water, mango pulp-alphonsa variety 15%, sugar (14.7%), acidity regulator (330), preservative (202), antioxidant (300), colour (102, 110) and flavouring agents (natural and nature identical)
Sprite	The Coca-Cola Company, East Godavari, Andra Pradesh, India	Carbonated water, sugar, acidity regulator (330, 331), class II preservative (211), synthetic food colour (110), added flavours (natural), contains no Fruit
Thumbs up	The Coca-Cola Company, East Godavari, Andra Pradesh, India	Carbonated water, sugar, acidity regulator (330, 331), class II preservative (211), synthetic food colour (110), added flavours (natural), contains no fruit, contains caffeine
Tropicana	Pepsico, Inc., West Bengal, India	Non carbonated water, fruit juice concentrate, natural fruit flavour

Table 3 Consumption of soft drinks by females and males and the corresponding index value.

			Smith and Knight Index (Females/Males)*				Total
			0	1	2	3	
Consumption of soft drinks	Yes	Females	177 (63.44%)	75 (23.88%)	26 (9.32%)	1 (0.36%)	279
		Males	59 (54.63%)	33 (30.56%)	16 (14.81%)	0	108
	No	Females	8 (100%)	0	0	0	8
		Males	5 (100%)	0	0	0	5

* $x^2 = 0.345$, $p = 0.557$.

Table 4 Type of soft drink consumed by females and males and the corresponding index value.

			Smith and Knight Index (Females/Males)*				Total
			0	1	2	3	
Type of soft drinks	No consumption	Females	8 (100%)	0	0	0	8
		Males	4 (100%)	0	0	0	4
	Carbonated	Females	63 (49.22%)	45 (35.16)	19 (14.84%)	1 (0.78%)	128
		Males	21 (34.43%)	27 (44.26%)	13 (21.31%)	0	61
	Non carbonated	Females	95 (84.07%)	18 (15.93%)	0	0	113
		Males	32 (96.97%)	0	1 (3.03%)	0	33
	Both	Females	19 (50%)	12 (31.58%)	7 (18.42%)	0	38
		Males	7 (46.67%)	6 (40%)	2 (13.33%)	0	15

* $x^2 = 5.719$, $p = 0.221$.

Table 5 Frequency of soft drink consumption by females and males and the corresponding index value.

			Smith and Knight Index (Females/Males)*				Total
			0	1	2	3	
Frequency of soft drink consumption	No consumption	Females	8 (100%)	0	0	0	8
		Males	4 (100%)	0	0	0	4
	Daily	Females	1 (2.27%)	21 (47.73%)	21 (47.73%)	1 (2.27%)	44
		Males	0	3 (17.65%)	14 (82.35%)	0	17
	Weekly	Females	38 (41.30%)	50 (54.35%)	4 (4.35%)	0	92
		Males	17 (34.69%)	30 (61.23%)	2 (4.08%)	0	49
	Monthly	Females	98 (95.15%)	4 (3.88%)	1 (0.97%)	0	103
		Males	32 (100%)	0	0	0	32
	Others	Females	40 (100%)	0	0	0	40
		Males	11 (100%)	0	0	0	11

* $x^2 = 11.886$, $p = 0.22$.

3.2. Type of soft drinks

Carbonated soft drinks were consumed by 128 female respondents as against 113 respondents who preferred non-carbonated soft drinks. 38 participants consumed both carbonated and non-carbonated soft drinks [Table 4].

Among males, 61 respondents consumed carbonated soft drinks as against 33 respondents who preferred non-carbonated soft drinks. 15 participants consumed both carbonated and non-carbonated soft drinks [Table 4].

Higher Smith and Knight Index values were seen comparatively in those who consumed carbonated soft drinks than those who consumed non-carbonated soft drinks in both males and females. The index values were relatively lesser for those who consumed both types of soft drinks than those who consumed only carbonated soft drinks, but higher than those who consumed only non-carbonated soft drinks [Table 4].

$x^2 = 5.719$, $p = 0.221$ – no significant association between genders and the type of soft drinks consumed [Table 4].

3.3. Frequency of soft drink consumption

Soft drinks were consumed daily (consumption of beverages once daily during meal time) by 44 female respondents as against 92 respondents who preferred weekly consumption. 103 participants consumed soft drinks monthly. 8 participants did not consume soft drinks [Table 5].

Among males, 17 respondents consumed soft drinks daily as against 49 respondents who preferred weekly consumption. 32 participants consumed soft drinks monthly had other

Table 6 Quantity of soft drink consumed by females and males and the corresponding index value.

			Smith and Knight Index (Females/Males)*				Total
			0	1	2	3	
Quantity of soft drinks	No consumption	Females	9 (100%)	0	0	0	9
		Males	6 (100%)	0	0	0	6
	300 ml	Females	131 (72.37%)	39 (21.55%)	11 (6.08%)	0	181
		Males	38 (63.33%)	16 (26.67%)	6 (10%)	0	60
	500 ml	Females	43 (50.59%)	34 (40%)	8 (9.41%)	0	85
		Males	19 (45.24%)	17 (40.48%)	6 (14.28%)	0	42
	1000 ml	Females	1 (16.67%)	2 (33.33%)	3 (50%)	0	6
		Males	1 (50%)	0	1 (50%)	0	2
	2000 ml	Females	1 (16.67%)	0	4 (66.66%)	1 (16.67%)	6
		Males	0	0	3 (100%)	0	3

* $x^2 = 2.859$, $p = 0.826$.

frequencies of consumption. 4 participants did not consume soft drinks [Table 5].

Any alternate frequencies of consumption were categorised under a separate variable as others which included 40 female and 11 male respondents [Table 5].

Higher Smith and Knight Index values were comparatively seen in those who consumed carbonated soft drinks daily than those who consumed it weekly. The index values were relatively lesser for those who consumed it weekly, but higher than those who had other frequencies of intake [Table 5].

$x^2 = 11.886$, $p = 0.22$ – no significant association between genders and the frequency of soft drinks consumed [Table 5].

3.4. Quantity of soft drink consumption

At a time, 181 female respondents consumed 300 ml of soft drinks as against 85 respondents who consumed 500 ml of soft drinks. 6 participants consumed 1000 ml of soft drinks and 6 respondent consumed 2000 ml of soft drinks [Table 6].

Among males, 60 respondents consumed 300 ml of soft drinks at a time as against 42 respondents who consumed 500 ml of soft drinks. 2 participants consumed 1000 ml of soft drinks and 3 respondent consumed 2000 ml of soft drinks [Table 6].

Higher Smith and Knight Index values were comparatively seen in those who consumed 2000 ml than those who consumed 1000 ml. The index values were relatively lesser for those who consumed 500 ml, but higher than those who had 300 ml [Table 6].

$x^2 = 2.859$, $p = 0.826$ – no significant association between genders and the quantity of soft drinks consumed [Table 6].

3.5. Favourite soft drink

Among females, 4 respondents consumed Appy Fizz, 52 respondents consumed Coke, 9 respondents consumed Fanta, 7 respondents consumed Frooti, 2 respondents consumed Limca, 51 respondents consumed Maaza, 9 respondents consumed Mirinda, 10 respondents consumed Mountain Dew, 1 respondent consumed Nimbuz, 55 respondents consumed Pepsi, 10 respondents consumed Seven Up, 50 respondents consumed Slice, 13 respondents consumed Sprite, 1 respondent consumed Thumbs up and 5 respondents consumed Tropicana [Table 7].

Among males, 2 respondents consumed Appy Fizz, 1 respondent consumed Bovonto, 17 respondents consumed Coke, 2 respondents consumed Fanta, 1 respondent consumed Frooti, 5 respondents consumed Limca, 20 respondents consumed Maaza, 4 respondents consumed Mirinda, 4 respondents consumed Mountain Dew, 26 respondents consumed Pepsi, 2 respondents consumed Red Bull, 4 respondents consumed Seven Up, 15 respondents consumed Slice, 6 respondents consumed Sprite and 4 participants did not consume soft drinks [Table 7].

Higher Smith and Knight Index values were comparatively seen in carbonated drinks such as Coke, Pepsi, Appy fizz, Mountain Dew, and Sprite than non-carbonated drinks such as Tropicana, Frooti, Slice, and Maaza [Table 7].

$x^2 = 2.810$, $p = 0.126$ – No significant association between genders and the favourite soft drink [Table 7].

4. Discussion

The study proves that there is no sex predilection in the consumption level, type, quantity, frequency of intake and favourite brand of soft drinks. The presence of erosion was more apparent in individuals who consume soft drinks than those individuals who did not [Table 3]. This outcome supports previous studies done by Leslie et al. and Lussi et al. [7,8].

Data illustrates that significant difference in the amount of erosion experienced by the individuals varied with the type of soft drink consumed. Individuals who preferred carbonated drinks (35.16% of female participants showed index score of 1) had an increase in erosion rate of enamel and dentin compared to those who consumed non-carbonated soft drinks (15.93% of female participants showed index score of 1) [Table 4]. Those who consumed both carbonated and non-carbonated drinks had a relatively lesser erosion than those who consumed only carbonated drinks [Table 4].

The frequency of consumption of soft drinks was significantly related to dental erosion in the present study. Weekly consumption (17.65% males showed index score of 1) resulted in lesser erosion than those who consumed it daily (61.23% males showed index score of 1) [Table 5]. The findings are supportive of previous surveys done by Talebi et al., Lussi et al. and O'Sullivan et al. [18–20]. Johansson et al. had stated that an increase in daily fluid consumption particularly that of soft

Table 7 Favourite soft drink brand for females and males and the corresponding index value.

			Smith and Knight Index (Females/Males)*				Total
			0	1	2	3	
Favourite soft drink brand	No consumption	Females	8 (100%)	0	0	0	8
		Males	4 (100%)	0	0	0	4
	Appy fizz	Females	3 (75%)	1 (25%)	0	0	4
		Males	0	0	2 (100%)	0	2
	Bovanto	Males	0	1 (100%)	0	0	1
	Coke	Females	26 (50%)	18 (34.62%)	7 (13.46%)	1 (1.92%)	52
		Males	4 (23.53%)	9 (52.94%)	4 (23.53%)	0	17
	Fanta	Females	6 (66.66%)	2 (22.23%)	1 (11.11%)	0	9
		Males	2 (100%)	0	0	0	2
	Frooti	Females	6 (85.71%)	0	1 (14.29%)	0	7
		Males	1 (100%)	0	0	0	1
	Limca	Females	1 (50%)	1(50%)	0	0	2
		Males	4 (80%)	1 (20%)	0	0	5
	Maaza	Females	38 (74.50%)	13 (25.50%)	0	0	51
		Males	17 (85%)	2 (10%)	1 (5%)	0	20
	Mirinda	Females	3 (33.33%)	6 (66.67%)	0	0	9
		Males	1 (25%)	3 (75%)	0	0	4
	Mountain dew	Females	3 (30%)	4 (40%)	3 (30%)	0	10
		Males	1 (25%)	2 (50%)	1 (25%)	0	4
	Nimbooz	Females	1 (100%)	0	0	0	1
	Pepsi	Females	24 (43.64%)	19 (34.54%)	12 (21.82%)	0	55
		Males	11 (42.30%)	10 (38.47%)	5 (19.23%)	0	26
	Red bull	Males	0	1 (50%)	1 (50%)	0	2
	Seven up	Females	6 (60%)	3 (30%)	1 (10%)	0	10
		Males	1 (25%)	2 (50%)	1 (25%)	0	4
	Slice	Females	48 (96%)	2 (4%)	0	0	50
		Males	14 (93.33%)	1 (6.67%)	0	0	15
	Sprite	Females	9 (69.23%)	3 (23.08%)	1 (7.69%)	0	13
		Males	4 (66.66%)	1 (16.67%)	1 (16.67%)	0	6
	Thumbs up	Females	0	1 (100%)	0	0	1
	Tropicana	Females	3 (60%)	2 (40%)	0	0	5

* $x^2 = 2.810$, $p = 0.126$.

drinks increases with increase in the temperature of the environment [21].Carbonated soft drinks (238 respondents) were preferred when compared to that of non-carbonated soft drinks (150 respondents), with the favourite soft drink being Pepsi (55 respondents) [Table 7].

In previous studies [22–28] conducted in school children, Al-Majed et al. [22] found a significantly higher prevalence of dental erosion in girls (29.9%) than in boys (25.7%), which is in agreement with the results of previous investigation of 12-year-old Cuban children by Künzel et al. [23]. However, Dugmore et al. and Truin et al. [24,25] have found a significantly higher prevalence in boys than in girls, while Correr et al., Peres et al. and Ping Wang et al. [26–28] found no difference between genders.

The present study conducted on adults shows that there was no significant association between genders. This could probably be due to the difference in the pattern of drinking. Some individuals tend to gulp, while others prefer the usage of straw. The amount of time the individuals hold the drink in the oral cavity before swallowing has considerable variations. Ping wang et al. [28] had stated that females have a tendency to suck the fluid more quickly than males, but these variables have no significant difference between adults with and without dental erosion. The reason behind the gender difference in the occurrence of dental erosion is not within the scope of the present study and further research is needed to evaluate the rationale.

The present study had limitations because of recall bias, the cross-sectional study design [29], and the relatively small sample size of urban residents. Data provided are the observation done at one specific point of time [29]. The progressive nature of dental erosion and the long term effects of soft drinks cannot be evaluated. Subjects and their families are generally from middle-income families and are not representative of children throughout India. Socioeconomic status is associated with oral health behaviours and oral diseases [30]. Association between soft drinks and dental erosion experience could be more pronounced in a lower income group [31]. Thus a diverse socioeconomic group is required to assess the relation between dental erosion and soft drinks.

5. Conclusion

The result of the study proves that no sex predilection is seen with consumption of soft drinks and dental erosion. Contemporary changes in beverage patterns cause deleterious effects to the dental hard tissues. Soft drinks are a matter of concern to dentists. It is necessary to educate patients about the harmful effects of excessive soft drink consumption and advise them

to choose a low erosive soft drink, such as a non-carbonated soft drink to alleviate dental erosion.

Conflict of interest

No conflict of interest was present between the authors.

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