Original Research Article

Evaluating the association of dietary habits with dental caries and occlusal plaque using visible occlusal plaque index and caries index

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Abstract

Background: Dietary habits are essential in the development of occlusal plaque and, consequently, caries. Several indices are used to measure occlusal plaque. VOPI (Visible Occlusal Plaque) is an important tool for diagnosing and monitoring occlusal plaque. This study aims to find a relationship between dietary habits, occlusal plaque, and dental caries among adolescents in a hospital setting.

Materials and Methods: This hospital-based analytical cross-sectional study was conducted at Dow Dental College, Dow University of Health Sciences. A total of 440 participants were included in this study. A questionnaire regarding their socio-demographic profile, oral hygiene, and dietary habits was administered, and the intra-oral examination comprised of recording plaque and caries scores through the VOPI and caries index. Chi-square tests were performed to compare caries incidence and VOPI between sweet and soft drink consumption groups. The Pearson correlation was used to measure the strength of the relationship between the VOPI and caries severity.

Results: The study provided valuable insights regarding the dietary habits of adolescents. The binary logistic regression resulted in a strong association between sweet consumption and gender. Sweet consumption in candies showed a significant relationship with plaque and caries, however, soft drinks showed an insignificant relationship.

Conclusion: The consumption of sweets at a young age can be associated with the development of dental caries and occlusal plaque. VOPI can be used as an essential diagnostic tool to measure occlusal biofilm. The oral hygiene habits at such an age must be monitored, and periodic dental visits should be considered.

Keywords: Adolescents, Dental caries, Dietary habits, occlusal plaque, Oral hygiene, Visible occlusal plaque index.

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1. Introduction

Caries is a process of demineralization of the hard structures of the tooth, which can lead to cavitated or non-cavitated lesions. Caries has numerous etiological and stimulating factors such as sugar consumption, genetics, brushing habits and plaque. Plaque accumulation is not given much attention in relation to caries as it is more relevant in periodontitis.[1] Plaque is uncalcified deposit attached to the surface of teeth and the oral cavity; the main organic components of plaque is calcium, magnesium, phosphorus, potassium, and sodium. It can cause both periodontal disease and dental decay.[2] Biofilm accumulation is closely related to the progression of caries in the oral cavity. Bacteria in biofilms disturb the ecological environment of the oral cavity.[3] Several indices have been used for measuring plaque.[4] Assessing occlusal caries lesion activity and its' further management is an arduous task,[5] the Visible Occlusal Plaque Index (VOPI) can be used as a helpful tool for determining the extent of plaque biofilm in connection to caries.

Most importantly, occlusal caries initiation has been noted to be very troublesome as it starts progressing as soon as the molars erupt in the oral cavity.[6] Caries lesions are termed active and inactive depending upon the demineralization process.[7] Occlusal surfaces are associated with more aggressive carious lesion activity than proximal surfaces in young adults.[8] Cohort studies have indicated that carious lesion activity measured by VOPI during tooth eruption is associated with increased accumulation of heavy

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and thick plaque due to limited mechanical function and difficult toothbrushing. To evaluate the initiation of this demineralization process, we need to move forward from traditional approaches to contemporary approaches, including validated indices, which provide early information on the activity of carious lesions.

A sugar-rich diet contributes to caries activity; bacteria convert these sugars into acid that demineralizes the enamel and leads to caries progression.[9] In a study by PJ Moynihan, 42 out of 50 students reported a positive association between sugar consumption and dental caries.[10] Another study concluded that caries was predicted by consuming snacks, biofilm accumulation, and brushing habits in older children.[11] The cariogenic and erosive potential of soft drinks has been devastating in recent years as the manufacturing need for fruit drinks and soft drinks continues to increase.[12] If left untreated, dental caries can significantly affect quality of life.[13] The far more concerning consequence of sugar dependency in childhood is following a similar lifestyle in adulthood.[14]

Despite extensive research on caries and plaque, there is a noticeable gap in the literature regarding the interplay between caries progression and plaque accumulation and dietary habits, especially in children and adolescents. Therefore, this study aimed to identify associations between nutritional habits, caries, and plaque among children and adolescents aged 7-15 years. Specifically, this study focused on occlusal plaque in molars and used VOPI to promote its use in clinical settings.

2. Materials and Methods

This was a public hospital-based analytical cross-sectional study. The study was conducted from May 2021 to October 2021 in the outpatient departments (OPDs) of Dow Dental College, Dow University of Health Sciences, Karachi. The study received ethical approval from the Institutional Review Board of Dow University of Health Sciences, Ref: IRB-1994/DUHS/Approval/2021. The sampling was purposive, with the examiners approaching the targeted age group. Each selected participant and their parents were briefed and then asked for written informed consent, after which an adapted questionnaire[1] was administered. They were then taken for a thorough clinical examination, which was performed in under 10-15 minutes. The respondents were then referred for proper diagnosis and treatment of their cavitated lesions and given oral hygiene instructions. All COVID-19 protocols were followed. Their scores were recorded, and there was no follow-up. Our inclusion criteria were children and adolescents aged between 7 and 15 years who were willing to consent and had no chronic medical illness. The exclusion criteria were fractured or filled molars, uncooperative participants, and children with any serious medical/mental conditions.

2.1. Recording of data

The VOPI was recorded on the following established criteria: 0) no visible plaque identified when carefully running a dental probe on the groove-fossa-system, 1) thin plaque: hardly detectable plaque that is restricted to the groove-fossa system and identified by carefully running a dental probe on the groove-fossa-system, 2) thick plaque: easily detectable plaque on the groove-fossa-system identifiable with the naked eye, and 3) heavy plaque: occlusal surfaces partially or covered with heavy plaque accumulation identifiable with the naked eye. The caries status was classified according to Carvalho et al.[1] into 1) sound site/surface, 2) site/surface with inactive lesion, 3) site/surface with an active non cavitated lesion, and 4) site/ surface with an active cavitated lesion. The mean occlusal plaque score was classified as 0–1 or 2–3.

2.2. Statistical analysis

The data were entered on SPSS Version 25.0 (IBM, Chicago, IL, USA). Descriptive statistics such as frequency and percentages were reported for demographic data, oral hygiene, and dietary habits. Chi-square tests were performed to compare caries incidence and VOPI between sweet and soft drink consumption groups. The Pearson correlation was used to measure the strength of the relationship between the VOPI and caries severity. The level of significance was set at less than 0.05. Finally, binary logistic regression was conducted to determine the status of caries and associated factors.

3. Results

This study included 440 participants, the only ones who consented to participate. Among these, 56.4% (n=248) were male and 43.6% (n=192) were female. The age groups were divided into 7-10 (n=289) and 11-14 (n=151) as shown in **Table 1**. Almost all of the participants brushed their teeth apart from the 6 participants. Only 2 participants used a toothbrush alone for cleaning, and the remaining used toothbrush with toothpaste. None of the participants (100%) used dental floss. Soft drinks were consumed "Often" by 68.8% (n=132) females and 62.9% (n=156) males. Furthermore, 93.8% (n=180) of females and 98.4% (n=244) of males did not take energy drinks. The participants' answers reflecting their oral hygiene habits are shown in **Table 2**.

Table 1: Socio-demographic data of the participants

Age		N	%
Mean /SD	9.68 + 2.09		
7-10		289	65.7%
11-14		151	34.3%
Gender			
Male		248	56.4%
Female		192	43.6%

Table 2: The oral hygiene and dietary habits of the participants

Question statements		Gender			
		Female		**Male**	
		Count	Column N %	Count	Column N %
Do you brush your teeth?	Yes	190	99.0%	242	97.6%
How many times do you brush your teeth?	once a day	115	59.9%	137	55.2%
	twice a day	77	40.1%	111	44.8%
How do you clean your teeth?	toothbrush and toothpaste	190	99.0%	247	99.6%
	toothbrush alone	2	1	1	0.4
What kind of toothpaste do you use?	Medicated	38	19.8%	70	28.2%
	Fluoridated	146	76.0%	174	70.2%
	Whitening	4	2.1%	0	0.0%
Do you brush your teeth after 30 minutes of sweet consumption?	Yes	4	2.1%	16	6.5%
	No	188	97.9%	232	93.5%
How often do you use dental floss?	No	192	100.0%	248	100.0%
Do you consume soft drinks?	Often	132	68.8%	156	62.9%
	Rarely	40	20.8%	60	24.2%
	Never	20	10.4%	32	12.9%
How often or rarely?	*Once a day*	*20*	*10.4%*	*24*	*9.7%*
	2-3 times a day	*20*	*10.4%*	*40*	*16.1%*
	2-3 times a week	*76*	*39.6%*	*88*	*35.5%*
	Less than once a week	*32*	*16.7%*	*36*	*14.5%*
Do you consume fruit juices?	Often	144	75.0%	156	62.9%
	Rarely	40	20.8%	72	29.0%
How often or rarely?	Never	8	4.2%	20	8.1%
	Once a day	*24*	*12.5%*	*28*	*11.3%*
	2-3 times a day	*36*	*18.8%*	*44*	*17.7%*
	2-3 times a week	*72*	*37.5%*	*104*	*41.9%*
	once a week	*0*	*0.0%*	*4*	*1.6%*
	Nil	*8*	*4.2%*	*16*	*6.5%*
Do you consume energy drinks?	Often	8	4.2%	0	0.0%
	Rarely	4	2.1%	4	1.6%
	Never	180	93.8%	244	98.4%
How often or rarely?	2-3 times a day	8	4.2%	0	0.0%
	less than once a week	4	2.1%	0	0.0%
	Nil	180	93.8%	244	98.4%
Do you consume sweets?	Often	164	85.4%	204	82.3%
	Rarely	28	14.6%	40	16.1%
	Never	0	0.0%	4	1.6%
How often or rare is your sweet consumption?	*Once a day*	*28*	*14.6%*	*20*	*8.1%*
	2-3 times a day	*116*	*60.4%*	*152*	*61.3%*
	once a week	*20*	*10.4%*	*8*	*3.2%*
	2-3 times a week	*24*	*12.5%*	*64*	*25.8%*
	More than 3 times a week	*4*	*2.1%*	*0*	*0.0%*
What kind of sweets do you consume?					
	Candies	4	2.1%	8	3.2%
	Chocolates	4	2.1%	12	4.8%
	Mithai	0	0.0%	4	1.6%
	Biscuits	4	2.1%	4	1.6%
	all of the above	180	93.8%	216	87.1%

Table 3: Comparison of caries status and VOPI with sweets and soft drink consumption

			Sweet_Consumption		Total	Soft-Drink		Total
			Everyday	Sometimes		Everyday	Sometimes	
Caries status	Sound	N	148	52	200	51	149	200
		%	46.3%	43.3%	45.5%	49.5%	44.2%	45.5%
	Inactive lesion	N	8	8	16	1	15	16
		%	2.5%	6.7%	3.6%	1.0%	4.5%	3.6%
	Active non-cavitated lesion	N	60	16	76	22	54	76
		%	18.8%	13.3%	17.3%	21.4%	16.0%	17.3%
	Active cavitated	N	104	44	148	29	119	148
		%	32.5%	36.7%	33.6%	28.2%	35.3%	33.6%
	P-value		0.099			0.132		
VOPI	No visible plaque	N	108	60	168	35	133	168
		%	33.8%	50.0%	38.2%	34.0%	39.5%	38.2%
	Thin plaque	N	164	56	220	50	170	220
		%	51.3%	46.7%	50.0%	48.5%	50.4%	50.0%
	Thick plaque	N	48	4	52	18	34	52
		%	15.0%	3.3%	11.8%	17.5%	10.1%	11.8%
	p-value		0.000			0.115		

Table 4: Correlation of VOPI with caries status

		VOPI_criteria	Caries_status
VOPI_criteria	Pearson Correlation	1	.158**
	Sig. (2-tailed)		.001
	N	440	440
caries_status	Pearson Correlation	.158**	1
	Sig. (2-tailed)	.001	
	N	440	440
**. Correlation is significant at the 0.01 level (2-tailed).			

Table 5: Binary logistic regression analysis showing risk factors for caries status

				95% C.I. for EXP(B)	
		Sig.	AOR	Lower	Upper
Variables	Do you brush teeth	.176	.325	.064	1.654
	Sweet consumption	.030	1.637	1.049	2.555
	Gender	.074	.704	.479	1.034
	Age	.286	1.236	.837	1.825
	Constant	.444	1.917		
Model Summary					
Step	-2 Log likelihood	Cox & Snell R Square		Nagelkerke R Square	
1	594.831ᵃ	.029		.038	
a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.					

Examining sweet consumption and caries, 46.3% (n=148) of participants who consumed sweets "every day" exhibited sound teeth, whereas 32.5% (n=104) participants who consumed sweets "every day" showed active cavitated lesions. On the other hand, 36.7% (n=44) of participants who reported sweet consumption "sometimes" showed active cavitated lesions. Comparison of sweet consumption with caries status showed a significant statistical difference (0.099), **Table 3**.

A comparison of sweet food consumption with VOPI criteria also revealed a significant difference (0.000), **Table**

3. Thin plaque was present in 51.3% (n=164) and thick plaque in 15.0% (n=48) of the participants who consumed sweets "every day." There was thick plaque in 3.3% (n=4) of the participants who "sometimes" consumed sweets.

Regarding soft drink consumption and VOPI status, 48.5% (n=50) of the participants had thin plaque, and 17.5% (n=18) had thick plaque among those who drank soft drinks "every day." Meanwhile, 50.4% (n=170) of the participants had thin plaque, and 39.5% (n=133) had no visible plaque among those who drank soft drinks "sometimes." The difference was not significant (0.115) when soft drink consumption and VOPI criteria were compared, **Table 3**.

The comparison of soft drink consumption with caries status also led to no difference (0.132), **Table 3**. Active cavitated lesions were present in 28.2% (n=29) of the participants who consumed soft drinks "every day", whereas they constituted 49.5% (n=51) sound teeth. A total of 44.2% (n=149) of the participants had sound teeth while drinking soft drinks only "sometimes." Moreover, 35.3% (n=119) of the participants had active cavitated lesions, and they "sometimes" consumed soft drinks.

A binary logistic regression model was utilized to quantify and assess the effects of dependent and independent variables, **Table 5**. The factors most strongly associated with caries were sweet food consumption and gender (AOR=1.637 and AOR=0.704, respectively). The model explained 38% (Nagelkerke R) of the variance in caries status and correctly classified all cases.

4. Discussion

The results of this study focused on the associations between dietary habits, plaque, and caries in children and adolescents. The caries index used in this study was adapted from another study that concentrated on occlusal caries and plaque and proposed these criteria for caries measurement.[1] We used VOPI as a plaque measurement index, and no other established indices.[15] The VOPI appears to be the only index that relates occlusal plaque to caries lesion activity.[1] We aimed to emphasize the importance of obtaining dental decay data among this age group, particularly in low- and middle-income countries. As the developed world has, to a certain extent, taken control of dental decay, socioeconomic disparities are only ever increasing.[16,17] Dietary habits play an essential role in the development and progression of dental caries. Almost all of our participants (99%) brushed their teeth, which is more than the percentage (96%) in a study conducted in Sudan.[18] 42.73% of participants achieved brushing twice a day, which is less than that reported in a study conducted in Bangladesh (62.8%).[19] The frequency of brushing twice a day was greater in males (44%) than females (40%), which contradicts the findings of a study in Iran in which female students were predominant in this practice—brushing teeth 30 minutes after sweet consumption was performed by only 8.6% of students, which shows a lack of

awareness regarding the stickiness of sweets and how damaging it is to let them remain on the tooth surface. All of our participants ignored flossing, and most of them did not even know what a floss was or looked like; this result is in concordance with a study in Portugal.[20] We believe that this is because of a lack of awareness regarding the protective effect of dental floss.

A total of 65.4% of participants with a male predominance consumed soft drinks, which is opposite to the female predominance in a study conducted in Iran, where soft drinks were consumed by 25.6%. Most participants did not consume[21] energy drinks; this could be due to the high price of energy drinks as the study participants were from low socioeconomic backgrounds. The relationship between socioeconomic status and processed foods can be seen in a Korean longitudinal survey.[22] Soft drink consumption has increased exponentially in the last 50 years, with children and young adults serving as the primary consumer base.[23] However, in our study, soft drink consumption was not significantly related to caries or plaque; thin and thick plaques were more common in children who drank cold drinks sometimes than in those who drank beverages every day. We believe this difference could be due to recall bias, as various studies have shown that children who consume cold drinks are 1.8 times more prone to dental caries than those who drink milk.[24-27]

Most participants who consumed sweets were male, opposite to the female majority in the Iranian study.[21] Our participants consumed sugar at least 2-3 times a day, and we found a significant relationship (0.099) between sweet food consumption and caries. This is similar to the findings of a study conducted in Romania, where frequent sugar consumption was related to a high DMFT (decayed, missing due to caries, filled teeth) score.[28] Nevertheless, this finding is the opposite of a study conducted in the Philippines, where no relationship between sugar consumption and caries was established.[29] In a Guinean study, those with high DMFT scores also had increased consumption of candies among the other associated risk factors.[30] Sweet consumption also exhibited a significant difference (0.000) with the VOPI criteria, as the sugar substance sucrose, in particular, is known to adhere to the tooth's surface and promote plaque adherence.[31] A study conducted among adolescents measured plaque through the full mouth visible plaque index (FMPI) with sugar intake. It has a positive relationship with periodontal disease.[32] Similarly, sugar products have been correlated with higher mean plaque scores in other studies.[33,34] We could not find any study that related the VOPI to sugar intake.

We assessed the relationship between caries and VOPI, and found a weak positive relationship, which negated our hypothesis of a strong relationship. There could be many reasons for this: recall bias, participants brushing their teeth before dental visits, confounding variables, cross-sectional

data, or the fact that we found a significant number of highly cavitated lesions and could not visualize any plaque biofilms on the lesions. We believe this index is essential for recording the progression of dental caries, as highlighted in a study by Carvalho et al.[1] A larger sample size with a longitudinal or experimental research design could lead to a strong positive relationship. According to the binary logistic regression, sugar was one of the factors most strongly associated with caries; this finding is consistent with the findings of the studies conducted in China and Ethiopia.[35-37] Gender was the other factor strongly associated with caries; this finding is unlike that of the study conducted in China, where female participants had a significant association with caries;[37] however, in other Chinese individuals, male students had a stronger association with caries.[35] It should be noted that the relationship between gender and caries may vary depending on geographical location and context, but the association between sugar and caries has been determined and found to be consistent.

The limitation of our study is its cross-sectional nature, which prevented us from interpreting any direct causal relationships. The other limitation was recall bias, resulting in highly cavitated lesions and thick plaque variation. The one-time patient interaction also prevented us from assessing the exact condition of the oral biofilm. All these factors can be addressed in future studies to yield more positive results.

5. Conclusion

Sugar consumption in the form of sweets is significantly related to the presence of dental caries and plaque biofilms among children and adolescents. Oral hygiene habits such as flossing and frequent brushing should be stressed at this age, as inefficient childhood habits lead to problems in adult life. Our study revealed that the frequency of soft drinks and fruit juices is alarming and a risk factor for future dental decay. The routine use of VOPI as a plaque-measuring index in OPDs must be explored further. Oral health care programs focusing on the relationships among dietary habits, plaque, and caries should be devised and tailored to the needs of low socioeconomic groups in the country.

6. List of Abbreviations

DMFT: Decayed, missing due to caries, filled teeth; FMPI: Full mouth visible plaque index; OPDs: Outpatient departments; VOPI: Visible occlusal plaque index.

7. Ethics Approval and Consent to Participate

The study was performed in accordance with the Declaration of Helsinki. Ethical permission was taken from Institutional Review Board of Dow University of Health Sciences, Ref: IRB-1994/DUHS/Approval/2021. Written consent was obtained from all participants and their parents before administering the questionnaire. All protocols were carried out in accordance with university guidelines and regulations.

8. Consent for Publication

Not Applicable

9. Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on request.

10. Source of Funding

11. Conflict of Interest

The authors declare that they have no competing interests.

12. Acknowledgements

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