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CUMULATIVE DIETARY CARIOGENICITY AND DENTAL CARIES IN ADULTS

YETİŞKİNLERDE KÜMÜLATİF DİYET KARYOJENİTESİ VE DİŞ ÇÜRÜKLERİ

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ABSTRACT

Objective: This study was conducted to determine the total cariogenic load of diet and its effect on dental caries in adults.

Method: Patients aged 19-65 years (n=506) who applied for dental treatment were included in the study. A questionnaire including sociodemographic characteristics, a food consumption frequency questionnaire, and a decayed, missing, filled teeth (DMFT) index calculation were used to collect the data. The data were evaluated using SPSS (Statistical Package for Social Sciences) and Jamovi 2.3 package program and the level of significance was accepted as $p<0.05$. Mann Whitney U, Kruskal Wallis H, One-Way ANOVA, Spearman Correlation, Linear Regression, and Mediator Analysis tests were used to analyze the data.

Results: In our study, the DMFT index score increased with increasing age, and the total cariogenic diet score increased as the education level decreased. There was a weak statistically significant positive correlation between the DMFT index scores and the total cariogenic diet score. It has been shown that an increase of 1 unit in the total cariogenic diet score causes an increase of 0.011 units in the DMFT index. In addition, it was found that the cariogenic diet had a positive mediator effect of 3.91% on the DMFT index.

Conclusion: It is important to determine the cariogenic properties of the diet and to reduce the total cariogenic load of the diet in preventing dental caries and protecting oral and dental health in adults. For this reason, it may be more beneficial to evaluate the diet as a holistic and develop nutritional recommendations to reduce the risk of caries.

Key Words: Cariogenic Diet, Dental Caries, Oral Health

ÖZ

Amaç: Bu çalışma, yetişkinlerde diyetin toplam karyojenik yükünün belirlenmesi ve diş çürükleri üzerine etkisinin belirlenmesi amacıyla yapılmıştır.

Yöntem: Araştırmaya diş tedavisi için başvuran 19-65 yaş aralığındaki yetişkin hastalar (n=506) dâhil edildi. Verilerin toplanmasında sosyodemografik özellikler, besin tüketim sıklığı anketi ve çürük, eksik, dolgulu, diş (DMFT) indeks hesaplanmasını içeren anket formu kullanıldı. Veriler SPSS (Statistical Package for Social Sciences) ve Jamovi 2.3 paket programı kullanılarak değerlendirildi ve anlamlılık düzeyi $p<0.05$ olarak kabul edildi. Verilerin analizinde Mann Whitney U, Kruskal Wallis H, One-Way ANOVA, Spearman Korelasyon, Lineer Regresyon ve Mediatör Analiz testleri kullanıldı.

Bulgular: Çalışmamızda yaş arttıkça DMFT indeksi puanı arttı, eğitim düzeyi azaldıkça toplam karyojenik diyet skoru arttı. DMFT indeksi puanları ile toplam karyojenik diyet skoru arasında pozitif yönde zayıf istatistiksel olarak anlamlı korelasyon bulundu. Toplam karyojenik diyet skorundaki 1 birimlik artışın DMFT indeksinde 0.011 birimlik artışa neden olduğu gösterildi. Aynı zamanda karyojenik diyetin DMFT indeksi üzerinde %3.91 oranında pozitif mediatör etkisi olduğu bulundu.

Sonuç: Yetişkinlerde diş çürüklerinin önlenmesi ve ağız ve diş sağlığının korunmasında diyetin karyojenik özelliklerinin belirlenmesi ve diyetin toplam karyojenik yükünün azaltılması önemlidir. Bu sebeple çürük riskini azaltmak için diyetin bütünsel olarak değerlendirilmesi ve beslenme önerileri geliştirilmesi daha yararlı olabilir.

Anahtar Kelimeler: Karyojenik Diyet, Diş Çürükleri, Ağız Sağlığı

INTRODUCTION

Dental caries is an oral infectious disease caused by organic acids produced via the metabolism of dietary fermentable carbohydrates by biofilm bacteria, demineralization of tooth enamel, and subsequent proteolytic degradation of tooth structure [1,2]. Pathological factors such as frequent consumption of simple carbohydrates, insufficient fluoride intake, poor oral hygiene, and salivary dysfunction increase demineralization. On the other hand, factors such as a healthy diet, brushing twice a day with fluoride toothpaste and dental sealants increase remineralization and contribute to the prevention of dental caries. Demineralization and remineralization continue in cycles during the day, and if demineralization becomes dominant, dental caries occurs [1]. Dental caries is a dynamic process involving susceptible tooth surfaces, cariogenic bacteria, particularly Streptococcus mutans, and a source of fermentable carbohydrates. Diet is one of the most important modifiable factors that contribute to the development of caries. Prolonged and frequent exposure of teeth to fermentable carbohydrates, especially sugars, creates an acidic plaque environment that promotes the demineralization of tooth enamel and causes tooth decay. Simple carbohydrates are defined as all monosaccharides and disaccharides added to foods and found naturally in honey, syrups, juices, and juice concentrates [3]. Sucrose, which is a disaccharide, is the most widely consumed and the most cariogenic type among simple carbohydrates. It is considered the most suitable

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dietary factor for the development of dental caries, which is one of the global health problems [4]. Therefore, limiting sugar consumption is an important strategy to prevent dental caries, and the World Health Organization (WHO) recommends reducing sugar intake to 10% or even 5% of daily energy intake [3].

The cariogenicity of a food or beverage is determined by physical properties such as processing and refining, acidic properties, the type and content of carbohydrates, and the presence of protective factors such as calcium, phosphate, and casein.

In addition to these features, the amount, time, and frequency of consumption, eating pattern, and combination of foods (e.g. consuming cariogenic foods together with anticariogenic foods) are also important [5]. Nutrients are basically divided into 3 categories in terms of cariogenicity [2];

i. Anticariogenic: Foods that contain casein, calcium, and phosphate and prevent plaque.

ii. Cariostatic: Foods that are not metabolized by microorganisms, do not cause a decrease in saliva pH of 5.5 or less within 30 minutes after consumption, and do not contribute to the decay process.

iii. Cariogenic: Contains fermentable carbohydrates that can stimulate the decay process by lowering the pH of saliva to 5.5 or below as a result of fermentation by oral microbiota.

Studies examining the relationship between dental health and nutrition mostly only examined the cariogenic content of the diet and the frequency of cariogenic foods consumption. The missing point of these studies is that the cariostatic and anticariogenic food consumption of the diet is ignored. In this study, we aimed to evaluate the diets of adult individuals in terms of cariogenicity and to correlate them with dental caries indices.

METHOD

In this cross-sectional study, the effects of cariogenic, cariostatic, and anticariogenic food consumption frequencies on oral and dental health in adults were investigated.

The sample of the study consisted of adult individuals between the ages of 19-65 who applied to the Cukurova University Faculty of Dentistry. Pregnant and lactating women, those who use drugs that affect appetite (antidepressants, metformin, etc.), those who have a psychiatric illness, and/or those who receive eating behavior therapy were excluded from the study. Research data were collected face-to-face between May-July 2023. The sample size was calculated as a minimum of 490 individuals in the G*Power program with α=0.05 and a power of 90% [6].

Data Collection Tools

In the study, a questionnaire consisting of four parts was used as a data collection tool. These; i) sociodemographic characteristics, ii) information on nutritional habits, iii) information on oral and dental health habits, iv) food consumption frequency questionnaire, and v) decayed, missing, filled teeth (DMFT) index calculation. In the section about eating habits, the frequency of main and snack meals, skipping meals, and the foods and beverages they prefer to consume for snacks were questioned.

Cariogenic Diet Score: A food consumption frequency questionnaire consisting of 46 foods was applied to all participants. In this questionnaire, foods were classified into 6 categories: anticariogenic, cariostatic, low cariogenic, moderate cariogenic, highly cariogenic, and severe cariogenic [5]. According to the cariogenic levels of the foods, the coefficients were determined as 0 for anticariogenic and cariostatic foods, 1 for low cariogenic, 2 for medium cariogenic, 3 for high cariogenic, and 4 for severe cariogenic foods (Table 1) [7]. The frequency of consumption of these foods (never, 1 in a month, once in 15 days, 1-2 times in a week, 3-4 times in a week, 5-6 times in a week, every day) was questioned and each of them ranged from 0 (never) to 6 (every day), respectively. value has been assigned.

The cariogenic scores of the participants were found by multiplying the coefficients of each food according to the cariogenic levels with the coefficients of consumption frequency and adding the values calculated for 46 foods. For example, when chocolate with a cariogenicity score of 4 (severe cariogenic) is consumed 3-4 times a week, the consumption frequency coefficient is multiplied by 4. A total cariogenicity score between 0 and 510 was obtained for each participant by summing the scores of all foods and beverages.

Table 1. Classification of foods according to their cariogenicity and applied coefficients

Cariogenicity classification/ Coefficient	Foods	Cariogenicity classification/ Coefficient	Foods
Anti-cariogenic/0	Whole milk Semi-skimmed milk Skimmed milk Cheese	**Moderate cariogenic/2**	Banana Cornflakes White bread and its varieties Whole wheat/whole grain bread Other types of bread Simit Ice cream Stewed fruit Sugar added milk
Cariostatic/0	Egg Oily seeds Red meat Chicken Fish Unsweetened tea Unsweetened coffee Unsweetened herbal tea	**High cariogenic/3**	Chips Sugar in tea, coffee or other beverages Fresh juice Instant juice Coke Sports drinks Energy drink
Low cariogenic/1	Apple, pear, quince Mandarin, orange, grapefruit, lemon Strawberry, blackberry, grape, pomegranate Other fruits Popcorn Potatoes Vegetables Rice Pasta Bulgur	**Severe cariogenic/4**	Dried fruits Pudding Jam Honey Chocolate Spread, Hazelnut/Peanut Butter Sticky candy, hard candy, bonbon etc. Chocolate, chocolate bars and waffles Biscuits, cookies, cakes

DMFT Index: The DMFT index, which is widely used in dental caries epidemiology, measures the level of dental caries over the lifetime. It is obtained by adding up the number of caries (D: decayed), missing (M: missing), and filled (F: filled) teeth in the permanent dentition. The DMFT index takes a value between 0-28 or 0-32, depending on whether third molars are included in the evaluation [8].

Ethical Approval

Ethics committee approval was obtained from the Çukurova University Faculty of Medicine Non-Interventional Clinical Research Ethics Committee with decision number 51 on 05.05.2023. In addition, written Informed Consent was obtained from all participants participating in the study.

Statistical Analysis

All statistical analyses, IBM SPSS Statistics Version 25.0 (IBM, Armonk, NY, USA) and Jamovi 2.3 [9]. The Kolmogorov-Smirnov test was used to check whether the quantitative data fit the normal distribution, and non-parametric tests were used in the analysis of the data that did not fit the normal distribution. For descriptive analysis, median (interquartile range) and percentile values were given. Mann Whitney U, Kruskal Wallis H, Spearman Correlation, Linear Regression, and Mediator Analysis tests were used in the analysis of the data. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 506 adults, 176 (34.8%) male and 330 (65.2%) female, with a mean age of 36±13.3, were included in the study. The DMFT scores of the participants were compared in Table 2 according to their sociodemographic characteristics, nutritional and oral care habits.

While there was no difference between the genders in terms of DMFT scores, the DMFT score increased with increasing age. Individuals aged 18-25 and 26-35 had lower DMFT scores than individuals aged 36-45 and over 45 years old. There is no difference in DMFT scores between individuals aged 18-25 and 26-35, and individuals aged 36-45 and over 45 years old.

Considering their educational status, lower DMFT scores were observed in high school or university graduates compared to illiterate, primary, and secondary school graduates. Married people had higher DMFT scores than singles and those without additional chronic diseases. While there was no difference in DMFT scores in terms of smoking, those who did not drink alcohol had higher DMFT scores. There was no relationship between the frequency of having main and snack meals and DMFT scores, but those who skipped evening meals had higher DMFT scores than those who skipped breakfast.

A lower DMFT score was observed in those who did not brush their teeth regularly once or twice a day, and those who flossed compared to those who did not brush their teeth regularly. The total cariogenic score was statistically lower in individuals over 45 years of age compared to other age groups. A higher total cariogenic score was found in secondary school graduates than in university graduates. Being married, having an additional chronic disease and not drinking alcohol were associated with a lower total cariogenic score. It was observed that the total cariogenic score was higher in those who consumed the main meals 3 times compared to the other groups, and those who consumed the snacks twice a day compared to those who consumed the snacks once.

The total cariogenic score was statistically significantly lower in those who skipped meals compared to the other two groups (Table 2).

Table 3 shows that when the relationship between DMFT scores and total scores from low, medium, high, and severe cariogenic foods and total cariogenic score is examined, there is a positive but weak correlation between DMFT index scores and total scores from high cariogenic foods and total cariogenic score. Since the DMFT score increases with increasing age, when the age factor is corrected, there is a weak and positive correlation between the DMFT index scores and the total score obtained from high cariogenic foods and the total cariogenic score.

Table 2. The DMFT index and total cariogenic scores of the participants according to their sociodemographic characteristics, nutritional and oral care habits

Variables		DMFT index score	p	Total cariogenic score	p
Age	18-25	6 (6)	**<0.001**[a]	189.7±55.8	**< 0.001**[c]
	26-35	8 (6)		185±58.7	
	36-45	11 (7)		180.4±49.7	
	45+	13 (8)		163.7±48.4	
Gender	Female	9 (7)	0.459[b]	174 (70)	0.230[b]
	Male	9 (8)		179 (83)	
Educational status	Illiterate	13 (12)	**< 0.001**[a]	179.5 (64)	**< 0.001**[a]
	Primary school	12 (9)		153 (53)	
	Middle school	11 (9)		199.5 (80)	
	High school	9 (7)		179 (76)	
	University	8 (7)		166 (72)	
Marital status	Married	11 (9)	**< 0.001**[b]	170 (69)	**0.018**[b]
	Single	7 (7)		183.5 (81)	
Chronic disease	Yes	11 (8)	**<0.001**[b]	165 (67)	**0.003**[b]
	No	9 (8)		178.5 (78)	
Smoking	Currently smoking	9 (8)	0.101[a]	175 (72)	0.939[a]
	Never smoked	9 (7)		177 (75)	
	Ex-smoking	12.5 (7)		170.5 (92)	
Alcohol	Yes	8 (8)	**0.020**[b]	184 (81)	**0.030**[b]
	No	10 (8)		172 (73)	
Main meal frequency	1	8 (10)	0.316[a]	140 (60)	**< 0.001**[a]
	2	9 (7)		162 (71)	
	3	9 (8)		184 (73)	
Frequency of snacks	0	9 (8)	0.091[a]	177.5 (108)	**0.005**[a]
	1	9 (7)		165 (70)	
	2	10 (8)		183 (64)	
	3+	8 (6)		180.5 (90)	
Skipping meals	No	10 (8)	0.050[a]	181 (79)	**0.005**[a]
	Sometimes	10 (8)		183 (68)	
	Yes	8 (7)		155.5 (68)	
Which meal are you most likely to skip?	Breakfast	8 (7)	**0.022**[a]	182.3±50.8	0.298[c]
	Lunch	10 (10)		174.4±52.8	
	Dinner	12 (8)		174.2±58.6	
Regular tooth brushing	No	13 (12)	**<0.001**[a]	145 (70)	0.152[a]
	1 per day	10 (8)		169 (60)	
	2 per day	8 (6)		176 (76)	
Regular use of dental floss	No	10 (8)	**0.003**[b]	172 (71)	0.114[b]
	Yes	8 (7)		169 (76)	

[a]Kruskal-Wallis H Test, [b]Mann-Whitney U Test, [c]One-Way ANOVA

Table 3. Age-controlled partial correlation between DMFT index and cariogenic score (Spearman's rho)

	DMFT index	LC	MC	HC	SC	TC
DMFT index	-					
LC	0.033	-				
MC	0.006	0.419***	-			
HC	0.162***	0.214***	0.329***	-		
SC	0.080	0.411***	0.428***	0.499***	-	
TC	0.113*	0.509***	0.626***	0.751***	0.896***	-

*LC: Low carioscore, MC: Moderate carioscore, HC: High carioscore, SC: Severe carioscore, TC: Total carioscore, Controlling for 'age'. H_a is positive correlation, *p<.05, **p<.01, ***p<.001, one-tailed*

In the linear regression model (ANOVA p<0.001, adjusted R2=0.190) it was found that a one-unit increase in the total cariogenic diet score caused an increase of 0.011 units in the DMFT index, and each unit increase in age caused an increase of 0.206 units (Table 4).

Table 4. Linear regression analysis of the effects of total cariogenic score and age on the DMFT index

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	0.804	1.198		0.671	0.503		
Total carioscore	0.011	0.005	0.093	2.265	0.024	0.961	1.041
Age	0.206	0.019	0.449	10.990	0.000	0.961	1.041

In mediation analysis with cariogenic diet, age, and DMFT index, it was found that the cariogenic diet had a mediator effect on the DMFT index. Cariogenic diet is indirectly effective and the mediation percentage is 3.91%.

Age had a negative effect on the cariogenic diet and a positive effect on the DMFT index, while the cariogenic diet had a positive effect on the DMFT index (Table 5).

Table 5. The mediation analysis of the effect of cariogenic score and age on the DMFT index

				95% Confidence Interval				
Effect	**Label**	**Estimate**	**SE**	**Lower**	**Upper**	**Z**	**p**	**% Mediation**
Indirect	a × b	-0.00839	0.00413	-0.0165	-2.95	-2.03	0.042	3.91
Direct	c	0.20582	0.01867	0.1692	0.242	11.02	<0.001	96.09
Total	c + a × b	0.19744	0.01840	0.1614	0.233	10.73	<0.001	100.00

DISCUSSION

The World Health Organization (WHO) pointed out that the high prevalence of oral diseases is an important public health problem due to its high economic costs and its association with chronic diseases such as cardiovascular disease, diabetes, and cancer [10]. Numerous cross-sectional studies in Turkey have revealed poor oral and dental health in adults [11-14]. However, no study has been conducted on the relationship between the total cariogenic score of the diet and dental caries in Turkish adults. In this cross-sectional study, it was found that the increase in the cariogenicity of the diet in adults aged 19-65 years increased the DMFT index score. We investigated the cumulative cariogenic load of the diet by considering the cariogenic contributions of all foods, rather than the consumption of individual foods. A recent study found that foods high in sugar were associated with caries prevalence and severity, but this association was more evident in the context of general dietary patterns [15]. The authors reported an association between DMFT and dietary patterns that included sugar-sweetened beverages and sandwiches in adults over 30 years of age in the United States [15].

Since the DMFT index, which is used especially in epidemiological studies as an indicator of dental caries experience, includes lifetime experience, it is natural that the DMFT index score increases with age [16]. In our study, a statistically significant increase was observed in DMFT scores with increasing age, but it was found that the total cariogenic score decreased (Table 2). Studies have shown that both oral and dental health care and diet quality are closely related to education and socioeconomic level [17-19]. Individuals with higher income and education levels had a higher healthy eating index and a higher probability of going to the dentist [18]. Similarly, in our study, both the DMFT index score and the total cariogenic score decreased as the education level increased (Table 2).

Different mechanisms have been proposed that explain the relationship between oral and dental health and systemic diseases, such as infection by oral bacteria causing systemic damage by entering the circulation, and low-grade inflammation being involved in the development of other chronic diseases [20]. On the other hand, it is possible to have oral and dental health problems and chronic diseases as comorbidities due to common risk factors such as smoking, alcohol, and malnutrition [21,22]. In this study, the DMFT index was higher in patients with chronic disease (type 2 diabetes, hypertension, hyperlipidemia, etc.), while cariogenic diet scores were found to be lower (Table 2). This finding may be due to the possibility that individuals with chronic diseases tend to prefer healthier food choices due to medical diet therapy. Individuals who consume alcohol have lower DMFT index scores, while cariogenic diet scores are higher. This finding may be due to the higher age of those who declared that they did not drink alcohol. There are conflicting results in the literature, such as low-dose alcohol consumption may be protective in terms of oral and dental health [22,23], on the other hand, it may cause the progression of periodontal diseases [24].

By performing partial correlation analysis, we found that there is a statistically significant positive weak correlation between the DMFT index and total cariogenic score (Table 3). Our linear regression analysis found that an increase in the cariogenicity of the diet was associated with an increase in the DMFT index score (Table 4). A similar relationship was observed between age and DMFT index score. Also, our findings revealed that the cariogenic diet had an indirect positive effect on the DMFT index score (Table 5). This relationship is consistent with the evidence showing the determinant role of a diet with a high cariogenic content on dental caries [25].

Limitations

Studies examining the relationship between dental health and nutrition have mostly focused on the consumption of certain cariogenic foods. To the best of our knowledge, this is the first study in Turkey to evaluate the relationship between the total dietary cariogenic scores and dental caries, according to the cariogenic classification of foods in adults. There were also some limitations of our study. First of all, since it is a cross-sectional study, a strong cause-effect relationship could not

be established. In addition, some confounding factors may have been overlooked in our analysis. Therefore, our findings need to be confirmed by prospective cohort studies.

CONCLUSION

In our study, the total cariogenic load of the diet is associated with the dental caries index in adults. Therefore, in order to reduce the risk of caries, the dietary pattern should be evaluated and holistic nutrition recommendations should be developed instead of focusing on individual foods or nutrients.

Ethical Approval: *2023/51 Çukurova University Faculty of Medicine Non-Interventional Clinical Research Ethics Committee*

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