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THE IMPACT OF ARTIFICIAL SWEETENERS AND SUGARS AS A POSSIBLE RISK FACTOR FOR INCREASED DMFT INDEX IN CHILDREN WITH MIXED DENTITION

ВЛИЈАНИЕТО НА ВЕШТАЧКИТЕ ЗАСЛАДУВАЧИ И ШЕЌЕРИ КАКО МОЖЕН РИЗИК ФАКТОР ЗА ЗГОЛЕМЕН КЕП ИНДЕКС КАЈ ДЕЦА СО МЕШОВИТА ДЕНТИЦИЈА

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Abstract

Introduction: A diet rich in sugars and artificial sweeteners has always been the subject of research in determining the factors that directly influence the occurrence of caries from a young age, mainly due to the connection with increased acid production in the mouth as a result of prolonged presence of sugars that directly affect the demineralization of tooth enamel. **Aim:** The aim of this study is to determine the state of oral health by determining sugars as a possible risk factor for the occurrence of caries. **Material and methods:** The research included a total of 80 children, aged 9, randomly selected from two primary schools in Skopje, Municipality of Centar (Primary Schools "KiroGligorov" and "Kocho Racin"), of which 37 were girls and 43 were boys. **Results:** The results we obtained regarding DMFT in deciduous dentition were 2.6, which, according to WHO, is in the medium DMFT index in relation to the results of the use of products enriched with artificial sweeteners. t Start=7.9356 and p<0.01 confirms sugar as a possible risk factor for the occurrence of an increased DMFT index. The results we obtained for the DMFT in permanent dentition are 0.58, which, according to WHO, is considered a low DMFT index in relation to artificial sweeteners t Start=0.62131 and p<0.01. The result shows that the short-term presence of permanent dentition and the duration of exposure to carbohydrates represent a reduced risk for an increased DMFT index in the stomatognathic system. **Conclusion:** Daily education of children in order to improve their oral hygiene habits and proper and balanced nutrition would contribute to better results in the dmft/DMFT values. Health education and motivation as a multidisciplinary approach among dentists, teachers, children, and parents should be a basic imperative as the most important preventive measure. Introducing appropriate controls for the availability of sugars and similar sweeteners in any form near schools will significantly reduce the risk factor - sugar and caries incidence. **Keywords:** sugar, dental caries, dmft/DMFT index.

Апстракт

Вовед: Исхраната богата со шеќери и вештачки засладувачи од секогаш била предмет на истражување во областа на детерминирање на факторите кои директно влијаат на појавата на кариес од најмала возраст. Особено поради поврзаноста на зголемена продукција на киселини во устата поради подолгото присуство на шеќерите кои непосредно влијаат на деминерализација на забната глеѓ. **Цел:** Целта на оваа студија е утврдување на состојбата на оралното здравје преку детерминирње на шеќерите како можен ризик фактор за појава на кариес. **Материјал и методи:** Во истражувањето беа вклучени вкупно 80 деца, на возраст од 9 години по случаен избор од две основни училишта во Скопје, општина Центар (о.у. Киро Глигоров и о.у.Кочо Рацин), од кои 37 се девојчиња и 43 момчиња. **Резултати:** Резултатите кои ги добивме во однос на кеп кај млечна дентиција изнесуваше 2,6 што според СЗО влегува во среден кеп индекс во соооднос со резултатите на употребата на производи збогатени со вештачки засладувачи t Start=7.9356 и p<0.01 ни го потврдува шеќерот како можен ризик фактор за појава на зголемен КЕП индекс. Резултатите кои пак ги добивме за КЕП кај трајна дентиција изнесуваа 0.58, што според СЗО влегува во низок КЕП индекс во сооднос со вештачките засладувачи t Start=0.62131и p<0,01. Резултатот ни покажува дека краткотрајното присуство на трајната дентиција и времетраењето на изложеност на јаглехидрати претставува намален ризик за зголемен КЕП индекс во стоматогнатниот систем. **Заклучок:** Секојдневната едукација на децата во насока на подобрување на навиките за подобра орална хигиена и правилна и балансирана исхрана би придонеле за

подобри резултати на КЕП вредностите. Здравствената едукација и мотивација како мултидисциплинарен пристап мегу стоматолозите, наставниците, децата и родителите треба да биде основен императив како најважна превентивна мерка. Воведување на соодветни контроли за достапност на шекерите и слични засладувачи во било каква форма во близина на училиштата значително ќе го намали ризик факторот-шеќер и кариес инциденцата. **Клучни зборови:** шеќер, забен кариес, КЕП индекс

Introduction

According to the World Health Organization (WHO), caries is a localized process of exogenous origin, i.e., a multifactorial disease with a progressive course that occurs through the interaction of primary (causal) and secondary (conditional) factors.

The modern way of life, the rapid progress of food technology, and the wide range of refined food choices are the reasons for the emergence of an increasing number of chronic diseases. Since ancient times, the saying that health enters through the mouth speaks of the importance of dietary choices. The increase in the production and implementation of sugars (carbohydrates) in numerous food products is proportional to the increasing incidence of dental caries as a chronic disease from a very young age in developing countries. The disruption of the balance, i.e., the increase in the dietary-bacterial balance on one hand and the host on the other, leads us to the terminal phase of this chronic disease - the carious lesion.

A diet rich in sugars and artificial sweeteners has always been the subject of research in determining the factors that directly influence the occurrence of caries from a young age. Mainly due to the connection with increased production of acids in the mouth that directly affect the demineralization of tooth enamel, it was a reason to conduct this research and confirm these factors as possible risk factors for an increased dmft/DMFT index in children.

The primary factor is the host, i.e., the tooth substance with the cariogenic microorganisms (oral microflora) found on the dental surfaces and the substrate of sugars that provide the energy and nutritional needs of the cariogenic bacteria. However, dental caries occurs only if all three primary factors are present simultaneously over a long period, which is why the time factor is also included among the basic factors.

Secondary factors related to the dietary substrate are the physical and chemical properties of the food, the frequency of sugar intake, the clearance of food, and oral hygiene habits. Streptococcus mutans is potentially the most cariogenic bacteria. It is the main initiator of the carious process because it has a high selectivity for sucrose, which firmly adheres to the tooth enamel, causing caries in correlation with poor oral hygiene and improper diet. It forms a water-resistant glucan responsible for creating dental plaque, which immediately after consuming sugars has a pH value of less than 5.5, resulting in demineralization of the enamel. In addition, Lactobacillus are cariogenic microorganisms that are most abundant in saliva, plaque, and dental caries and are responsible for the further course of the carious process.

Secondary factors are directly related to the primary factors and influence the intensity and speed of progression of the pathological process. Thus, secondary factors related to the host factor include: the anatomical and morphological characteristics of the teeth and their placement in the dental arch, heredity, gender, pregnancy and breastfeeding, hormones and various general diseases. Secondary factors influencing the causative agents themselves are: the composition and properties of the oral microflora, the quality and composition of saliva, and the presence of fluorides. On the other hand, secondary factors related to the suitable substrate where the metabolism of cariogenic microorganisms takes place are: the physicochemical properties of food, the frequency of meals, the clearance of food from the oral cavity, and oral hygiene habits.

Aim

The aim of this study is to determine the state of oral health by identifying sugars as a possible risk factor for the occurrence of caries.

In order to achieve the set goal, a total of 80 respondents, children aged 9, were included in the research. For all respondents, we individually determined:

- The ratio between the values of the dmft/DMFT index and the values obtained from the questionnaire regarding the diet and oral hygiene of each child individually;
- The value of the DMFT index compared to the dmft of the deciduous dentition and the DMFT of the permanent dentition in all respondents.

Material and methods

The research included a total of 80 children, aged 9, randomly selected from two primary schools in Skopje, Municipality of Centar (Primary Schools “Kiro Gligorov” and “Kocho Racin”), of which 37 were girls and 43 were boys.

These examinations were conducted at the Polyclinic.

All respondents were provided with:

- Clinical trials,
- Patient questionnaire
- Statistical processing of the obtained results.

The children were examined with appropriate instruments (probe and dental mirror) to determine the condition of the oral cavity, which was recorded individually in a chart using the new marking method in accordance with the new WHO criteria. dmft/DMFT index was determined individually for each child using the Klein-Palmer system. The DMFT index is the average number of decayed, missing, and filled permanent teeth per student.

dmft/DMF = total number of decayed teeth+total number of missing teeth+total number of filled teeth/examined x100

The data was collected by filling out a questionnaire regarding the amount and form of sugar, fat, and protein intake, as well as the way the child maintains their oral hygiene. The respondents entered them into a questionnaire specially designed for that purpose. In this way, we attempted to obtain data on the state of dental health and determine possible risk factors.

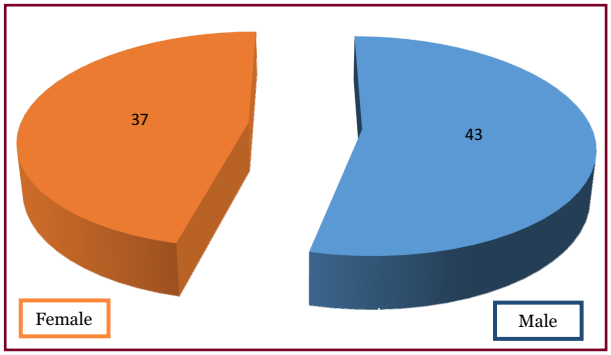
The questions were asked in a dental office individually in the presence of a parent, followed by a clinical dental examination by a preventive team.

For the statistical processing of the obtained data, a student's t-test was used to compare numerical data between corresponding groups, with $p<0.01$ being considered significant.

Results

The research included 80 respondents, children aged 9from two primary schools in Skopje.

Graph no.1 shows the ratio of male and female respondents, i.e., out of a total of 80 respondents in the survey, 43 were male respondents, and 37 were female respondents.



Graph 1: *Display of respondents by gender*

Table 1. Presentation of DMFT in permanent teeth and dmftin deciduous teeth separated by gender.

	DMFT	dmft	DMFT Index	Dmft Index
Male	25	123	0.58139	2.86046
Female	22	89	0.59459	2.40540
Total	47	212	0.5875	2.63293

According to the formula for calculating the DMFT index, i.e., number of decayed teeth + total number of missing teeth + total number of filled teeth divided by the number of respondents, the following values were obtained (Table 1).

dmft in the primary dentition was 2.6, which according to WHO is included in the medium DMFT index, while DMFT in the permanent dentition was 0.58, which is included in the low DMFT index according to WHO.

The results of the analysis of dmft by gender show that dmft in boys is 2.86 and dmft in girls is 2.4, which is in favor of a better dmft index in girls in the primary dentition.

The DMFT index of the permanent dentition in boys was 0.58. In girls, the DMFT was 0.59, with no statistically significant difference in the values of DMFT in the permanent dentition in relation to gender.

Table 2. Student's t-test: on two samples representing unequal variances of the dmft index in deciduous teeth in relation to the type of food consumed by the respondents.

	dmft/cookies	dmft/gummy candies	dmft/ lollipops	Overall average value
t Stat	4.8568444	9.25404209	9.696212	7.935699
p	0.0000014	0.0000000	0.0000000	0.0000004
t Critical	1.6545549	1.65455488	1.654555	1.65455492

According to the Student's t-test,the difference between the DMFT of permanent teeth and the dmft of deciduous teeth is statistically significant, t-Stat=7.37203, and p<0.01.

Regarding nutrition, according to the Student's t-test (Table 2), there is a statistically significant difference between the DMFT index and the different types of food, where the alpha value was set to α=0.05 and p<0.01.

There is a statistically significant difference between the dmft index in deciduous teeth and the intake of cookies, t Stat =4.856 and p<0.01. There is a significant difference between the dmft index in deciduous teeth and the intake of gummy candies, t Stat =9.254 and p<0.01.

There is a statistically significant difference between the dmft index in deciduous teeth and the intake of lollipops, t Stat=9.696 and p<0.01.

If all the obtained values are summed up in relation to the use of sugars and artificial sweeteners, the mean value of t Stat=7.9356 and p<0.01 will be obtained. This value, in correlation with the dmft index in the deciduous dentition, which is 2.6, points to artificial sugars as one of the risk factors that increase the dmft/DMFT index in the stomatognathic system.

According to the Analysis of Variance (ANOVA), Table 3a, there is a statistical difference between the different types of food (healthy and cariogenic) consumed by the respondents in relation to the present dmft index of the deciduous teeth, F=74.34806 and p<0.01.

Table 3. View of Analysis of Variance - ANOVA between the dmft index in deciduous teeth in relation to the type of food (healthy and cariogenic) consumed by the respondents.

SUMMARY				
Groups	***Count***	***Sum***	***Average***	***Variance***
proteins	80	123	1.5375	0.251741
fast food	80	171	2.1375	0.196044
fruit	80	97	1.2125	0.194778
cookies	80	115	1.4375	0.274525
gummy candies	80	28	0.35	0.23038
lollipops	80	20	0.25	0.189873
chocolate	80	78	0.975	0.024684
sweetened drinks	80	45	0.5625	0.249209
dmft	80	212	2.65	4.711392

Table 3a. Display of analysis between different types of food

ANOVA						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	417.8444	8	52.23056	74.34806	0.00000000	1.951408
Within Groups	499.4875	711	0.702514			
Total	917.3319	719				

Table 4. Student's t-test: two samples representing unequal variances of the DMFT index in permanent teeth in relation to the type of food (healthy or cariogenic) consumed by the respondents..

	DMFT/Cookies	**DMFT / Gummy candies**	**DMFT / Lollipops**	**Overall average value**
t Stat	6.042159828	-1.71229	-2.465922	0.6213159
p	0.00000001	0.044402	0.007367	0.0172563
t Critical	1.654554876	1.654555	1.654555	1.654554

Regarding nutrition, according to the Student's t-test (Table no. 4), there is a statistically significant difference between the DMFT index and the different types of food, where the alpha value was set to $\alpha=0.05$, and $p<0.01$. There is a statistically significant difference between the DMFT index in permanent teeth and the intake of cookies, t Stat=6.04215 and $p<0.01$, which is not the case with the use of gummy candies and lollipops. If all the obtained values are summed up in relation to the use of sugars and artificial sweeteners, the average value of t Stat=0.62131 and $p<0.01$ will be obtained. This value in correlation with the DMFT index in permanent dentition, which is 0.58, which falls into low DMFT, is another confirmation that the connection between the use of artificial sweeteners is closely correlated with the values of the DMFT index.

Table 5. View of Analysis of Variance – ANOVA between the DMFT index in permanent teeth in relation to the type of food (healthy and cariogenic) consumed by the respondents.

SUMMARY				
Groups	***Count***	***Sum***	***Average***	***Variance***
DMFT	80	47	0.5875	1.308703
proteins	80	123	1.5375	0.251741
fast food	80	171	2.1375	0.196044
fruit	80	97	1.2125	0.194778
cookies	80	115	1.4375	0.274525
gummy candies	80	28	0.35	0.23038
lollipops	80	20	0.25	0.189873
chocolate	80	78	0.975	0.024684
sweetened drinks	80	45	0.5625	0.249209

According to the Analysis of Variance (ANOVA), there is a statistical difference between the different types of food (healthy and cariogenic) consumed by our respondents in relation to the present DMFT index of permanent teeth, F=97.59308 and $p<0.01$.

Discussion

Artificial sweeteners and sugars, as the most commonly used products by the food industry, are increasingly posing a risk factor for the occurrence of caries in people, especially young children.

All this has been an area of investigation in many countries and studies in which direct correlations were made between the DMFT index in children and the frequent use of foods and beverages with enriched sweeteners[1,2]. Knowing the chronology of pH disturbance in the oral environment,as a result of these artificial sweeteners and sugars, research was conducted in a Belgian study that included children from 7 years of age, which proved that those who were exposed to the consumption of artificial sweeteners had a lower pH value and represented a suitable environment for the development of cariogenic bacteria, compared to children who did not consume artificial sweeteners[3,4].

A study conducted in England among children aged 12-15 found that children who consumed foods and drinks enriched with artificial sweeteners were more likely to develop dental caries. However, if these children who consumed foods enriched with artificial sweeteners were to increase the frequency of drinking water in fluoridated areas, there was a greater possibility of reducing the percentage of dental caries. This study demonstrated a direct connection between the occurrence of dental caries and the consumption of artificial sugars[5].

Wang YC, Bleich SN, Gortmaker in a study examining the intake of 100% fruit juices enriched with artifi-

Table 5a. Display of analysis between different types of food

SUMMARY						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	253.3028	8	31.66285	97.59308	0.00000000	1.951408
Within Groups	230.675	711	0.324437			
Total	483.9778	719				

cial sweeteners in children and adolescents found that children and adolescents in today's modern society receive 10 to 15% of their total calories from sugar-sweetened beverages and 100% fruit juice. This analysis indicates an increased consumption of these supplements across all age groups. Schools are places where children are most exposed to the intake of beverages enriched with artificial sweeteners, which would be an incentive to implement an initiative to limit the sale and availability of these beverages in and near schools.

In this process, the advice and dedication of pediatricians who can educate parents of children from a young age that increased sugar intake can have a very harmful effect on the overall health of children, including the stomatognathic system[6], are of great importance. These are more frequent examinations and proven impacts on the overall health of children with their exposure to all kinds of artificial sweeteners that daily affect the increasing prevalence of dental caries in children, WHO has implemented special guides that help dentists and pedodontistsprovide appropriate guidelines for prevention and early care for excessive consumption of artificial sweeteners in everyday practice[7].

Infants, especially those living in poor socioeconomic conditions, are at high risk for early childhood caries. The most influential factor in this uncontrolled process of caries development is the prolonged use of baby bottles, during the day or night, containing highly fermentable sugars (e.g., fruit juice and other sweetened beverages) and pacifiers dipped in sweet additives (such as sugar, honey, or syrups). Therefore, during this period of development, the word of pediatricians is of great importancein encouraging mothers in a traditional way to wean their infants from a bottle with a pacifier to a cup as soon as their first birthday. However, frequent exposure to sweet liquids, even in a cup, can also increase the risk of caries. Therefore, drinks (other than milk or water) in a bottle or cup should be limited and given mainly during main meals[8].

Another study conducted to determine the frequency of sugar consumption in everyday life showed that most preschool children consumed sweets daily - an average of 9.7±6.2 times per week.The most popular were cookies, gummy bears, and chocolate. Sweets consumption did not show a significant correlation with sociodemographic factors such as age and gender but was associated with cultural and contextual factors such as the origin of the respondents, parental education, and specific levels of knowledge about nutrition and oral hygiene. The identified consumption patterns are the result of high availability and parental influence (factors such as parental knowledge level, interest, and habits regarding their child's diet)[9].

According to a study with saliva samples from three different types of carbohydrates (banana, chocolate and white bread), it has been proven that the clearance of other sugars from the teeth (fructose, sucrose and maltose) is significantly higher in chocolate and banana compared to white bread, which requires more time due to the breakdown of starch under the action of amylase. Foods with a high concentration of starch (chips, donuts, and cakes) remain in the mouth longer and have less self-cleaning by saliva compared to foods with less starch (milk chocolate, jelly candies, and caramels). Donuts and potato chips processed at the highest temperature have the highest starch concentration compared to the other test products because starch in the mouth breaks down (into maltose and maltotriose) and has the highest cariogenic potential[10].

The daily intake of sugars per person should be 30g per day for preschool children and 60g per day for school children and teenagers[11].

According to the study on restriction of sugar intake, i.e. quantity and frequency[12], it has been proven that after sugar intake, a drop in pH in the mouth occurs that lasts for 30 minutes, which would mean that additional intake after these 30 minutes is less harmful than in the first 30 minutes.

According to Woodward and Walker[13], who analyzed data from the WHO database from a total of 90 countries, there is a correlation between carbohydrate intake and caries in 29 developed and 61 developing countries, with 23 out of 29 countries having 12-year-old children consuming less than 50 g of carbohydrates per day, the DMFT value being less than 3.0, and in more than 78% of countries with lower carbohydrate consumption, around 10 kg per year, the DMFT is less than 2.0.

The National Strategy for Oral Health Prevention in children up to 14 was adopted in 2008[14]. The aim is timely education and motivation, raising awareness of the oral health of the individual by incorporating effective methods of fissure sealing in school children as well as implementing fluoride prophylaxis and training in proper oral hygiene from an early age, thus enabling the improvement of overall oral health and reducing the percentage of caries in children. This strategy is a step closer to approaching the standards for quality of life offered by the WHO worldwide, and with its implementation we would get a complete picture of the proper growth and development of the orofacial system as well as success in reducing caries incidence by controlling the intake of sugars as one of the main determinants of caries.

The analyses conducted according to the survey questionnaire and the statistical processing of the tables and their parallel analysis proved there is a direct connection between the use of artificial sweeteners in the

daily diet of children and that it represents a high risk factor for the occurrence of a higher DMFT index in the analyses. Of course, in everyday practice, it is necessary to conduct additional parallel analyses, especially in children with only deciduous dentition, and separately in children with permanent dentition, to establish age as a possible risk factor in relation to the control of dmft/DMFT compared to the intake of sugars, where greater self-awareness of older children could be expected, primarily due to the greater availability of information about sugars and their harmful effects on teeth.

The results we obtained in terms of dmft in the deciduous dentition were 2.6, which according to the WHO is included in the medium DMFT index in relation to the results of the use of products enriched with artificial sweeteners t Stat=7.9356 and $p<0.01$, which confirms sugar as a major risk factor, while DMFT index in the permanent dentition was 0.58, which is included in the low DMFT index in relation to artificial sweeteners t Stat=0.62131 and $p<0.01$, which clearly shows that the reduced intake of sugars represents a reduced risk for an increased DMFT index in the stomatognathic system. The data obtained in this way results from the age of the students who are in the period of mixed dentition, which makes the need for visiting a dentist and providing dental interventions greater. At the same time, the higher socio-economic status, primarily the education of the parents, the culture, and the way of life of this group of students impact the provision of preventive measures.

Conclusions

From the results obtained, we concluded that educating children and parents about the daily routine habits that families have inside and outside the home regarding nutrition should be a priority for all communities and societies, in order to influence the reduction of the occurrence of caries in children from the youngest age. Numerous epidemiological studies conducted at the population level indicate a direct correlation between the form, quantity, and frequency of carbohydrate consumption and the development of caries.

Consuming sugars or artificial sweeteners in any form more than four times a day increases the risk of dental caries by more than 50%. The recommended daily intake should be no more than 60 grams per day for teenagers and adults, and for preschoolers and young children, the intake should be no more than 30 grams per day.

Daily education of children in order to improve their oral hygiene habits and proper and balanced nutrition would contribute to better results for the DMFT values. Health education and motivation as a multidisciplinary approach among dentists, teachers, children, and parents should be a basic imperative as the most important preventive measure. Considering the causes that lead to the occurrence of caries on a global level, one of the most effective measures is fluoride prophylaxis and its implementation at an early age. Introducing appropriate controls for the availability of sugars and similar sweeteners in any form near schools will significantly reduce the risk factor - sugar and caries incidence. These strategic measures aim to preserve overall oral health in the most vulnerable age to ensure proper growth and development of the stomatognathic system.

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