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Relationship of Chemical Composition of Saliva, Body Mass Index, and Nutrition with Permanent First Molar Caries in 6–12 Years Old

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Abstract

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BACKGROUND: Dental caries is a major health problem worldwide, which negatively affects the quality of life. The salivary concentration of calcium, phosphorus, pH, and flow rate of the saliva plays a role in its cariostatic activity.

AIM: This study aimed to assess the relationship of biochemical composition of the saliva, body mass index (BMI), and nutrition with permanent first molar caries in 6–12 years old.

MATERIALS AND METHODS: This descriptive, cross-sectional study was conducted on 47 children between 6 and 12 years with four fully erupted first molars. Their weight and height were measured and BMI was calculated. Dental examination was performed, saliva sample was collected, and a questionnaire was filled out. Data were analyzed using the SPSS version 21.

RESULTS: A significant association was noted between BMI and caries ($p = 0.002$). The association between caries and frequency of drinking soft drinks per week ($p = 0.002$), frequency of eating sugary foods per week fast food per month ($p = 0.001$), saliva pH ($p = 0.001$), and saliva flow rate ($p < 0.0001$) was statistically significant. Although a significant association was noted between BMI and pH, saliva flow, and dental caries, no significant association was found between the composition of saliva (level of calcium and phosphate) with dental caries and BMI ($p > 0.05$).

CONCLUSION: It appears that reduction in saliva flow and pH and high sugar intake in overweight subjects increase the risk of caries. Further studies on a larger sample size are required to evaluate the role of other constituents of saliva in this respect.

Introduction

Dental caries is a major health dilemma, which can negatively affect the quality of life. Its prevalence is increasing in developing countries and it is now considered one of the most common diseases during childhood [1]. Dental caries, resulting in loss of dental substrate, is an infectious disease caused by a combination of factors such as microorganisms, carbohydrates, decreased resistance of tooth structure, and time [2]. At present, despite advances in dental science, carious tooth structure can only be removed and the cavity should be restored with restorative materials. It can only be prevented by implementation of preventive measures such as efficient oral hygiene and healthy nutrition [3]. Permanent first molars are the first permanent teeth erupting into the oral cavity. However, due to their morphology and function in mastication, they are highly susceptible to caries soon after their eruption. Caries not only affects the oral health but also compromises general health and the quality of life [4] because untreated

carious lesions cause pain and discomfort and affect the appetite and subsequently the growth and development of children. Sleep disturbances and irritability are among other consequences of severe dental caries, which impair the production of glucocorticoids and the growth hormone. On the other hand, dental caries causing pulp involvement affects the release of cytokines and impairs the blood supply; thus, dental caries can also affect the body mass index (BMI) [5]. This index is calculated by dividing the weight (in kilograms) by the square of the height (in meters) and is used for the estimation of weight distribution [6]. Overweight can significantly compromise health and is attributed to physiological, biochemical, metabolic, or anabolic mechanisms [7]. Moreover, obesity is a risk factor for many diseases. Dental caries may be associated with overweight due to high consumption of carbohydrates [7], [8]. At present, considering the change in lifestyle, obesity is considered as the most common nutritional disorder, especially among children [8]. For instance, in a study by Mirmohamamdi *et al.*, in 2011, on 30,029 males and females between 6 and 18 years in several cities in Iran, it was reported that 12.67%

and 10.47% of subjects were overweight and obese, respectively [9].

Juarez-Lopez discussed that high consumption of carbohydrates, especially snacks between meals, is a major risk factor for obesity and dental caries [10]. Thus, nutritional habits affect virulence of microorganisms of dental plaque and negatively affect tooth resistance to caries as well as saliva properties.

Saliva has a protective role in the oral cavity (lysing property, buffering capacity, maintaining dental integrity, antimicrobial activity, taste, and food digestion), and change in its composition can significantly affect oral and dental health [11]. Salivary concentration of calcium, phosphate and fluoride, saliva pH, and saliva flow rate affects its cariostatic properties [7]. Thus, considering the fact that the assessment of saliva properties, instead of serum, has advantages, saliva has been suggested as a diagnostic fluid in recent years [12]. For instance, regarding the obesity epidemics in today's world, systemic markers of obesity have been paid much attention and it has been revealed that adipoleptin present in the saliva and plasma of adults has an inverse correlation with obesity. However, the correlation of dental caries and obesity (based on BMI) is complex because these two factors are influenced by many different biological, financial, social, environmental, and lifestyle parameters [13]. The relationship of BMI and dental caries has been the topic of many studies. However, studies on the relationship of saliva, BMI, nutrition, and dental caries altogether are scarce. Bayada assessed the correlation of saliva composition and root caries in 55–65-year-old obese patients, while Modeer *et al.* assessed the relationship of obesity, saliva flow rate, and dental caries in a group of adult population [14], [15]. Considering the significance of caries prevention, assessment of the afore-mentioned relationships in 6–12 years old is particularly important because children in this age range are in the mixed dentition period and many oral hygiene and nutritional habits form during this period [16], [17], [18]. Anamaria *et al.* evaluated the correlation of buffering capacity of the saliva, BMI, and dental caries in primary and permanent teeth of 6–12 years old, while Rodríguez *et al.*, evaluated the relationship of saliva flow rate, nutrition, and dental caries in 3–6 years old [19], [20]. However, since the permanent first molars are the most susceptible teeth to caries and considering their strategic role in mastication and digestion, this study sought to assess the relationship of biochemical composition of the saliva, BMI, and nutrition with permanent first molar caries in 6–12 years old.

Materials and Methods

This descriptive, cross-sectional, and analytical study was conducted on 47 children between 6 and 12 years. Data were collected by filling out a questionnaire,

measurement of weight and height, examination of permanent first molars, and saliva collection. Participants were chosen using convenience sampling from the Pediatric Department, School of Dentistry, Shahid Beheshti University of Medical Sciences. The parents were briefed about the study and signed informed consent forms prior to the participation of their children in the study. A questionnaire asking for information about their age and sex, presence of systemic disease, drug use, frequency of fast food consumption, and frequency of use of sugary foods and soft drinks was filled out by the parents [16]. Subjects with systemic diseases affecting weight and height (such as endocrine disorders) or drug use were excluded from the study. All measurements, examination, and saliva collection were performed by one experienced operator as follows:

Weight was measured with subjects wearing light clothing and no shoes on using a scale (Health Scale, SMIC) with 0.5 kg accuracy. The scale was calibrated each day before and after measurements. Height was measured with 1 cm error percentage with the subjects standing against the wall with no shoes on, feet next to each other, and head leaned on the wall using a ruler placed on the head parallel to the ground. BMI was then calculated by dividing weight in kilograms by the square of the height (in meters) and compared with the standard percentiles (2000 CDC) for age and gender [6]. Children between the 5th and 85th percentiles were assigned to “normal weight” group, those between the 85th and 95th percentiles were assigned to “at risk of overweight” and those over the 95th percentile were assigned to “overweight” group. In this study “at risk of overweight” and “overweight” groups were considered as (>normal) group.

Caries in permanent first molars was assessed by clinical examination of these teeth according to the WHO standards using a disposable mirror by the same examiner under dental unit light. Smooth and occlusal surfaces of teeth were examined and those with brown or black discoloration or cavity were considered to be carious. Prior to saliva collection, the children were requested not to eat or drink, not to practice oral hygiene or place anything in the mouth for 90 min prior to saliva collection. Saliva was collected in a calm environment with the child in seated position by the spitting method. Unstimulated saliva was collected during 5 min at rest and stored in sterile Falcon tubes for transfer to the lab [17]. The pH was measured using a pH indicator (Merck, Germany). Saliva flow rate was calculated by dividing the volume of saliva (in liters) by time (in min). The salivary concentration of calcium and phosphate was determined using a photometer (Clinic 2; Tajhizat Sanjesh, Iran) and biochemical autoanalyzer (Technicon, Germany), respectively.

Data were analyzed using IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp. Descriptive statistics were reported as mean and standard deviation for quantitative variables. The frequency and percentage were reported for qualitative variables. Chi-square test

was used to assess the correlation of qualitative variables. Independent t-test was used to compare quantitative variables between the two groups and Mann–Whitney U-test was applied for non-normal distributed or ordinal variables. To assess the effect of different variables on the odds of caries development, binary logistic regression model was applied. p-Value < 0.05 was considered as statistically significant.

Results

A total of 47 children were evaluated. Dental examination showed that 22 children (9 males and 13 females) did not have caries in their permanent first molars and had a mean age of 8.5 years. In this group, the mean level of salivary calcium and phosphate was 0.56 and 4.28 mM/L, respectively, and the mean pH and salivary flow rate were 6.8 and 0.48 mL/min, respectively. Moreover, 17 children in this group had normal BMI and five had a BMI higher than normal range. In the caries-free group, the mean frequency of using sugary foods and soft drinks was 2 and 0 times/week, respectively. The consumption of fast food was once a month. Dental examination performed in 47 subjects revealed that 25 children (13 males and 12 females) had at least one carious permanent first molar. The mean age of children in this group was 10 years. The mean salivary level of calcium and phosphate was 0.60 and 4.13 mM/L, respectively, and the mean pH and saliva flow rate were 6.4 and 0.28 mL/min, respectively. Eight of these children had a normal BMI and 17 had a BMI higher than normal. The mean frequency of using sugary foods and soft drinks in children with dental caries was 3 and 1 times/week, respectively. The frequency of using fast foods was twice a month.

Table 1 compares the distribution of some of the interested variables on two groups of children according to their caries experience in their permanent first molars.

No significant association was noted between dental caries and salivary concentration of calcium and phosphate. Caries had a significant inverse association with pH ($p = 0.001$) and saliva flow rate ($p < 0.0001$). Caries had a significant direct relation with the frequency of use of sugary foods ($p = 0.001$), soft drinks

($p = 0.002$), fast food ($p = 0.001$), BMI ($p < 0.0002$), and age ($p = 0.002$) (Table 1).

According to Table 2, no significant association was noted between BMI and salivary concentration of calcium ($p = 0.2$) and phosphate ($p = 0.64$). However, a significant inverse association was noted between BMI and saliva pH ($p = 0.003$) and saliva flow rate ($p = 0.006$) (Table 2). Eight (32%) of children with normal BMI had at least one caries versus 17 (77.3%) of children with BMI higher than the normal range ($p = 0.002$).

Table 3 shows the results of logistic regression model, and the odds of occurrence of caries were determined considering the effect of age, frequency of using sugary foods per week, BMI (being higher than normal vs. normal) salivary level of calcium and phosphate, saliva flow rate, and pH of saliva.

Using backward selection method, the least significant explanatory variables were eliminated from the regression model. The results of the fifth step showed that saliva flow rate (OR = 0.002, $p = 0.001$), frequency of consumption of sugary foods per week (OR = 1.996, $p = 0.006$), and BMI (OR = 6.44, $p = 0.022$) significantly affected the odds of caries development such that the odds of caries occurrence were 6.44 times higher in the group with BMI > normal compared to the group with normal BMI. The results showed that decrease in saliva flow rate and more sugary food consumption were positively related with the higher odds of dental caries development (Table 4).

Discussion

This study showed that permanent first molar caries in 6–12 years old was significantly correlated with the frequency of consumption of sugary foods, soft drinks, and fast foods and the odds of caries occurrence were 6.44 times higher in overweight children compared to others. Although pH and saliva flow had a significant correlation with caries and BMI, the association of salivary level of calcium and phosphate with caries and BMI was not significant.

Based on the results of this study, age and BMI were significantly correlated, which was in agreement with the results of Jusupović *et al.* [21]. In contrast, Pannunzio *et al.*, in 2010, evaluated overweight

Table 1: The association of caries experience with nutritional habits, composition of saliva, BMI, and age

Variable	Nutrition			Saliva composition				BMI	Age
	Frequency of consumption of soft drink per week	Frequency of eating sugary foods per week	Frequency of eating fast food per month	pH	Saliva flow rate	Calcium	Phosphorus		
Absence of caries									
Mean	0.45	1.91	0.64	6.82	0.49	0.56	4.3	16.68	8.4
SD	0.67	1.41	0.66	0.33	0.14	0.25	0.81	2.6	1.46
Presence of caries									
Mean	1.2	3.36	1.4	6.42	0.28	0.6	4.13	20.71	9.96
SD	0.82	1.38	0.71	0.42	0.12	0.3	0.98	2.72	1.74
p value	0.002	0.001	0.001	0.001	<0.0001	0.627	0.566	<0.0002	0.002

BMI: Body mass index.

7–10 years old and reported that in obese children, the saliva pH was higher than that in the control group [22]. However, in our study, the saliva pH in overweight children was less than that in the control group. Furthermore, in their study, different groups in terms of BMI did not show significant differences in terms of salivary level of calcium and fluoride, but salivary level of phosphate in obese children was less than that in the control group.

Table 2: Association of BMI with salivary level of calcium and phosphate, flow rate, first molar caries, pH, age

Variable	Calcium	Phosphate	Saliva flow rate	First molar caries	pH	Age
Normal BMI						
Mean	0.53	4.13	0.44	0.52	6.78	8.84
SD	0.27	0.81	0.14	0.87	0.36	1.77
BMI>normal						
Mean	0.64	4.28	0.3	1.45	6.41	9.64
SD	0.29	1	0.15	1.1	0.43	1.76
p-value	0.2	0.64	0.006	0.002	0.003	0.13

BMI: Body mass index.

However, in the current study, no significant association was noted between the salivary level of calcium and phosphate and BMI. Controversy in the results may be due to difference in nutritional habits, saliva collection method, and age group of subjects because in the study by Pannunzio *et al.*, stimulated saliva was assessed [22], but in the current study, unstimulated saliva was collected. Saliva plays a role in mastication, deglutition, carbohydrate digestion, elimination of oral bacteria, antibacterial activity, and protection of enamel.

Table 3: The first step in logistic regression analysis for determining the effect of interested variables on the odds of caries experience in permanent first molars

Variable	B	SE	OR	p-value
Age	0.311	0.249	1.365	0.212
BMI (>normal)	1.710	0.936	5.531	0.068
Frequency of consumption of sugary foods	0.559	0.341	1.749	0.102
Calcium	0.743	1.693	2.103	0.661
Phosphate	-0.607	0.561	0.545	0.279
pH	0.040	0.550	1.041	0.942
Flow rate	-7.533	3.949	0.001	0.056

BMI: Body mass index

Thus, change in the amount and composition of saliva can compromise oral and dental health [17]. Saliva contains specific serum components originated from the gingival crevicular fluid [23]. Thus, unstimulated saliva is preferred for the determination of biochemical markers. This type of saliva is dominant in the oral cavity in most hours of the day and, thus, plays an important role in maintenance of oral health. Thus, unstimulated saliva better reflects the physiological status of the oral cavity and the entire body [24]. For this reason, we evaluated unstimulated saliva in this study.

Table 4: The result of logistic regression after backward selection method

Variable	B	SE	OR	95% CI for OR	p-value
BMI (>normal)	1.862	0.815	6.438	(1.302, 31.825)	0.022
Frequency of consumption of sugary foods/week	0.691	0.253	1.996	(1.215, 3.280)	0.006
Flow rate	-6.402	1.930	0.002	(0,0.073)	0.001

BMI: Body mass index

The results of the study by Costa in 2013 on 6 years old were in contrast to our results since they showed that 50% of children had early caries and 25% of them were obese. However, they found no significant

association between dental caries and obesity [25]. Difference in nutritional habits of different populations, number and age range of subjects, and resistance of dental substrate to caries may explain the controversy in the results of studies. In a study by Shahraki *et al.* conducted in 2013 on 6–11-year-old children in Zahedan, the number of obese girls was higher than obese boys, and a significant association was noted between caries and BMI in females [1]. However, in our study, the number of obese boys was higher than girls. Moreover, Shahraki *et al.* found no significant association between daily consumption of sugary substances and caries or BMI while this association was significant in our study. This controversy in the results of the two studies may be due to differences in nutritional habits, geographical location, age range, and sample size. Food culture and habits in each population may be different from those of other populations [1]. Moreover, microorganisms present in microbial plaque use the sugar in foods and ferment it to acid. Acid dissolves the enamel and initiates caries. Thus, based on the results of this study, it is obvious that the use of sugary substances and higher frequency/volume of use can lead to obesity and caries.

In a systematic review on 47 articles by Hooley *et al.*, in 2012, a significant association was reported between BMI and caries in 15 articles while this correlation was inversed in nine studies; 23 articles found no such a correlation between these two factors [26]. Severe caries affects the sleep quality and appetite of children, and this may explain the inverse correlation of BMI and caries. Some studies have discussed that dental caries causes loss of appetite and reduction of BMI while studies reporting a direct association between BMI and caries explained that high carbohydrate consumption and obesity cause caries.

Bayada, in 2012, evaluated root caries in 55–65-year-old obese subjects and showed that salivary levels of urea and phosphate were significantly correlated with BMI. However, we did not find such an association. Furthermore, in their study, a significant association was noted between root caries and BMI such that the rate of caries in obese individuals was less than that in normal-weight subjects, which was different from our results [14]. It appears that high level of urea and phosphate in the saliva of obese subjects decreases the rate of caries. On the other hand, the assessment of different surfaces of teeth in terms of caries and the age range of subjects may be variable in studies and explain the difference in findings.

Anamaria *et al.*, in 2015, evaluated 144 children between 6 and 12 years in Romania and showed that the buffering capacity of the saliva and dental caries was not correlated. Rate of caries in primary teeth of underweight children was higher than that in others. In contrast, our study showed that dental caries had a significant inverse correlation with saliva pH, and the rate of caries was higher in overweight children [19]. Moreover, Rodriguez *et al.*, in their study on 60 children

between 3 and 6 years in Argentina showed that the odds ratio of dental caries in normal-weight children was 4 times higher than that in others, and dental caries was significantly correlated with the saliva flow ($p = 0.0017$). However, no significant association was noted between the saliva flow and nutrition or obesity [20]. On the contrary, our results showed that dental caries was significantly correlated with the saliva flow and the odds ratio for caries development in overweight children was 6.44 times higher and the association between the saliva flow and overweight was statistically significant. Moreover, caries had a significant association with nutritional habits and BMI. Controversy in the results of studies may be due to difference in type of tooth (primary or permanent), number and age range of children, and difference in nutritional habits of different populations. Considering the strategic role of permanent first molars, the assessment of the correlation of permanent first molar caries with BMI, biochemical composition of the saliva, flow rate, and pH of the saliva and nutritional habits was a strength of our study compared to that of Anamaria *et al.* and Rodriguez *et al.* [19], [20].

Review of the literature revealed that many previous studies reported results similar to ours. Gerdin *et al.*, in their study on 4, 5, 7, and 10 years old residing in Oster Gotland city in Sweden, reported that a significant association existed between overweight and caries [27]. The results of a study by Hilgers *et al.* indicated a significant association between carious lesions of dental surfaces of permanent molars and BMI in children 8–11 years, which was in agreement with our results regarding caries in smooth surfaces of the first molars [13]. However, some studies reported results different from ours. For instance, Shailee *et al.*, in India, reported that BMI had an inverse correlation with decayed, missing, and filled teeth (DMFT) index [28]. Sadeghi and Alizadeh found no significant relationship between BMI and DMFT in 6-11-year-old children [29]. Mecek and Mitola did not find any significant association between BMI and age or dental caries in 2–17-year-old Americans, which was in contrast to our results [30]. This difference in the results of the two studies may be attributed to difference in geographical location, nutritional habits, sample size, and age range of participants.

Conclusion

It appears that reduction in saliva flow and pH and frequent consumption of carbohydrate-rich and sugary foods in overweight and obese individuals increase the odds of dental caries. Considering the limitations of this study (exclusion of some children since they could not refrain from eating for 1 h before saliva collection or not having four fully erupted first molars),

further studies with a larger sample size are required to assess the role of other saliva constituents such as urea, sialic acid, and fluoride in the development of caries.

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