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The Relationship of Nutrition Components and Life Style to Dental Caries: A Review Article

Elham Razmpoosh; MSc [1,2], Shima Abdollahi; MSc [1,2] & Amin Salehi Abargouei; PhD*[1,2]

[1] *Nutrition and Food Security Research Center, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.*
[2] *Department of Nutrition, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.*

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Corresponding author:
abargouei@hlth.mui.ac.ir
PhD in Nutritional Sciences
Department of Nutrition, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.

Postal code: 8915173160
Tel: +983538209100

ABSTRACT

Background: This review aimed to express the exact role of nutrition components including carbohydrates, fats, proteins and other dietary factors such as probiotics, micro and macro nutrients and the life pattern including body weight in the development of dental caries. **Methods**: Carbohydrate", "fat", "protein", "vitamin and mineral", "probiotics" and "lifestyle", along with "dental caries", "cavitation" and "or dental cavitation were searched in PubMed, SCOPUS and Web of sciences databases. **Results**: In this study, 28 articles were included; since cariogenic effects of fermentable carbohydrate containing foods and the amount and frequency of consuming such foods have been known, recommendations to replace sugar with starchy foods to avoid dental caries are of questionable value; vitamins and minerals are important in controlling the occurrence of oral inflammation and enhancement of immunity; fat containing foods that play a role as bacterial adherence could be induced by hydrophobic interactions which get facilitated by a lipid-rich environment. Although there are differences in the salivary lipid content of caries-sustainable and caries-resistant individuals, a meta-analysis showed that there was a moderate association between dental caries and the salivary lipid content. Proteins also are known as cariostatic agents; however, their effects might differ according to their types of amino-acids. Probiotics might play beneficial roles as antagonistic agents on acidogenic bacteria that will reduce dental decay. Sedentary lifestyles among children associated with an increased consumption of unhealthy diet rich in sugar can increase the risk of both weight gain and dental caries. **Conclusions**: Specific programs focusing on health promotion and education strategies are needed.

Keywords: *Life style; Nutrition; Nutrients; Dental caries*

Introduction

Nutrition, defined as the process of obtaining the necessary food for growth and health, is considered as a substantial factor for the proper function of immune system against any infections or diseases (World Health Organization, 2014). On the other, hand dental caries, that is still one of the

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most common diseases worldwide, is widely affected by the interaction among many factors including cariogenic microorganisms, saliva secretion and diet (Wojcicka *et al.*, 2012).

Indeed, dental caries is a diet-dependent disorder that is potentially assigned to the presence of oral bacteria. As dietary components might contribute to the development of enamel defects, it is mainly associated to the etiological cause of dental erosions (Cagetti *et al.*, 2013). The periodontal disease is occurred as a result of an inflammatory response to plaque, while dental caries is due to the irreversible solubilization by acid produced by dental plaque (Page and Schroeder, 1976). Therefore, concerning periodontal diseases, there have been many published articles that precisely reported the associations of either of the dietary factors including fatty acids and lipids (Varela-Lopez *et al.*, 2016), proteins and amino acids (Ceog, 2002), carbohydrates and sugars (Freeman, 2014) or probiotics with the incidence of dental diseases (Cagetti *et al.*, 2013), while there are limited data on the relation of nutritional factors and dental caries (Sonarkar *et al.*, 2014).

Diet consists of carbohydrates, proteins, lipids, vitamins, minerals and other trace elements which could all affect the process of dental caries. The most responsible dietary factors known for the development of dental caries are carbohydrates and sugar, which are supported by a large body of evidence (Bernabe *et al.*, 2014, Freeman, 2014, Gupta *et al.*, 2013, Palacios *et al.*, 2016, Pollard, 1995, Touger-Decker and van Loveren, 2003). Studies reported that there is a strong correlation between both the amount and frequency of sugar consumption and the development of dental caries, even in the use of preventative agents such as water fluoridation (Palacios *et al.*, 2016). It has recently found that in spite of the presence of cariogenic, anti-cariogenic, and cariostatic foods, other factors related to life status could also play important roles in the incidence of dental caries including body weight and childhood obesity (Costacurta *et al.*, 2014).

The hypothesis behind this review was that except for the presence of sugars and bacteria, other dietary micro and micronutrients as well as the life pattern including body weight might play crucial roles in the development or prevention of dental caries.

Materials and Methods

To identify the approaches of nutrition and dietary role in dental caries, a literature search within the SCOPUS, PubMed and Web of Science databases was conducted in November 2017; the search used the following two component search terms using “or” between them: “carbohydrate”, “fat”, “protein”, “vitamin and mineral”, “probiotics” and “lifestyle”, along with “dental caries”, “cavitation” and “or dental cavitation” as the second search component; the term “and” was used between the two components.

Inclusion criteria consisted of articles that reported any possible correlation between dietary components and dental caries; the search strategy yielded 190 publications; first, the abstracts were investigated and the articles that were irrelevant to the title were excluded which resulted in a set of 25 articles. Subsequently, the references of the publications yielded by the search were reviewed to identify additional relevant articles (3 articles), and a total of 28 papers were included in the review.

Results

The articles were classified according to the dietary component and their relation to dental caries, which are as the following:

Carbohydrate containing foods and dental caries as primary points

It has been many years that sugars have been known as the first important causes of the development of dental caries (Freeman, 2014). In fact, certain harmful oral bacteria feed on fermented carbohydrates (named as cariogenic foods) to create detrimental acids that destroy the tooth enamel which leads to decays. Fermented carbohydrates containing food means as well as sugars and sweats; refined carbohydrates such as rice, potatoes, bread, and even fruits can set the

scene for dental caries (Bernabe *et al.*, 2014). However, the exact cariogenicity effects of these food might differ from each other as in the study by Pollard et al. By measuring the acidogenicity and enamel demineralization of some fruits and food including oranges, apples, bananas, cornflakes, bran flakes, weetabix, alpen, white bread, whole meal bread, rice, and spaghetti, with positive and negative controls of sucrose and sorbitol, they found that although the low pH of oranges and apples caused more demineralization than sucrose, all foods were more cariogenic than sorbitol but less than sucrose (Pollard, 1995). Moreover, in a review by Moynihan et al, it was reported that dental caries increased with higher intake amounts of sugars up a 40% sucrose diet (Moynihan and Petersen, 2004). Thus, recommendations to replace sugar with starchy foods in order to avoid dental caries are of questionable value.

On the other hand, the food characteristic and the frequency of eating affect the dental decay equation (Palacios *et al.*, 2016). Physical characteristics of food link to the amount of time that they adhere to the teeth may increase the risk of tooth decay, since there is more time for bacteria to produce more acids. Furthermore, in between periods of meals, saliva works as neutralizing acids which helps the process of re-mineralization; hence, high frequency of eating may lead to dental erosion since the enamel does not have enough time to re-mineralize thoroughly (Touger-Decker and van Loveren, 2003). Concerning the frequency of eating carbohydrates, Bernabe et al. recently explored the relationship between the frequency of consumption of sugar sweetened beverages and caries increment over 4 years in adults and reported that a positive dose-response association existed regardless of the use of fluoride toothpaste and the participants' socio-demographic and behavioral characteristics. Precisely, he observed that adults drinking 1-2 and 3 or more of sugar sweetened beverages per day had, respectively, 31% and 33% greater significant net caries increments than those who did not drink any sugar sweetened beverages (Bernabe *et al.*, 2014).

Meanwhile, there are other dietary components than carbohydrates that are important in the incidence of dental caries.

Other dietary components and dental caries

Vitamins and Minerals: It has been recently stated that not only carbohydrates are linked to the development of dental caries but also other components including macro and micronutrients play important roles (Sonarkar *et al.*, 2014). In spite of the three common categories of foods including cariogenic foods such as fermentable carbohydrates, cariostatic foods that do not contribute to decay such as most vegetables, fats, and sugarless gum and anti-cariogenic foods that prevent dental decay such as cheese, proteins and chewing gum containing xylitol (Palacios *et al.*, 2016), vitamins and minerals deeply affect the prevention of tooth decay. Vitamin A, vitamin C, and vitamin D are crucial in the normal development and growth of epithelium cells and bone formations. Vitamin E and vitamin K involve in the enhancement of immunity and prevention of dental caries in mixtures of saliva and glucose, and the complex of vitamin B decrease caries by alleviating related organisms. On the other hand, despite the effects of minerals such as iron, copper and zinc on the collagen formation, wound healing and controlling the occurrence of oral inflammation, they prevent dental caries directly. Indeed, they are divided into four categories including; 1) cariostatic minerals; such as Fluoride and Phosphate, 2) mild cariostatic minerals; like Molybdenum, Galium, Strontium, Boron, Lithium, Aurum and Iron, 3) caries inert minerals which do not affect the process of decay such as Barium, Aluminum, Nickel, Palladium and Titanium, and 4) caries promoting minerals; such as Selenium, Magnesium, Cadmium, Platinum and Silicon. Hence, food containing such minerals may have different effects; for instance, various types of tea such as green, black and oolong which are rich sources of fluoride have anti-cariogenic actions as they inhibit bacterial adhesion, alpha-glucosyl

transferase, and salivary amylase. Furthermore, xanthene derivative property of caffeine has anti-cariogenic role; however, it is widely affected by the amount of used sugar.

Lipids: As it has been mentioned, lipids could have cariostatic characteristics and antibacterial properties at low ph. Lipids include oils, fats, waxes, triglycerides, and sterols and are defined as soluble organic compounds in nonpolar organic compound. They lead to enamel alteration by forming fatty films caused by reducing contacts between carbohydrates and bacteria (Sonarkar *et al.*, 2014).

However, data on the relation of salivary lipid contents with dental caries are conflicting. Kensche et al., who discussed the role of lipids in bio-adhesion and preventing caries in their review, reported that formation of a lipid enriched pellicle, which is the first step of bio-adhesion, might be more resistant against the acid exposure and could therefore reduce the loss of erosive mineral (Kensche *et al.*, 2013). Meanwhile, it is worth mentioning that the saliva of caries-susceptible individuals is similar in protein and carbohydrate distributions; while several differences were detected in their lipid contents. In fact, bacterial adherence could be induced by hydrophobic interactions and might be facilitated by a lipid-rich environment; however, the elevated levels of some specific lipids in saliva are more related to a higher incidence of dental caries and periodontal disease (Kensche *et al.*, 2013, Slomiany *et al.*, 1983). Neutral lipids in the glycoproteins derived from the saliva of caries-resistant individuals contain about 50 % and 38 % more cholesterol and cholestryl-ester, respectively, and 32 % less tri-acyl-glycerols than the related neutral lipids in salivary glycoproteins of caries-susceptible subjects. Moreover, concerning different phospholipids content of saliva, caries-resistant individuals had reported to have a higher content of phosphatidyl-ethanol-amine, while the salivary phospholipids among caries- susceptible subjects are rich in sphingomyelin and phosphatidyl-choline. Furthermore, the salivary glycoproteins of caries-susceptible persons contain more bound fatty acids which make them less prone to peptic degradation and thus exhibit a lower floating density and higher viscosity than those in the saliva of caries-resistant individuals (Slomiany *et al.*, 1983).

On the other hand, a recent meta-analysis was done by Fidalgo et al., who revealed that although higher concentration of total lipids, cholesterol, free fatty acids, glycolipids, glycerides, neutral lipids, phospholipids, and tri-acyl-glyceride existed more in the saliva of caries subjects than caries free ones, methodological quality and risk of bias have shown that there was a moderate association between dental caries and salivary lipid content (Tatiana Kelly da Silva Fidalgo *et al.*, 2012).

Regarding periodontal disease, another systematic review reported that types of lipids are associated with the onset and progression of this disease. On one hand, foods containing n-3 fatty acids have positive roles, due to their antioxidant and immuno-modulatory effects and on the other hand, as saturated fat-rich diets increase oxidative stress as well as intensity and duration of inflammatory processes, they must be avoided to intake (Varela-Lopez *et al.*, 2016). Findings suggest that vegetable oils can decrease the concentration of *Streptococcus. mutans* in human saliva as a supplement for oral hygiene and certain fatty acids such as linoleic and oleic acids might inhibit the overgrowth of bacteria. Vivo research studies also revealed such similarities for almond oil as well as positive effects of that on the buffer capacity of human saliva (Aguiar and Saliba, 2004, Kensche *et al.*, 2013).

Overall, edible oils might play a role as moderate supplements for the prevention of caries or periodontal diseases, but the exact benefits and mechanisms of action in different compositions of lipids in saliva or the interactions between lipids and oral pellicle layer have not been thoroughly investigated till now (Kensche *et al.*, 2013) and hence further research endeavors are necessary in this field.

Proteins: Although proteins are believed to have anti-cariogenic effects on teeth, studies reporting the beneficial relation of salivary proteins and dental caries are conflicting. In a meta-analysis by Martin et al., it was reported that although three of the seven included studies showed a relation between salivary proteins and dental caries in terms of protein phenotypes, total protein concentration and protein molecular weight, there was not sufficient evidence to establish salivary proteins as a biomarker for dental caries (Martins *et al.*, 2013).

Respecting the salivary composition, it is important to note that final structure of most proteins and peptides in saliva is defined by a complex series of molecular processes. Therefore, knowledge about the protein and peptide composition of saliva is necessary not just for the information about their functions but also for the growing interest in saliva based diagnostics (Helmerhorst and Oppenheim, 2007, Martins *et al.*, 2013).

An animal study assessed the effects of synthetic amino acid diets upon tooth decay in rats and showed that diet inclusion of penicillin, fluoride, and sodium bicarbonate and replacement of glutamic acid with monosodium glutamate could help to minimize dental erosion in rats. Indeed, when the basal amino acid mixture was altered by replacing glutamic acid with monosodium glutamate, the pH of the diet rose from 4.9 to 7.1 which leads to a reduction in molar damage. Furthermore, a similar reduction could be achieved when the basal amino acid diet was supplemented by sodium fluoride. On the other hand, administration of a casein diet enriched with 7% glutamic acid showed no signs of dental deterioration in rats (Ceog, 2002). It was suggested that replacement of sugar in the diet by equal amounts of casein, which is less susceptible to fermentation by the acid-producing bacteria, could be associated with the lower incidence of dental decay. Concerning lysine as another amino acids, significant reduction in dental caries among rats occurred when L-lysine was administered by diet or water (Harris, 1970, Nizel, 1970). Furthermore, Nizel et al. have reported that 0.5% L-arginine, 1% L-histidine, 0.25% L-ornithine, and L-cadaverine decreased caries development in rats that were fed with a skimmed milk powder diet (Nizel, 1970).

Taken together, animal studies have proved that addition of casein as a phospho-protein, appeared to be the most effective of all tested proteins in the reduction of dental caries. Moreover, it is known that both the amount and quality of protein affect the development of dental caries in the experimental animals (Nizel, 1970). However, there are limited published articles which prove that dietary supplements of protein can influence the development of dental caries among human.

Probiotics: The effect of probiotics was also investigated in a meta-analysis by Cagetti et al. and they found that probiotics, especially the *lactobacillus* and *bifidobacterium* strains, might play beneficial roles as antagonistic agents on mutans streptococci, acidogenic or aciduric bacteria which contribute to the reduction and prevention of caries process. Two-thirds of their selected papers showed that probiotics have demonstrated the capacity to reduce mutans streptococci counts in saliva and plaque which lead to a diminished tooth caries (Cagetti *et al.*, 2013). The effect of probiotics on plaque pH modification after a rinse with a 10% sugared solution was investigated and plaque acidogenicity significantly decreased in subjects that have used probiotic lozenges (Caglar *et al.*, 2008).

Probiotic bacteria are not able to colonize oral cavity permanently; therefore, a continuous regular, almost daily intake is required. A theoretical risk of the probiotic assumption is the increase of caries risk due to the capacity of probiotic strains to form biofilm and produce acids; however, this aspect was not taken into consideration by any papers (Cagetti *et al.*, 2013). A previous study showed that using probiotic and fluoride together had no statistically significant differences compared with either using probiotics alone or using combined effect of probiotics and low dosage of xylitol on cariogenic microorganisms. The currently available literature does not exclude the possibility that probiotic

bacteria can interfere with the oral biofilm; however, any clinical recommendation would be premature (Chuang *et al.*, 2011).

Life style and dental caries

It has been suggested that except for dietary factors, other life style factors such body weight and physical activity could be associated with tooth decay. Although both dental caries and obesity are associated with dietary habits, conflicting results have been published in this literature. Indeed, some studies have reported a positive association between obesity and dental caries (Alm *et al.*, 2008, Costacurta *et al.*, 2014, Hilgers *et al.*, 2006). Costacurta et al. confirmed the relationship between the prevalence of dental caries and body fat mass that was measured by DXA in their study. They also demonstrated that intake of sugar-sweetened drinks, frequency of sugar intake which is limited to main meals, and frequency of food intake between meals might be considered as common risk factors to both dental caries and childhood obesity (Costacurta *et al.*, 2014).

Alm et al. who investigated the relationship of body weight status in adolescents and snacking habits in early childhood with the prevalence of tooth caries using the International Obesity Task Force cut-off values, reported that overweight and obese adolescents had more caries on the approximal surface than normal weight individuals. Moreover, they have shown that the frequent consumption of snacking products during early childhood appears to be a risk indicator for caries at age of 15 years old (Alm *et al.*, 2008). Hyden et al. have done a meta-analysis and reported that a significant relationship between childhood obesity and dental caries was observed. In the analysis of dentition type (primary versus permanent), there was no significant association between obesity and dental caries in permanent and primary dentitions. However, after accounting for standardized definitions for assessment of child obesity using body mass index, a strong significant relationship was evident in children with permanent dentitions. Moreover, children in newly industrialized countries showed a significant relationship between obesity and dental caries compared to industrialized countries in which the cofactors such as age and socioeconomic class were significant moderators (Hayden *et al.*, 2013).

Age might be a significant confounding variable within the link between tooth development and dental caries (Hayden *et al.*, 2013). One possible explanation for this age-dependent relationship could be the increasingly sedentary lifestyles which are particularly seen among older children (Macek and Mitola, 2006). Increased rates of watching television in older children have been associated with an increased consumption of unhealthy diet and increased meal frequency, particularly snack intakes which is often rich in processed food and sugar (Stroebele and de Castro, 2004). This specific sedentary life style provides an opportunity for children to have increased energy intake from energy-dense; however, poor-nutrition foods that can augment the risk of weight gain, overweight and obesity which all accelerate the incidence of dental decay through an increased contact time between fermentable carbohydrates meals (Hayden *et al.*, 2013).

Conclusions

In this review, it was found that dental caries are not only related to simple dietary components such as sugars and sweetened beverages, but also to other existing factors including micro and micronutrients and probiotics as well as the life pattern. In this regard, intervention of specific programs focusing on health promotion and education strategies are needed which can promote healthy eating habits for dental health preventing the development of both dental caries and obesity. It can lead to alleviate the consumption of high sugar diets or other cariogenic foods that are associated with weight gain, and increasing the consumption of favorable cariostatic or cariogenic foods such as suitable proteins and fats.

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Authors' contribution

Salehi A conceived of the presented idea; Razmpoosh E conducted and wrote the article and Abdollahi S supervised the findings of this work; all authors read and approved the final manuscript.

Conflict of interest

The authors declare that they have no conflict of interest.

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