



The interrelationship between Nutrition and Periodontal Health among Children and Adults: A Literature Review

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ABSTRACT

Background and aim: Complex oral prophylaxis addressed to children and adults is conceptually related to contemporary dental medicine science and practice. Today, periodontitis is widely distributed worldwide, affecting between 40% to 90% of the global population. Many profound studies have been devoted to exploring, analyzing, and implementing the specifics of the interrelationship between dietary patterns and periodontal disorders. The purpose of the review is to investigate the interrelationship between periodontal health and nutrition among children and adults.

Material and methods: An initial analysis of 229 articles was performed. We investigated all the titles, abstracts, and available full-length texts, and, based on definite criteria, these papers were elected corresponding to the interrelation between various nutrients and periodontal health in children and adults. The analyzed 61 scientific resources, including reviews, clinical reports, and research articles from PubMed, Google Scholar, NIMH, and Elsevier, have been published in the last 15 years.

Results: Maintaining normal development and solid health corresponds to adequately arranged and properly performed dietary habits. Nutrition influences the health status during pregnancy and childbirth, through the stages of childhood development, and among adults.

Conclusions: Scientists established that the deviations from physiologically based nutrition, such as obesity and malnutrition, can affect periodontal health throughout the life of individuals. Future investigations can be useful for the clarification of the multi-aspect interrelations between nutrition and periodontal health.

1. Introduction

Complex oral prophylaxis addressed to children and adults relates to contemporary dental medicine science and practice. Today, periodontitis is widely distributed worldwide, affecting between 40% to 90% of the global population. The Seventy-fourth World Health Assembly accentuates the necessity of improving oral-dental health in multiple aspects. Scientists concentrate on increasing the quality of education and health care culture and training in various age groups. Parallel to promoting individual, group, and population well-being, the efficient management of poverty, food deprivation, and hunger have been thoroughly investigated.^[1, 2] An explicit tendency for the high rate of worldwide distribution of oral diseases affecting more than 3.5 billion people is based on scientific data from 1990 to 2017. Oral-dental disorders have been determined in complex interrelations with non-communicable diseases, resulting in significant health-related, social-economic, and behavioral-associated complications. The multifaceted problem of oral-dental diseases impacts the most vulnerable social categories,

reflecting the quality of life and psycho-emotional and physical welfare.^[3] The incessant and increasing interest of researchers on that topic also corresponds to the fact that the deteriorated oral health status among children and adults in different parts of the world amounts to the definite economic burden of US\$ 545 billion in direct and indirect costs. Oral-dental diseases have been categorized among the highest healthcare expenses-related common health disorders, such as cardiovascular diseases and diabetes mellitus.^[4] The review aims to investigate the interrelationship between periodontal health and nutrition among different age groups in the context of an integrative literature review.

2. Material and methods

An initial analysis of 229 articles was performed. We investigated all the titles, abstracts, and available full-length texts based on definite criteria; these papers were elected to correspond to the interrelation between various nutrients and periodontal health in children and adults. The analyzed 61

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scientific resources, including reviews, clinical reports, and research articles from PubMed, Google Scholar, NIMH, and Elsevier have been published in the last 15 years.

As inclusion criteria were determined:

Articles evaluating the role of macronutrients on periodontal health and prevention of periodontal diseases.

Papers assessing the importance of micronutrients- minerals for the health of the supporting apparatus and prevention of periodontal disorders.

Articles estimated the significance of micronutrients- vitamins for periodontal health and prevention of periodontal diseases.

The subject of the study was represented by individuals of different age groups- children and adults.

The excluded articles were equal to 168. All of them did not correspond to the inclusion criteria. As exclusion criteria were defined:

The study representatives come only from some parts of the world, with limited countries and regions.

The subjects of the study belong only to definite levels of social stratification.

Papers published earlier than the last 15 years.

3. Results

Today the problem of deteriorated oral-dental health affects unequally different countries. The most considerable impact is exerted upon people at the lower levels of social-economic stratification and those with physical and mental disabilities who cannot perform proper individual oral hygiene care.^[5] Simultaneously, in the context of the COVID-19 pandemic, complex dental prophylaxis procedures, therapeutic approaches, and oral health promotion have been distinguished by insufficiencies in their distribution in approximately 77% of the countries.^[5] The WHO focuses on a strategy for the period 2023-2030 related to identifying and limiting risk factors and providing favorable conditions for maintaining oral-dental health among children and adults. A definite accent is put on the utilization of the resources of teledentistry and telemedicine.^[5, 6] Periodontal diseases afflict the tissues that encircle and provide tooth stability. It has been established that almost 10% of the global population suffers from a severe degree of clinical manifestation of gum diseases and periodontal, bone resorption-related disorders, including the complications of tooth loss.^[6] Not to neglect the fact that the treatment of oral-dental diseases is expensive. It has been reported that dental therapeutic procedures in most high-income countries amount to almost 5% of the total health expenditure and 20% of out-of-pocket health expenditure. Many middle- and low-income countries are not provided adequate to the needs of patients preventive and therapeutic services concerning oral disorders.^[6] Individual nutritional status does not directly initiate oral disorders but impacts oral health.^[7] The Academy of Nutrition and Dietetics also focuses on the significance of nutrition for oral-dental tissues and structures. There are six basic categories of nutrients: proteins, lipids, carbohydrates, vitamins, minerals, and water. The macronutrients include proteins, lipids, and carbohydrates. These ensure the supply of energy and calories for the body.^[7] Vitamins and minerals are categorized as micronutrients. They are important for the development, growth, immune reactivity and resistance, and regeneration and protection of basic body structures and functions, including oral cavity tissues.^[7, 8] The specifics of the dietary regime on the individual, group, and population level can positively

or negatively influence the periodontium. In the norm, the processes of growth and development of the oral mucosa and periodontal tissues are initiated during gestation.^[7] The adequate intake of vitamins A, C, and B is a prerequisite for optimal oral health. Vitamin A is essential for salivary glands and epithelial tissues. Collagen and connective tissue depend on the sufficient supplementation of vitamin C. Vitamin B complex are of great importance for epithelial and connective tissues.^[7, 8] The 16th week of the intra-uterine development concerns the intensive processes of calcification and proper density of the alveolus and cementum, respectively, and the process of bone ossification, under conditions of an adequate supply of macro- and micronutrients, respectively, proteins, phosphorus, calcium, fat-soluble vitamins D and K, boron, and magnesium, iron, zinc, folic acid, copper and omega-3 fatty acids.^[8] Properly arranged and balanced nutrition patterns are also associated with adequate intake of minerals. They are categorized as major minerals and trace elements. Minerals represent approximately 4% of the body weight and are predominantly distributed in the skeleton, vitamins, hormones, and enzymes. Besides various functions, minerals are essential for bones and teeth.^[9] The deprivation of sufficient supplementation of nutrients affects oral cavity soft tissues, corresponding to the intensive 3- to 7-days-turnover of most oral mucosal cells.^[8, 10] In clinical cases of infection, blood loss, traumatic injuries, and tissue healing require high kilocalorie intakes. The clinical signs of disturbance of the periodontal ligaments' integrity, hemorrhage of gingival tissues, and pathological tooth mobility can be etiologically associated with insufficient amounts of vitamin C.^[7, 8] Calcium and vitamin D are important for ensuring proper bone homeostasis, including clinical attachment level and prevention of tooth loss. The successful outcome of periodontal surgery procedures and proper response of the immune system, with an efficient healing process and minimizing the risk of infections, also depends on the adequate intake of essential nutrients.^[7-10] The patients need to be regularly advised about the necessity and quantity of consumption of nutrients with direct or indirect impact on the morphological, physiological, and functional compound of periodontal structures and health.^[11-15] The collected, analyzed and summarized scientific literature sources, including reference 9 and references from 16 to 61 are interpreted and represented in Tables 1-3. There has been a tendency to increase the worldwide distribution of periodontitis. This inflammatory disease exercises a destructive impact upon the periodontal apparatus among 40% to 90% of the global population.^[53] There has been established a significant interrelation between obesity and periodontal diseases. Older patients' definite susceptibility to enhanced gingival bleeding has been related to a higher body fat content. In parallel, polyunsaturated fats (such as omega-3s) positively affect periodontal health.^[53] Recent research in Denmark shows that high protein intake is inversely related to periodontitis.^[54] Some alternatives to conventional sugars, such as xylitol, may exercise an antibacterial influence upon periodontal pathogens such as *Porphyromonas gingivalis* and *Aggregatibacter actinomycetemcomitans*.^[55] It is focused on the accumulative effect of limitation of sugar consumption, combined with scaling, root planning, and the use of xylitol- and maltitol-containing gums as prerequisites for improving the periodontal health of the general population.^[55]

Table 1. Macronutrients and periodontal health.

Macronutrients	Food Sources	Positive and Negative Roles for the Health Status of Periodontal Tissues	Periodontal Status-associated Insufficiency of Nutrients	References
Proteins	Meat, Fish, Dairy, Nuts, Seed	Essential for the assumption of dietary calcium and metabolism of vitamin D. ^[9, 60]	Delayed tooth eruption; decreased tooth size; reduced enamel sustainability; salivary gland dysfunction. ^[15-17]	[15-17, 9, 61]
Carbohydrates	Low-glycemic, unprocessed, complex carbohydrates (dairy, fruits, grains; whole grain, vegetables, legumes); high-glycemic, processed, fermentable carbohydrates (refined sugar, white wheat flour, sugary drinks).	A significant source of energy; support fat metabolism; low-glycemic carbohydrates, usually rich in fibers, are generally healthy; high-glycemic carbohydrates, usually poor in fibers as major causes of chronic inflammation; high caloric carbohydrate consumption causes systemic pro-inflammatory effects.	Influences the oral biofilm composition; may induce the onset of oral diseases (dental caries and periodontitis). ^[19-22] An influence of sugar on gingival inflammation; ^[22] Chewing raw vegetables promotes oral self-detoxification, less dental plaque build-up, reduction of periodontal inflammation. ^[23]	[19-23]
Lipids	Unhealthy saturated fats, such as trans fats and omega-6 fatty acids (industrial meat, dairy products, and eggs, vegetable oils (sunflower oil, sunflower oil, grape seed oil, and margarine); particular forms of food cooking, such as frying, baking or roasting.	Unhealthy saturated fats, such as trans fats and omega-6 fatty acids, promote inflammation. ^[24, 25, 29]	-----	[24, 25, 29]
Omega-3 fatty acids	Fish, Flax seed, Soybean oils	Improved healing after non-surgical periodontal therapy. ^[48-52]	-----	[48-52, 61]

Table 2. Micronutrients and periodontal health.

Micronutrients	Food Sources	Positive and Negative Roles for the Health Status of Periodontal Tissues	Periodontal status-associated Insufficiency of Nutrients	References
Calcium and Phosphorus	Dairy products, Fortified Foods, Seafood; Eggs, Canned Bony fish, Leafy vegetables, Nuts, Seeds	Formation of teeth and bones; improves outcomes of non-surgical periodontal therapy; local application for osseointegration. ^[19, 27] preventive effect of high dietary intakes on risk of periodontitis or gingivitis. ^[9, 59]	Lowered plasma calcium related to hypo-mineralization, compromised tooth integrity, delayed eruption pattern, absence of lamina dura, abnormal alveolar bone patterns. ^[16-19]	[9, 16-19, 27-29, 48-52, 59]
Boron	Fruits, Vegetables, Nuts	Useful for the maintenance of periodontal health	-----	[19, 28, 29, 48-52]
Copper	Shellfish, Oysters, Crabs, Liver, Nuts	Useful for the maintenance of periodontal health	-----	[19, 28, 29, 48-52]
Iron	Fish, Eggs; Red meat, Tuna, Dry beans, Spinach.	Possible anti-oxidant effect on periodontium. ^[19]	salivary gland dysfunction; very red, painful tongue with a burning sensation, dysphagia, angular cheilosis. ^[16-18]	[16-19, 28, 29, 48-52]
Magnesium	Whole-grain products, Nuts, Green leafy Vegetables; Cocoa, Soybeans, Spinach, Marine vegetables, Tomatoes.	Cell metabolism and bone formation; improvement of outcomes of non-surgical periodontal therapy. ^[19]	-----	[19, 28, 29, 48-52]
Zinc	Meat, Fish, Eggs, Nuts; Protein-rich foods, Spinach, Grains	anti-oxidant effect on the periodontium. Reduces the severity of diabetes-induced periodontitis. ^[19, 28, 29] In children, causes a decrease in the plaque index (P.I.) scores. ^[9, 59]	-----	[9, 19, 28, 29, 48-52, 59]

Probiotics	Yogurt, Cheeses, Kefir, Buttermilk, Sauerkraut	important for the maintenance of periodontal health	The impact on periodontal structures	[19, 48-52]
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Table 3. Vitamins and periodontal health.

Vitamins	Food Sources	Positive and Negative roles for the Health Status of Periodontal Tissues	Periodontal Status-associated Insufficiency of Nutrients	References
Vitamin A	Dairy, Eggs, fortified foods; cod liver oil, carrots, capsicum, liver, sweet potato, broccoli, leafy vegetables	Insignificant improvement in periodontal health upon supplementation. ^[26, 30] A higher intake of vitamins A, B, C, and E, along with omega-3 fatty acids, results in improved healing after non-surgical periodontal therapy. ^[52]	Decreased epithelial tissue development; impaired tooth formation; enamel hypoplasia. ^[16, 17, 19]	[16, 17, 19, 26, 28-30, 48-52]
Betacarotene	Yellow, Orange, and dark Green fruits, Vegetables			
Vitamin E (TOCOPHEROL)	Vegetable oils, Whole-grain, Nuts, Green vegetables, Egg yolk	A higher intake of vitamins A, B, C, and E, along with omega-3 fatty acids, results in improved healing after non-surgical periodontal therapy. ^[52]	Deficiency may lead to gingival bleeding. No known effects on periodontal therapy if supplementation is used as an adjunct. ^[16, 17, 19]	[16, 17, 19, 28, 29, 48-52]
Vitamin D (CALCIFEROL)	Sunlight, Fish, Fortified foods, Eggs, Mushrooms, Liver, Milk	Local application may accelerate post-surgical healing/osseointegration. ^[19, 26, 27, 29] The effect of dietary calcium amount may be depend on the adequacy of other nutrients such as vitamin D and proteins. ^[9, 60]	Lowered plasma calcium, hypomineralization; compromised tooth integrity; delayed eruption pattern absence of lamina dura, abnormal alveolar bone patterns. ^[16-18] Deficiency may lead to delayed post-surgical healing. ^[19, 26, 27, 29] Vitamin D deficiency contributes to negative outcomes following periodontal surgery. ^[52]	[9, 16-19, 26, 27, 29, 48-52, 61]
Vitamin K	Green leafy vegetables, Dairy products	-----	-----	[19, 48-52]
Folic acid (folate)	Green leafy vegetables, Fortified foods	-----	-----	[19, 48-52]
Vitamin C (ascorbic acid)	Citrus fruits and juices, Peppers, Broccoli, strawberries, Liver.	Maintaining and repairing the healthy connective tissue. ^[16, 17, 19, 20] Supplementation may improve outcomes of periodontal therapy. ^[19, 26, 29] A higher intake of vitamins A, B, C, and E, along with omega-3 fatty acids, results in improved healing after non-surgical periodontal therapy. ^[52]	Irregular dentin formation, dental pulpal alterations bleeding gums, delayed wound healing, defective collagen formation. ^[16, 17, 19] Gingival bleeding and inflammation as hallmarks of scurvy. ^[16, 17, 19]	[16, 17, 19, 20, 26, 29, 48-52]
Vitamin B Vitamin B1 /Thiamine/	Liver, Oats, Pork, Potatoes, Eggs	Supplementation results in higher clinical attachment following flap surgery. ^[52] A higher intake of vitamins A, B, C, and E, along with omega-3 fatty acids, results in improved healing after non-surgical periodontal therapy. ^[52]	Cracked lips, angular cheilosis. ^[16, 17, 19]	[16, 17, 19, 29, 48-52]
Vitamin B2 /Riboflavin/	B2—bananas, dairy, green beans	-----	Inflammation of the tongue, angular cheilitis, ulcerative gingivitis. ^[16, 18, 19]	[16, 18, 19, 29, 48-52]
Vitamin B3	B3—eggs, fish, meat,			

/Niacin/	mushrooms, nuts			
Vitamin B6	-----	-----	Periodontal disease, anemia, sore tongue, burning sensation in the oral cavity. ^[16, 18, 19]	[16, 18, 19, 29, 48-52]
Vitamin B12	Animal products	-----	Angular cheilitis, halitosis, bone loss, hemorrhagic gingivitis, detachment of periodontal fibers, painful ulcers in the mouth. ^[16, 18]	[16, 18, 19, 29, 48-52]

Some researchers accentuate the role of anti-oxidants in periodontal health. Under physiological conditions, aerobic respiration results in the production of Reduction Oxidative Stress (R.O.S.). R.O.S. and highly reactive free radicals are responsible for impairing cells and tissues. Simultaneously, the anti-oxidant defense enzymes decrease the levels of R.O.S., reducing the degree of cellular damage.^[52, 53] In parallel, the production of R.O.S., affecting periodontal tissues, is enhanced under conditions of inflammation or injuries of tissues. Oxidative stress status is ascertained when the equilibrium between R.O.S. production and the anti-oxidant system's enzymes has deteriorated. Some nutrients have the activity of anti-oxidants, with the explicit potential for maintaining periodontal health and optimizing the healing process.^[52, 53] Among the essential anti-oxidants are concerned vitamins A, C, and E, which have a role in the cells' metabolism and modulation of the anti-oxidant protection system, including in the periodontium. Some investigators established differences in the anti-oxidant capacity of vitamins A, C, and E for the reduction of the progression of periodontitis among non-smokers and smokers. The recorded tendency to decrease the severity of periodontitis in non-smokers has not been validated among smokers.^[52] Melatonin is not characterized as a basic nutrient. However, it has been commented that in supplement form, its anti-oxidative traits can be more explicit than those of vitamin E, including the eventual therapeutic potential of melatonin for the oral cavity structures, especially periodontium.^[52] Some authors have suggested that the adequate supply of lycopene by means of vegetables, such as tomatoes, carrots, and watermelons, may improve periodontal health.^[56]

Besides the various characteristics of nutrients, their role and significance for periodontal health are also associated with the age-related specifics on individual, group, and population levels. In the context of a dental health survey, a considerable rate of 85% of the participants with diagnosed periodontitis were 65 years or over. The decrease in the number of natural teeth parallel to the age corresponds to enhanced masticatory stress for the remaining teeth.^[57] A state of masticatory deficiency can also be related to the presence of dentures and implants and to xerostomia. Patients can have difficulty consuming definite types of foods, for instance, beef, carrots, crusty bread, and potato chips.^[57] Common health disorders and intake of medicines can afflict the absorption and metabolism of some nutrients resulting in nutritional deficits. There is an accent on the significance of thorough, regular, and adequately corresponding to the needs of patients and dental consultations in the scope of dietary habits and regime. Consequently, a definite increase in the quality and standard of life among older adults can be expected.^[57] Some researchers accentuate two micronutrients, selenium, and manganese, cofactors of anti-oxidant enzymes. Both of these minerals reduce the degree of oxidative damage to lipid membranes.^[9] Authors focus on the necessity of future investigations of magnesium, zinc, copper, manganese, and selenium in their role in the proper maintenance of the immune system and anti-oxidant

systems not only on the individual systemic level but also for the health status of the periodontal apparatus.^[9, 58]

4. Discussion

Nutrition is essential for the proper functionality of the immune system and efficient prevention of non-communicable diseases such as diabetes mellitus and cardiovascular disorders. It is with great significance also for oral-dental health. According to the W.H.O.: "Nutrition is the science of food and its relationship to health."^[61] In parallel, malnutrition is related to the insufficient supplementation of the body with the required quantity of minerals, vitamins, and other micro- and macronutrients, which are of great importance for the normal morphological traits and proper functionality of tissues, organs, and systems.^[16-19] There have been established interactions between malnutrition and the oral-dental state. From one side, some disorders, like salivary gland hypo-function and enamel hypoplasia, may result in malnutrition. On the other hand, malnutrition may affect the homeostasis in the oral cavity, reflecting upon teeth eruption, increased susceptibility to pathological microbial biofilm, and inhibition of the potential of tissues' recovery.^[16-19]

The health of periodontal tissues significantly correlates to the diet. Periodontal disorders are more explicitly manifested among undernourished individuals. Some researchers emphasize the role of malnutrition and bad oral hygiene as predisposing factors to necrotizing gingivitis.^[16-19] A retrospective cohort study confirmed that exposure to Early Childhood Protein-Energy Malnutrition (E.C.P.E.M.) corresponds to a poor periodontal status in the permanent dentition during adolescence. The authors focused on the influence of nutrition on the development of the immune system and immunological reactivity to the invasion and colonization by periodontal pathogens.^[16-20] A recent tendency among adults has outlined a definite increase in the burden of oral-dental disorders on the quality and standard of life. Various studies have demonstrated the interrelations between malnutrition and oral health in older people.^[11, 13-16] Deteriorated oral health can be clinically manifested by initiated or progressing periodontal disorders, tooth loss, masticatory problems, and oral pain. These can afflict the nutritional intake, respectively the nutritional status, with a risk of malnutrition.^[18-22]

In the context of systemic reviews of scientific literature sources from the period 2000-2020 has been investigated and analyzed the relation between malnutrition and oral health, with accents on hard and soft tissues, dynamics of salivary flow, and xerostomia among people of or over the age of 60 years.^[19-21] A large number of cross-sectional studies focused on the role of malnutrition among adults in provoking and aggravating pathological conditions such as gingival inflammation and bone loss-associated periodontal diseases, candidiasis, glossitis, and cheilitis.^[22-47, 48-52] The process of periodontal inflammation can be positively influenced by the proper

consumption of vitamins, minerals, omega-3 fatty acids, vegetable proteins, and unprocessed complex carbohydrates. Simultaneously, the deterioration of the condition of periodontal inflammation can be associated with the intake of pro-inflammatory saturated fatty acids, non-vegetable proteins, refined carbohydrates, unbalanced supply of vitamins and minerals.^[19-21] Some scientists ascertain that among individuals following a vegetarian diet, a decreased rate of gum inflammation was recorded, combined with improved oral hygiene levels.^[19] A cross-sectional clinical study examined the periodontal status of 100 vegetarians compared to 100 non-vegetarians. The researchers established that the vegetarian group of participants was characterized by considerably lower levels of pocket depth and reduced bleeding on probing compared to the non-vegetarian participants.^[19] Macro- and micronutrients are characterized by the potential to modulate pro-inflammatory and anti-inflammatory cascades, respectively, the host immune response. That is associated with the activity of periodontal pathogenic bacteria and its metabolic products, which aggravates tissue damage. In parallel, fibroblasts and leucocytes release many inflammatory mediators: proteolytic enzymes, metalloproteinases, cytokines, and prostaglandins. The inflammatory substrate originating from the periodontal structures causes tissue and bone destruction.^[20-22] Many factors can affect the absorption and utilization of nutrients. These factors are age, dietary patterns, medical conditions, harmful habits (smoking), and genetics.^[9, 19, 48-52]

5. Conclusion

A great variety of research has been devoted to analyzing the complex interrelations between nutrition and oral-dental health among children and adults. It has been established that nutrition influences oral-dental health status through the stages of childhood development and among adults. Scientists ascertained that the deviations from physiologically based nutrition, such as obesity and malnutrition, can affect periodontal health throughout the life of individuals. Future investigations can be useful for the detailed clarification of these multi-aspect interrelations.

Conflict of Interest

The authors declared that there is no conflict of interest.

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