

Host response, obesity, and oral health

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Abstract

Proper food choices are part of preventing or reducing the risk of dental caries and periodontal disease. A significant association has been proven between oral diseases and the incidence of systemic diseases. Obesity, just like smoking, is one of the major risk factors for oral disease and is a serious social problem that has reached epidemic proportions in many developed countries. The results of studies on periodontitis confirm the relationship between the values of body mass index (BMI) and the prevalence of periodontal diseases. Adipose tissue is an active endocrine organ and it performs many important functions in the body, such as thermal isolation and protection, storage, and secretion. Many cytokines are secreted proportionally to the amount of fat present and are actively involved in the metabolism of the whole system, including the functioning of the immune system. Therefore, obesity may alter the response of the host to the antigens derived from bacterial plaque, and thus cause disturbances in the inflammatory response in the course of periodontal disease.

Key words: obesity, host response, oral health, oral diseases.

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The modern definition of health takes into account human nutrition in the context of the broadly understood promotion of a healthy lifestyle. Health promotion includes the rational choice of diet for both the individual and particular social groups. Proper nutrition of the organism consists of providing a suitable amount of proteins, carbohydrates, lipids, and mineral salts. Proper food choices are part of preventing or reducing the risk of dental caries and periodontal disease. A significant association has been proven between oral diseases and the incidence of systemic diseases. Many patients do not realise the connection between the general state of human health and oral health and diet. Providing clear and accurate information on proper nutrition and a well-balanced diet, as well as a basic knowledge of oral health, will allow patients to understand the importance of a proper diet, not only for the prevention of systemic diseases, but also for the prevention of diseases of the teeth and periodontium. Preventive dentistry consists primarily of adherence to a regimen of daily home oral hygiene and proper eating habits [1]. Consistent implementation of the basic principles of a balanced and optimally matched diet to an individual patient's needs is also very important in this respect, which recommends appropriate consumption of proteins, carbohydrates, and fats as well as products containing minerals and vitamins. The nutrition and quality of the supplied nutrients play a crucial role in the comfort of human life, and have a significant impact on

the preventive and health actions, and the course of possible therapeutic intervention. It should be emphasised that both the presence of excess adipose tissue, and its deficiency, may lead to disturbances in the normal regulation of systemic metabolic processes. Failure to comply with the basic dietary principles, and long-term improper nutrition, can lead to pathological conditions involving significant malnutrition or obesity, which in turn has a negative impact on oral health.

Obesity, just like smoking, is one of the major risk factors for oral disease and is a serious social problem that has reached epidemic proportions in many developed countries. In the United States of America, obesity is considered one of the most common causes of death that could be prevented [2, 3]. Improper lifestyle is responsible in 70% for the risk of obesity, and only 30% of the risk is attributable to genetic factors [4, 5]. High blood pressure, high cholesterol, type 2 diabetes, cardiovascular disease, stroke, kidney disease, certain cancers, and diseases of the oral cavity are examples of chronic conditions negatively associated with obesity [6-8]. Especially dangerous is an early form of obesity that occurs in very young persons, which, if left untreated and unmanaged, deepens into adulthood and leads to serious metabolic and organ disorders [9]. There was a positive correlation found between the presence of periodontal disease and obesity in adults aged 17-21 years [10]. It has been shown that the prevalence of periodontal disease in obese

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young people aged 18-34 years is, by approximately 76%, significantly higher compared with those of the same age with normal body weight [11].

Special anthropometric indicators are applied in the case of obesity diagnosis to assess the degree of the risks of various systemic and general diseases, including periodontal disease [12, 13]. The most common way to measure obesity is to calculate body mass index (BMI). Body mass index is calculated by dividing weight in kilograms by the square of height in metres. This gives information on the extent of body fat and at the same time the risk of diseases associated with obesity. The results of the studies on periodontitis confirm the relationship between the values of BMI and the prevalence of periodontal diseases [14]. Studies conducted in the United States in subjects with overweight and advanced obesity showed a positive correlation between BMI and parameters estimating the level of oral hygiene and describing the clinical condition of the gingiva and periodontium [15, 16]. A study conducted in Japan showed a statistically significant correlation between BMI and the depth of periodontal pockets in women with obesity, and demonstrated that BMI above 30 kg/m² increased by more than four-fold the risk of periodontitis [17]. Other Japanese studies that analysed the periodontal status using CPITN index (Community Periodontal Index of Treatment Needs), evaluating the periodontal treatment needs, demonstrated a positive correlation between the exacerbation of symptoms indicating significant progression of periodontal disease and the increase in body weight measured by BMI [18].

Other parameters that are used to determine the progress of obesity are an assessment of waist circumference, the ratio of waist to hip circumference, and the measurement of total body fat. There are also works in the literature, providing evidence for the existence of a relationship between the above-listed parameters of the degree of obesity qualification and indicators evaluating the progression of periodontal disease and oral hygiene [19].

Adipose tissue is an active endocrine organ, and it performs many important functions in the body, such as thermal isolation and protection, storage, and secretion. The cells of adipose tissue, called adipocytes, secrete dozens of biologically active molecules, which can significantly modulate reactions occurring in the body. These include leptin, resistin, tumor necrosis factor α (TNF- α), interleukins: IL-1, IL-6, IL-8, and IL-10, growth factors, complement components, angiotensinogen, plasma plasminogen activator-1 (PAI-1), and a number of other substances. Many cytokines are secreted proportionally to the amount of fat present and are actively involved in the metabolism of the whole system, including the functioning of the immune system. Therefore, obesity may alter the response of the host to the antigens derived from bacterial plaque, and thus cause disturbances in the inflammatory response in the course of the periodontal disease [20, 21].

Periodontitis is a disease process that causes progressive destruction of the periodontal tissues, including the loss of gingival connective tissue, destruction of periodontium, and alveolar bone resorption. Aetiological factors are microorganisms derived from plaque, while inflammation is a host response to bacterial antigens. The most commonly isolated bacteria from pathological periodontal pockets in chronic periodontitis diagnosed in patients over 35 years of age are: *Porphyromonas gingivalis*, *Treponema denticola*, and *Tannerella forsythia*, whereas in young people before the age of 35 *Aggregatibacter (Actinobacillus) actinomycetemcomitans* is the main species found in the periodontal pockets. The latter bacterium has been associated with aggressive periodontitis. Multiple mediators of inflammation and immune response are detected in gingival crevicular fluid during periodontitis [22, 23]. Patients with periodontitis show a significant increase in the levels of IL-6, IL-8, and TNF- α in gingival crevicular fluid. A positive correlation was demonstrated in patients with significant obesity and coexisting periodontal disease between the concentrations of these cytokines in gingival fluid and BMI values. The study by Bruun *et al.* showed a significant reduction (25-30%, $p < 0.001$) in the levels of TNF- α and IL-6 in the peripheral blood serum of obese patients after switching to a calorie-restricted diet [24].

A statistically significant increase in TNF- α in peripheral blood serum has been found in overweight and obese people, which was derived from the accumulated body fat, which could promote the development of periodontal disease or exacerbate the course of already existing disease. Tumor necrosis factor α stimulates fibroblasts to synthesise enzymes degrading extracellular matrix proteins, and osteoclasts to activate bone resorption. The expression of IL-6 starts in adipose tissue, and it is subsequently released into the circulation. It is a cytokine, the elevated serum of which is considered an indicator of increased risk of cardiovascular events, especially in obese individuals. Interleukin 6 is also involved in the mechanisms of uncontrolled gains of body weight in patients with refractory obesity. In the course of periodontitis, IL-6 activates osteoclasts in the process of destruction of lamina dura of alveolar bone and induces periodontal tissue destruction via activation of matrix metalloproteinases, collagenases in particular [25].

Most obese people have abnormal lipid parameters, including mainly significant increase in triglycerides. Hyperlipidaemia is one of the symptoms that are often observed in the course of infectious diseases. A significant positive correlations was found in overweight and obese people between elevated levels of peripheral serum lipids and indicators of periodontitis [26].

Blood vessels of periodontium in obese people have thickenings on the most inner walls, which is a symptom of reduced blood flow. It is believed that this is the effect of action of the PAI-1 – adipokine, the level of which is markedly increased in visceral fat in obese individuals.

The reduction of blood flow in periodontal vessels is one of the pathogenic mechanisms of the development of periodontal disease [27].

In recent years, a significant increase in the proportion of people suffering from type 2 diabetes among adults has been shown, which is primarily due to increased obesity induced by the decrease in glucose tolerance. The incidence of type 2 diabetes among obese adolescents is increasing significantly. Type 2 diabetes primarily affects obese middle-aged people who have a sedentary life style. It is believed that TNF- α produced by adipose tissue is critical in the pathogenesis of insulin-dependent diabetes mellitus and in the presence of insulin resistance. It is also a common “denominator”/factor linking obesity and periodontitis. Patients with type 2 diabetes are twice as likely to suffer from periodontal disease compared with those without diabetes. Obesity is a risk factor for both type 2 diabetes and periodontal disease. Moreover, diabetes increases the risk of gingivitis. Inflammation induced by pro-inflammatory cytokines produced in adipose tissue, and locally in the case of gingivitis, is a common feature of insulin-dependent diabetes, periodontal disease, and obesity [28].

It is known that obesity lowers insulin sensitivity, which leads to insulin resistance. Giant fat cells – adipocytes – occurring in adipose tissue in obese patients, have a number of metabolic functions, including the regulation of energy levels in the body by the secretion of biologically active molecules and hormones [29]. One of them is leptin – a hormone produced by fat cells, which plays a key role in regulating body weight. Leptin increases fat storage, reduces appetite, and is one of the inducers of insulin secretion by the pancreas. The concentration of leptin in the blood plasma of obese people is significantly increased due to the storage of large amounts of adipose tissue, which in turn causes a lack of the suppressive action of leptin on appetite. This paradox is known as leptin resistance. Obese patients can be characterised by two states of resistance: insulin resistance and leptin resistance [30]. These characteristics must be complemented with a very high risk of periodontal disease and gingivitis as well as increased risk of incidence of dental caries [31-33].

Dental caries is a chronic pathological condition, attacking mineralised structures of teeth, with a multifactorial but well understood aetiology. The main link in the aetiological chain of dental caries is obviously cariogenic microorganisms from dental plaque, mainly *Streptococcus mutans* group, in combination with carbohydrate diet. The passage of time is required, so that the demineralising action of the acid, which is a product of sugar metabolism by bacteria, can injure the hard tissue structure of the tooth. Various additional parameters should also be included, of which the most important are dietary habits and socioeconomic and demographic factors. Numerous studies exist, both clinical and experimental, concerning dental caries.

However, little is known about the relationship of caries with obesity. The available literature shows that obesity is certainly associated with the occurrence of early childhood and puberty caries. Mod er *et al.* demonstrated that children/adolescent obesity (age of patients: 10-17 years) was significantly correlated ($p < 0.001$) with the surface of teeth affected by caries as well as plaque and gingivitis indices [34]. Studies carried out in adults with severe overweight, obesity, and coexisting diabetes indicate a significantly higher frequency of caries in these patients compared to the control group, i.e. people with diabetes without obesity [35, 36]. However, it is difficult to clearly ascertain whether this is only due to the significant overweight or diet, nutrition, and hygiene negligence, which are often caused by an extremely complex and difficult to diagnose psychological and image situation, in which obese adult patients often find themselves.

A separate discussion should be dedicated to so-called metabolic syndrome (MS), which is very often diagnosed in patients with overweight and obesity. This syndrome, also known as insulin resistance syndrome, is caused by both genetic and environmental factors, of which the most important are the lack of physical activity and excessive food intake [37-39]. There are several definitions concerning this disease entity, provided by the World Health Organisation (WHO 1998), the International Diabetes Federation (IDF 2006), the European Group for the Study of Insulin Resistance (EGIR 2002), and several other medical organisations. These definitions possess several common biological and clinical features, which as a consequence of chronic synergistic action lead to serious systemic disorders. The clinical diagnosis of MS is based on the identification of three of the five recognised criteria, including mandatory abdominal obesity. These are: abdominal obesity – for women (waist circumference) > 88 cm; for men (waist circumference) > 102 cm; elevated triglyceride levels > 150 mg; reduced HDL cholesterol < 50 mg for women and < 40 mg for men; glucose in blood glucose on an empty stomach > 100 - 110 mg; and high blood pressure $> 130/85$ mm Hg. It has been shown that individuals diagnosed with MS are significantly more prone to caries and periodontitis compared with the reference group. What is more, a statistically significant positive correlation was found between the diagnostic criteria of metabolic syndrome and clinical parameters estimating the severity of periodontal disease [40].

The severe and often irreversible effects of obesity on health and the mental condition of the obese person indicate that studies on a possible association of obesity with many systemic and oral diseases are extremely important and necessary. Obesity has a negative impact on both general health and the health of the oral cavity. Promoting healthy eating behaviour and appropriate physical activity are fundamental elements of modern prophylaxis of periodontal and teeth diseases and prevention or reduction of

obesity. Highly important is the selection of adequate nutrients, in relation to the age group, health status, physical activity, and the type of work performed by the person for whom the diet is designed. Nutrients should be consumed in adequate quantities and proportions. Restriction of carbohydrates and a reduction in fat intake cause not only a significant decrease in the incidence of dental caries and a significant improvement in clinical condition of periodontium, but also considerably affect the processes that reduce body weight. Children from an early age should be provided with a diet rich in minerals and vitamins, which directly affects the proper development of teeth and periodontal tissues and is of great importance in preventive dentistry. School meals for children in preschool and school age should contain all the recommended nutrients: first of all milk, cheese, cottage cheese, lean meat, fish, eggs, fresh vegetables, and fruit. It should be ensured that meals are eaten at least five times a day. Regular drinking of milk and dairy products and increased consumption of fruits, vegetables, and whole grains is beneficial to the clinical condition of the teeth, periodontium, and oral mucosa. Similar recommendations should also be addressed to adults. Another important element of proper nutrition for children and adults is to reduce frequent eating between meals, called snacking. This particularly applies to sweet snacks.

A properly constructed diet and adequate nutrition are some of the most important factors conditioning normal development of the entire stomatognathic system, primarily including the morphological and histological structure of the teeth and specific structure of periodontal tissue, which in combination with daily and regular oral hygiene will help to maintain healthy teeth and periodontium for a long time.

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