The role of natural antioxidants in the prevention of periodontal diseases

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Abstract

Background: Oxidative stress is a key causative factor in chronic inflammation and plays a key role in the pathogenesis of many chronic inflammatory diseases, including periodontitis. A properly balanced diet abundant in vegetables and fruits can be a rich source of biologically active substances that inhibit reactions with oxygen and ozone. The aim of the study is to assess the influence of natural antioxidants contained in vegetables and fruits on the occurrence and progression of periodontal diseases. Methods: The study covered a group of 368 students of the third grade (at the age of 18) of general secondary schools from the urban environment. The surveyed youth completed a survey regarding their dietary and hygienic habits. Subsequently, they participated in an oral cavity study in which the values of the plaque PL.I and gum GI index were assessed. Results: The beneficial effect on periodontal tissues resulted from eating of fruits and vegetables and frequent consumption of apples and carrots (median GI = 0). Eating of potato chips and crisps and the use of quick-service bars intensified gingivitis (median GI = 0.1). Conclusions: A diet intensifying oxidative stress influenced the deterioration the clinical status during the developmental age.

Background

Periodontal disease is inflammation, atrophy or abnormalities of surrounding and supporting tissues, i.e.: gums, alveolar bone, periodontium and root cement. They are classified as gum disease, chronic periodontitis, aggressive periodontitis, periodontitis in the course of systemic diseases, acute periodontitis and deformations and congenital or acquired defects. The most common form of diseases of the teeth supporting structures is inflammation. It usually begins as a related or non-plaque associated gingivitis, which if left untreated changes into periodontitis [1].

Periodontal diseases are social diseases. Currently, it is assumed that periodontitis is so-called a comprehensive disease which clinical picture depends on the interaction of many environmental factors and genetic determinants. The main social and environmental risk factors determining the occurrence of periodontal disease include stress, social and living conditions, education, nicotinism, general illnesses, obesity, bad oral hygiene. In etiopathogenesis, the immune-inflammatory response and the host genotype are also important. The literature has also proved a significant influence of oxidative stress on the severity of abnormalities in periodontal tissues [1, 2].

Oxygen is essential for the proper functioning of the human body, however, this element can also be a source of adverse reactions to the body. This is related to the formation of reactive oxygen species (reactive oxygen species–ROS, RFT) and free radical reactions [3]. The formation of ROS should be under the control of an enzymatic and non-enzymatic antioxidant system. If this system is impaired, then the cell disturbs the pro-oxidative-antioxidant balance, which we call oxidative stress [4,5]. It is the result of many factors. These include, among others: toxins (including heavy metals, herbicides, pesticides), heavy physical exercise, poor diet (diet low with vegetables and fruits, high fat), cold, stress (emotional or physical), past viral and bacterial infections, some drugs (e.g. chloramphenicol, nitrazepam, cyclosporin), as well as stimulants such as alcohol consumption or smoking [6]. The source of endogenous ROS are lung endothelial cells, neutrophils and eosinophils, macrophages and monocytes. ROS may also arise due to physical factors such as ionizing and ultraviolet radiation or ultrasound [7]. An important source of reactive oxygen species are, moreover, pathological processes occurring in cells, which are inflammatory processes [8].

The most important reactive forms of oxygen are ozone , singlet oxygen), superoxide anion radical a hydroperoxide radical (hydroxyl radical dihydrogene dioxide nitric oxide and nitrogen dioxide [9]. In physiological concentrations, ROS perform important regulatory functions, such as signal transmission intracellular or between cells, influence on signalling cells or relay molecules, participate in processes such as muscle contraction, hormone secretion, regulation of vascular tone or in immune system reactions. In addition, they determine the bacteriostatic and germicidal activity of saliva, and also take part in the elimination medicines from body cells [10]. At concentrations higher than physiological, ROS can damage cells. Some effects of this action include: oxidation of low molecular weight compounds (glutathione, ascorbate, nicotinamide adenine nucleotides), depolymerization of hyaluronic acid, deterioration of the function of pulmonary surfactant, oxidation of haemoglobin, DNA strand breaks, chromosomal damage, membrane lipid peroxidation, erythrocyte lysis, platelet aggregation or neoplastic transformation of cells. The two most important mechanisms causing oxidative stress in the body are inflammation and tissue ischemia followed by reperfusion [9].

The activity of reactive oxygen species is balanced by antioxidants, i.e. antioxidants. This term, very popular in recent times, means compounds that have properties that protect the body's cells from oxidation, causing the transformation of reactive oxygen into inactive derivatives.

There are two mechanisms involved in the removal of reactive oxygen species: an enzymatic system consisting of superoxide dismutase, catalase and peroxidase and glutathione reductase, and a non-enzymatic system that forms self-supporting protective substances in the oxidized form, and thus characterized by low reactivity. Transmission of free radicals to their electrons prevents the oxidation of other components. These substances are distinguished by exogenous compounds that are soluble in both water and fats and endogenous compounds [11]. The best-known exogenous antioxidants include (among others): vitamin C, vitamin A (retinol), β-carotene (provitamin A), vitamin E, α-lipoic acid, coenzyme Q10, polyphenols (including flavonoids), carotenoids and melatonin [12].

The rich source of natural antioxidants are vegetables and fruits. These compounds are mainly polyphenols, vitamins A and C, tocopherols, carotenoids, selenium, indoles, phytonates, toluine, chlororiline and glutathione [13]. A diet abundant in antioxidant-rich products can be an important component in the prevention of periodontal disease.

The paper attempts to evaluate the effect of a diet rich in antioxidants on the occurrence of periodontal diseases. The influence of the frequency of fruit and vegetable consumption on the occurrence of GI changes in the gum index was assessed.

Methods

The study covered a group of 368 students in the third grade of general secondary schools from the urban environment. Consent to its conduct was expressed by the Medical University of Bialystok Bioethical Committee (Nr R-I-002/74/2011). The study was voluntary and individual. Each person has given written consent to participate in the study.

The first part of the study consisted in filling in an original questionnaire consisting of 72 questions regarding the socio-economic situation of students and their eating habits. The questions concerned issues related to the type of food consumed, eating, diets used by the students, self-assessment of diet, as well as a qualitative assessment of the food and drink consumed.

The second part of the study concerned a clinical evaluation of oral health. The students were subsequently admitted to the school nursing office. According to the guidelines of the World Health Organization, tests were carried out with artificial lighting, using basic dental diagnostic tools: mirror, probe and periodontal probe, including all aseptic and antisepsis principles.

Data obtained during the study was applied to a specially designed clinical trial card. The oral health assessment was based on the state of dentition, mucous membrane and periodontium.

Oral and periodontal hygiene assessments were made using the following indicators:

- plaque index P1.I according to Silness and Loe

- gingival index GI

The clinical advancement of gingivitis was assessed according to the criteria given in Table 1.

The set of results for the above-mentioned tests was obtained for a group of 284 patients.

The obtained test results were subjected to statistical analysis. Nonparametric tests were used: the Mann-Whitney test - when comparing two groups of data and the Kruskal-Wallis nonparametric analysis of variance test, with Dunn-Bonferroni post-hoc test - when comparing more groups. Statistical calculations were done using Statistica 12.0 from StatSoft. A level of significance was assumed for all verified hypotheses at
$\alpha = 0{,}05$.

Results

In the study group, female students accounted for 69.0%, and male students 31.0% (Fig.1).

The reported values of gingival index GI, which determined the inflammation of the gums, ranged from 0 to 2.5. The histogram of the distribution of the index values in the studied group of adolescents is shown in Fig. 2. Low values of the indicator prevail. Among 44.0% of subjects, no gum disease (index equal to zero) was found. In the case of 50% of the tested values, the index did not exceed 0.2 (median 0.2), and among 75.0% persons did not exceed 0.5 (upper quartile 0.5). Only in less than 3.0% of people, the index values exceeded 1.5.

Gingival Index GI was analysed for the effects of various nutritional factors. One of them was eating fruit between meals (Mann-Whitney test, value of test statistic Z = -2.08, p value = 0.038). Distributions of the index value for those who eat fruit between meals and do not eat fruit are presented in statistical data from Fig. 3. In the case of people who eat fruit, the average values of the indicator were lower, which means that fruit-eating contributes to the maintenance of healthy gums.

A statistically significant effect was also found in the case of vegetables being eaten (Mann-Whitney test, value of Z = 2.87, **p = 0.004**). The distribution of selected statistical parameters for those who eat vegetables between meals and do not eat vegetables is presented in Table 2. In the case of people who eat vegetables, average GI values were lower.

A statistically significant effect was also found in the case of potato chips eating between meals (Mann-Whitney test, value of Z = -2.11, **p = 0.035**). Distributions of the index value for those who eat chips between meals and do not eat chips show the frame charts from Fig. 4, in the case of persons eating chips, the average values of the GI index were higher.

Statistically significant influence on the GI index value was the frequency of fruit consumption (Kruskal-Wallis test, test statistic value H = 10.74, **p value = 0.013**). Selected statistical parameters for the compared groups are presented in Table III. In the group of students consuming fruits several times a day, the average values of GI were the lowest (mean value of 0.2, median 0.0). In the multiple comparisons test, statistically significant differences in the index value were found between a group of these people and a group of people declaring fruit consumption once a day (Dunn-Bonferroni multiple comparison test, test statistic value Z = 2.95, **p value = 0.019**).

In the case of other groups, the differences in the distributions of the index turned out to be statistically insignificant.

Statistically significant impact was also found when using fast food bars (Mann-Whitney test, value of Z = -2.33, **p = 0.020**). Distributions of statistical parameters of the indicator value for persons using fast food bars and non-users are presented in Table 4. In the case of people using quick service bars, the average values of the GI index were higher.

Among the hard fruits, statistically significant influence was also found in the case of eating apples (Mann-Whitney test, value of Z = -2.87, **p = 0.004**). The distributions of selected statistical parameters for both groups are presented in Table 5. In the case of people who frequently eat apples, the average values of the indicator were lower.

Statistically significant impact on the value of the indicator was also the consumption of carrot in raw form (Mann-Whitney test, value of Z = -2.46, **p = 0.014**).

Distributions of index values for people who eat carrots frequently and do not eat them are presented in the frame charts from Fig. 7. In the case of people consuming carrots, the average values of the indicator were lower.

Discussion

Available literature data indicate that the increase in oxidative stress in cells carries a number of destructive molecular events. The diet plays an important role in this process. Increasing the amount of simple sugars in the diet increases the level of oxidative stress by generating superoxide radicals that are a side effect of ATP synthesis, which weakens the mechanisms of antioxidant defense. Similarly, increased intake of simple sugars and saturated fat increases oxidative stress by blocking neutrophil receptors. Controlling the intake of sugars and fat can help reduce the level of tissue oxidation and its further inflammatory consequences. Research shows that not only the total amount of carbohydrates and fat that enter into the bloodstream is important, but the frequency of their consumption may be a key factor in the generation of oxidative stress [14]. The analysis of eating habits in the own study showed an extremely unfavourable effect of the habit of eating potato chips on the condition of gum tissues. Students eating chips between meals were characterized by a much worse health condition of the gums (median GI = 0.2) compared to those who did not eat the chips (median GI = 0.0). This is probably due to the excessive supply of saturated fats enhancing inflammatory processes of the gums, as well as the consistency of these products [15, 16]. Such a hypothesis was founded years ago by Iwasaki *et al.* performing relevant studies that confirmed the significant impact of supply of saturated fat on the progression of periodontitis in older Japanese [17].

Another, statistically significant nutritive factor affecting the state of the gums was the use of fast food bars. Among students using this type of nutrition source, a much higher tendency to gingivitis was observed (median GI = 46) compared to those who did not use the bars (median GI = 0.14). Due to the range of dishes issued in this type of dining places, i.e. fat-rich dishes with a high content of saturated fat and low minerals and vitamins, it seems to be an obvious fact of increased susceptibility to the occurrence of periodontal diseases.

Helpful in reducing oxidative stress can be foods rich in antioxidants, i.e.: green leafy vegetables, berries, red beans, red wine or dark chocolate with over 70% cocoa content. Another way are foods that slow down stomach emptying with additional antioxidant properties, i.e.: nuts, olives and fish oils [18]. Recent studies have shown that supplements with a single vitamin or antioxidant do not show the expected benefits. Such supplementation does not take into account the complex of interactions occurring in the natural source of food. What's more, overloading with a single vitamin may destabilize antioxidant networks and generate free radicals that may be more harmful to health than oxygen radicals. It has been shown that interaction with the natural source of food provides many additional benefits in relation to a single ingredient and is the preferred path, as long as we do not understand better the complex interactions between antioxidant microelements [14]. The current literature on the relationship between diet and periodontal disease is largely ambiguous; most likely due to lack of clarity in the assessment of nutritional status. Over the past few years, understanding how to assess and study nutritional status has improved.

Fruit is a rich source of antioxidants. The amount of phenolic compounds contained in them depends on the maturity of fruits and the way they are stored after harvesting. High antioxidant activity is characterized by chokeberry and bilberry fruits. Strawberries, cherries, apples, blackberries, rose hips contain significant amounts of oligomers and flavonol monomers. Vegetables have definitely less antioxidant capacity than fruits. Highly binding oxygen free radicals are characterized mainly by garlic, Brussels sprouts, spinach and kale. Vegetables are a rich source of quercitin, kempferol and glycosides [13].

In our study, it was shown that eating apples significantly contributes to improving the condition of the gums. Among the students often consuming apples, the GI index was almost two times lower than those who rarely consumed apples. Similar effects were observed when examining the effect of vegetables on the occurrence of gingivitis. The students eating vegetables had healthy gums (median GI = 0). This involves both consistency and the nutritional values provided to the body along with the supply of vegetables. They purify the teeth (hard consistency) while reducing the possibility of periodontitis due to the content of antioxidants and a complex of vitamins and minerals.

Reports from the available world literature mostly confirm the results presented in the paper. The potential effects of vitamin C, antioxidants, omega-3 acids, vitamin D and magnesium on periodontal status are analyzed by Van der Velden *et al*. Burrill's early studies of 1942 and Russell's of 1963 did not show the effect of vitamin C on periodontal degradation. Another study by Vogel & Weschler from 1979 showed that the daily intake of vitamin C significantly improves the condition of the periodontium. In contrast, Ismail *et al*. in 1983 found a reverse relationship. Nishida *et al*. in 2000 showed that smokers with a lower daily intake of vitamin C present a worse state of periodontium. Similarly, in 2007, Chapple *et al.* observed a strong positive effect of vitamin C on the condition of tooth support tissues [19].

Another study by Jenzsch *et al.*, on which patients with periodontal disease received a special diet rich in vegetables, fruits, whole wheat bread, legumes and dairy products, showed a beneficial effect on the course of periodontitis. After one-year use of the diet, these patients showed a significant reduction in the GI index, a decrease in IL-1beta and IL-6 cytokines in the gingivol component of the saliva and a reduction in the depth of the periodontal pockets. In a clinical study including the measurement of pocket depths, 20 women with chronic periodontitis participated in the GI index and Quigley-Hein index. In addition, gingival fluid was collected from patients and the concentration level of IL-1beta and IL-6 was determined there. Measurements were made before the introduction of a special nutritional program and after 2 weeks, 3, 6 and 12 months from its start. In observations made after one year from the introduction of a special diet, a reduction in depth of periodontal pockets from 2.4 mm to 2.2 mm was observed, reduction of gingivitis expressed as GI (decrease from 1.13 to 0.9) and reduction of cytokine concentration in the gingival fluid IL-1beta from 4.63 to 1.10 pg / ml and IL-6 from 1.85 to 0.34 pg / ml [20].

Conclusions

Both literature data and own research indicate that the "antioxidant diet" should be promoted. The natural antioxidants provided in food are a natural defense against many inflammatory diseases. The use of such a diet gives the opportunity to improve the quality of life and reduce the risk of incidence of chronic periodontitis in the developmental period.

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Tables

Due to technical limitations, tables are only available as a download in the supplemental files section.

Table 1 *Criteria for determining the degree of gingivitis*

Table 2 *Values of statistical parameters of the gingival index (GI) depending on the eating vegetables between meals*

Table 3 *Values of statistical parameters of the gingival index (GI) depending on the frequent consumption of fruit*

Table 4 *Values of statistical parameters of the gingival index (GI) depending on the use of the fast food bar*

Table 5 *Values of the statistical parameters of the gingival index (GI) depending on the consumption of apples*

Figures

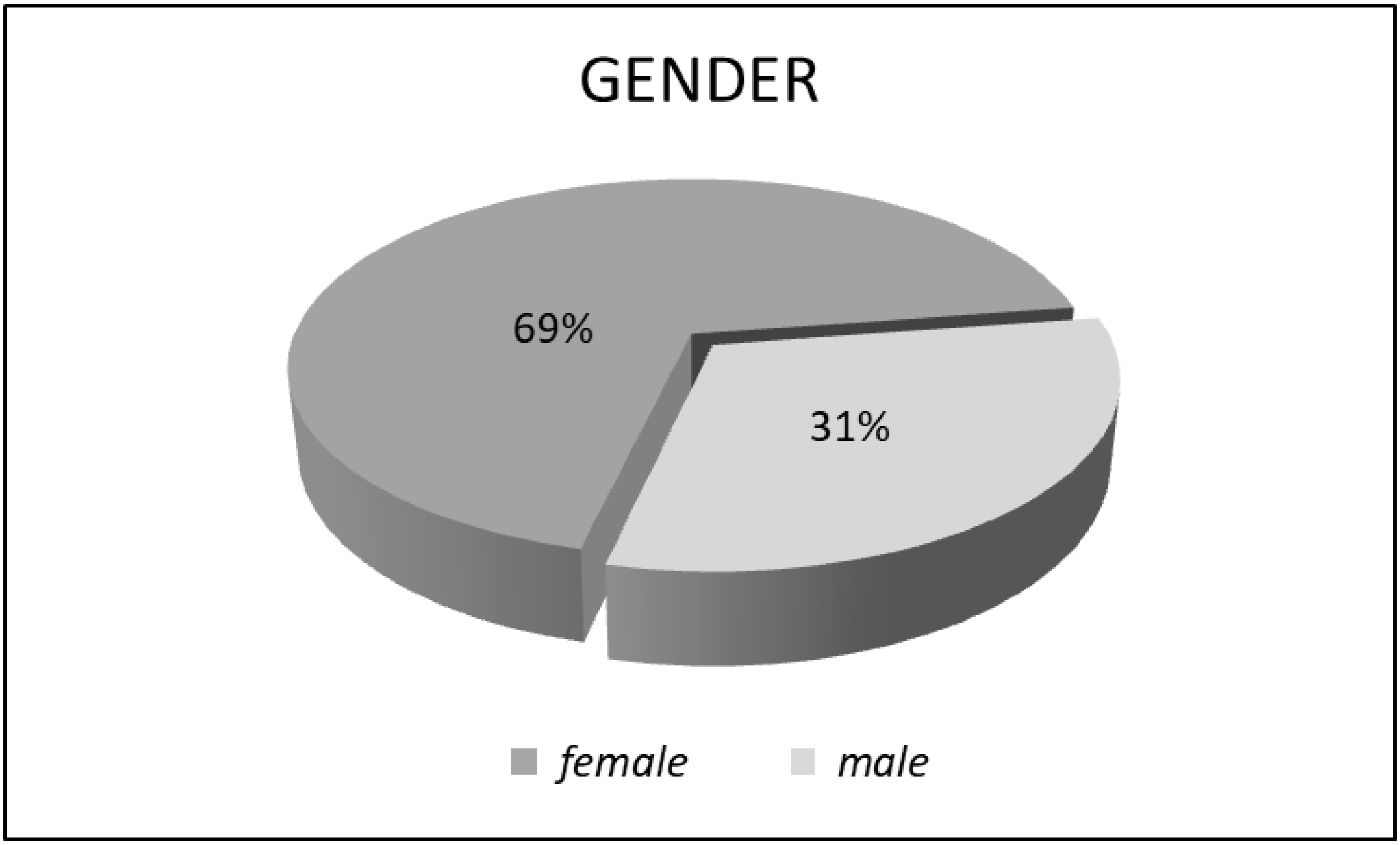

Figure 1

Characteristics of the studied youth, including gender

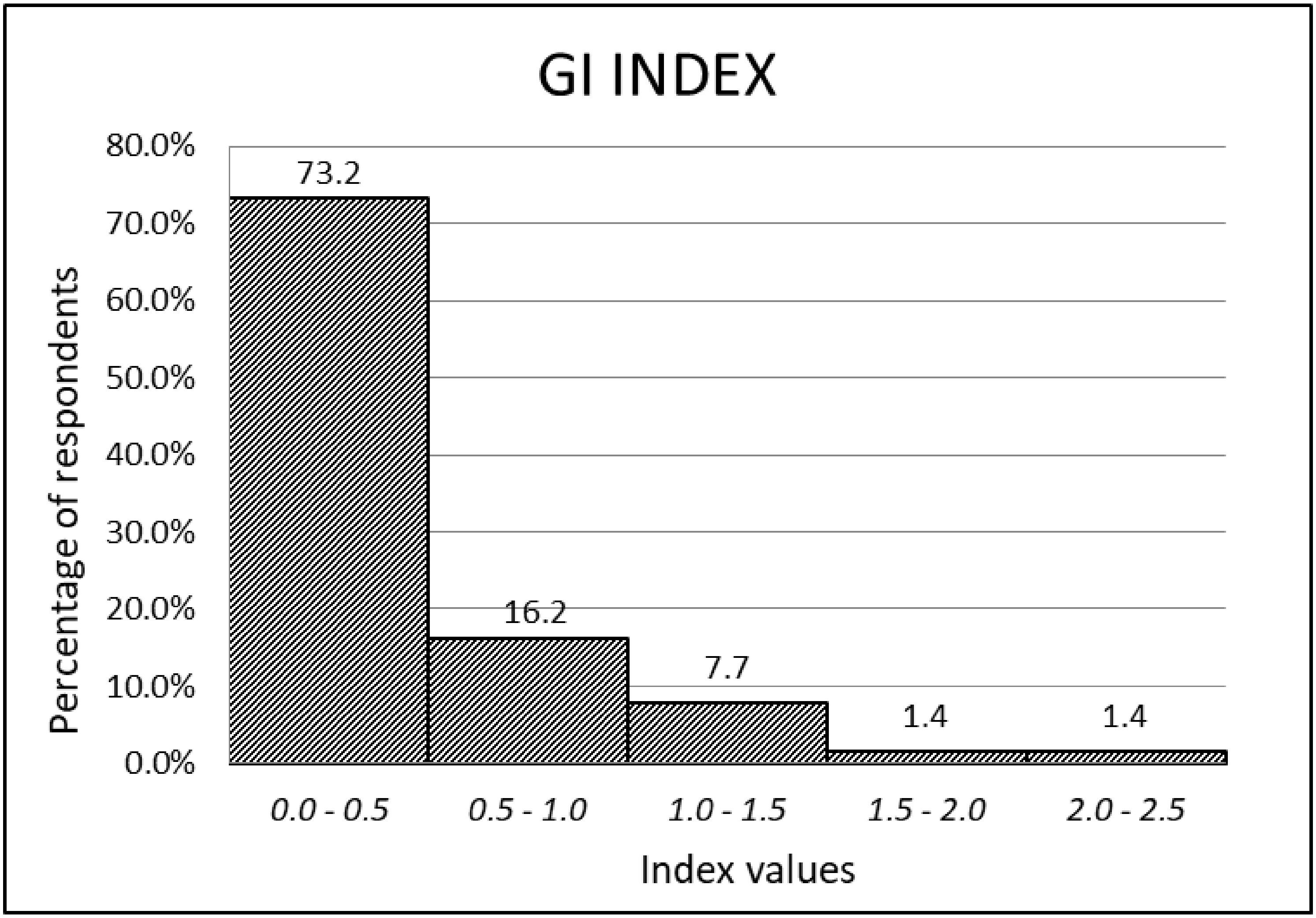

Figure 2

Histogram of the distribution of the gingival index (GI) values among the studied youth

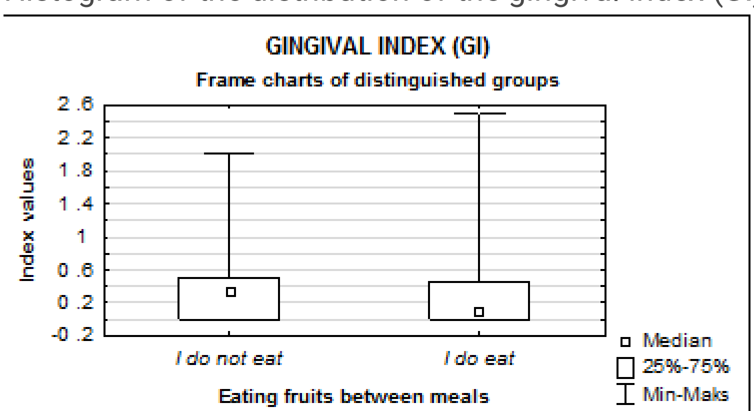

Figure 3

The effect of fruit consumption on the value of the gingival index (GI) among the studied youth

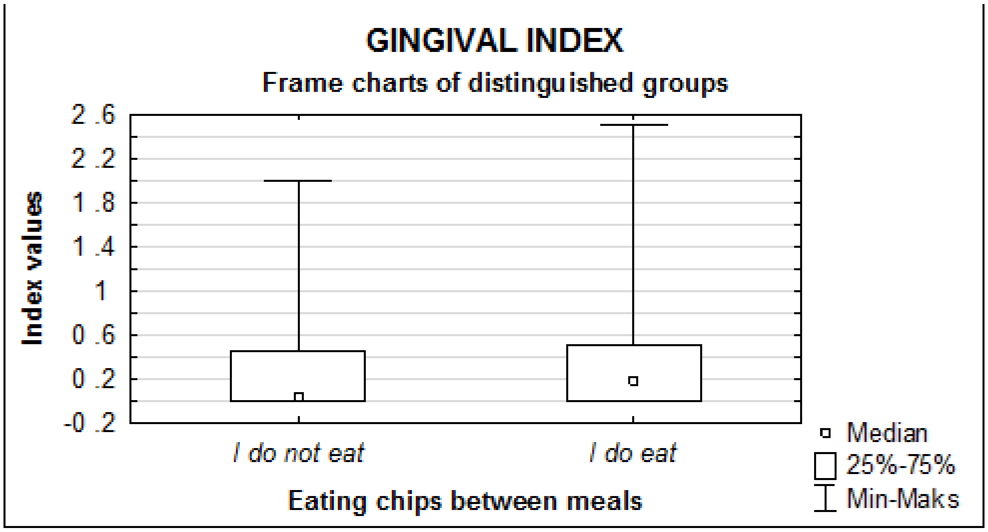

Figure 4

The influence of chips' eating between meals on the gingival index (GI) values among the studied youth

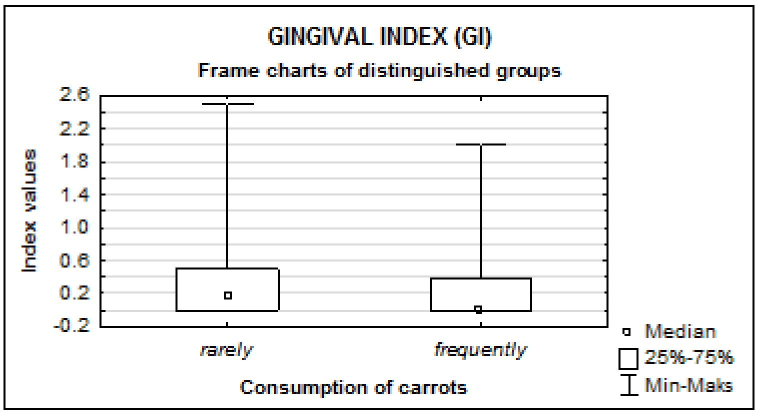

Figure 5

Influence of carrot consumption on gingival index (GI) values among the studied youth

Supplementary Files

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- table2.png
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- table1.png
- table3.png
- table4.png