Original paper

Impact of dietary habits on the incidence of oral diseases

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Abstract

Background. Diet is a factor that can modify the course of caries, dental erosion and periodontal diseases.

Objectives. The aim of this study was to examine the impact of dietary habits and the anthropometric parameters on oral health.

Material and methods. 50 females and 45 males aged 19–21 years were examined in a cross-sectional study. Oral health was assessed utilizing selected dental indices: approximal plaque index (API), bleeding on probing (BoP), community periodontal index (CPI), and DMFT (D – decayed, M – missing, F – filled, T – teeth). In addition, dental erosion was assessed. Anthropometric measurements included body mass, height, body mass index (BMI), waist circumference, skinfold thickness, fatty and lean body mass, body fat percentage, and total body water. The frequency of consumption of food products was determined with the use of the Questionnaire on Food Products Frequency Intake. Student's *t* tests, the χ^2 tests and Pearson's correlation coefficients were used to analyze the results.

Results. The average DMFT was 9.92, API was 52.97% and BoP was 20.46%. Dental erosion was observed in 44.21% of cases. A total of 11.58% of the study population were classified as CPI 0, 30.53% as CPI 1 and 57.89% as CPI 2. The consumption of crisps and cereal products increased caries ($p = 0.003$). Dental erosion was associated with the consumption of fruit, vegetables, meat, fish, and alcoholic beverages. The consumption of sugar, sweets and alcoholic beverages increased API and BoP. Caries rarely occurred in people who ate fruit and vegetables on a daily basis. The anthropometric parameters were associated with oral hygiene, gingivitis and body weight disorders ($p < 0.05$).

Conclusions. Rational nutrition not only plays a role in the development of general systemic diseases, but also has an effect on oral health. Besides providing instructions on oral hygiene, dentists should also assess the eating habits of their patients.

Keywords: nutritional status, diet, students, oral health

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Introduction

Maintenance of oral health is an important factor in the preservation of overall health.[1] Tooth loss can lead to a change in eating habits, which, in turn, increases the risk of certain systemic diseases.[2,3]

Although since the 1970s there has been a steady decline in the prevalence of caries,[4] this disease and its complications remain the most common causes of tooth loss. World Health Organization (WHO) studies clearly indicate that children and young people, as well as the majority of adults in highly developed countries, suffer from dental caries.[4,5] The formation of carious lesions depends on dental plaque, carbohydrates, a susceptible tooth surface, and time. Other risk factors include a difficult family situation, an imbalanced diet and poor dietary habits.[6] Dental plaque bacteria use carbohydrates to produce acids responsible for the destruction of dental hard tissues.[4,6] Apart from caries, another growing problem is tooth loss caused by chronic periodontitis.[4] Researchers have examined the influence of nutrients on the human inflammatory-immune response and found that macro- and microelements affect the pro- and anti-inflammatory cytokine cascade.[7,8] High-calorie food rich in refined sugars can also lead to chronic inflammation in the body.[7] An independent, inverse correlation exists between the consumption of omega-3 unsaturated fatty acids and the progression of periodontal disease, especially in the elderly.[8]

Dental erosion occurs as a result of the chemical and biochemical effects of extrinsic and intrinsic acids, the biochemical action of proteolytic enzymes, and the piezoelectric effect on the organic dentin matrix.[9] The main exogenous factor responsible for the onset and development of erosive lesions is the excessive consumption of foods and beverages with an acidic pH.[10] The erosive effect of low pH foods depends on the frequency and method of their consumption as well as immediate teeth brushing before and after food intake. The erosive potential of meals increases during and after physical exertion as a result of the reduced secretion of saliva.[10]

The aim of this study was to assess oral health in relation to dietary habits and selected anthropometric parameters in first-year university students.

Material and methods

This study protocol was approved by the Ethics Committee of Jagiellonian University, Kraków, Poland (approval No. KBET/77/B/2014). Informed consent was provided by all study participants. This was a cross-sectional study, with a total number of 50 female and 45 male volunteers aged 19–21 years. The participants were first-year students at higher education institutions. The exclusion criteria were any chronic systemic diseases and a current habit of smoking. The participants' medical and dental histories were recorded. The latter covered current complications in the oral cavity.

Dental examination

The following periodontal parameters were recorded: approximal plaque index (API; in %) and bleeding on probing (BoP; in %). The API was assessed by recording the presence or absence of dental plaque in approximal interdental spaces. The BoP index was determined for the entire mouth by recording the presence or absence of bleeding 10 s after probing. The API and BoP were expressed as a percentage of approximal sites with plaque/bleeding sites in relation to all sites examined. The DMFT index (D – decayed, M – missing, F – filled, T – teeth) was implemented to evaluate dental caries. The occurrence of dental erosion in dental hard tissue was also assessed. The epidemiological examination of the periodontium was based on the community periodontal index (CPI) and measured as follows: 0 – no gingival bleeding in sextant, 1 – bleeding on probing in at least 1 place in sextant, 2 – presence of supragingival calculus in sextant and/or factors favoring retention of dental plaque, 3 – periodontal pocket depth in sextant 3.5–5.5 mm, 4 – presence of at least 1 periodontal pocket in sextant with a depth of 5.5 mm or more.

Anthropometric measurements

In every participant, the following basic measurements were taken: body weight and height and body mass index (BMI). The following ranges of BMI were specified: <18.5 kg/m^2 – underweight, 18.5–24.9 kg/m^2 – proper weight, 25.0–29.9 kg/m^2 – overweight, and >30.0 kg/m^2 – obesity. The waist circumference (in centimeters) was also measured. Fatty body mass (FM; in kilograms), body fat percentage (% FM), lean body mass (fat-free mass (FFM); in kilograms), and total body water (TBW; in liters) were determined using the infrared interactance method with a Futrex Body Composition Analyzer Model 6100/XL 6100/ZL (Futrex Inc., Hagerstown, USA). The thickness (in millimeters) of the triceps skin-fat fold, subscapular skin-fat fold and suprailiac skin-fat fold were measured with the use of a Harpenden Skinfold Caliper (Cambridge Scientific Instruments, Cambridge, USA). All measurements were taken by the same investigator trained in this area.

Assessment of dietary habits

The frequency of consumption and preferences for certain foods were assessed using a modified Questionnaire on Food Products Frequency Intake. This questionnaire was recommended by the Polish National Food and Nutrition Institute (http://knozc.pan.pl).

Statistical analysis

For variables with a normal distribution, the following were calculated: mean (*M*), standard deviation (*SD*), minimum, and maximum. For variables with a non-normal distribution, median (*Me*), range, minimum, and maximum were calculated. Normal distribution of variables was tested with the Kolmogorov–Smirnov test. Quantitative variables for 2 groups were compared using Student's *t* test or the χ^2 test (based on Yates' correction for continuity in 2 × 2 tables). Correlations between 2 quantitative variables were assessed with Pearson's product-moment correlation coefficient. A significance level of $p < 0.05$ was adopted.

Statistical calculations were performed with R, v. 3.2.3 statistical software (R Foundation for Statistical Computing, Vienna, Austria; http://www.R-project.org).

Results

The opportunity to participate in the project was announced among students and a total of 95 individuals (50 females and 45 males) aged between 19 and 21 years volunteered. The mean DMFT index for females was 10.08, while for males it was 9.73 (overall mean: 9.92). Dental erosion was present in 44.21% of the participants (in 52% of females and 35.56% of males). The mean API for males was 34.73%. Within the group of females, half of the participants had an API lower than 78% and half had a value higher than this, with a range between 8% and 100%. The overall API was 52.97%. The mean BoP among females was 22.02% compared to 18% for males (the mean BoP for the whole study population was 20.46%). Regarding CPI, 11.58% of the study population were classified as CPI 0, 30.53% as CPI 1 and 57.89% as CPI 2. Further

Table 1. Association between the frequency of consumption of various products and approximal plaque index (API)

Consumption of food products		*M*	*SD*	*SEM*	*p*-value
1. Milk and dairy products	not every day	57.2	27.6	3.7	0.105
	every day	47.1	32.6	5.2	
2. Eggs	≤ 3 times a week	54.2	30.4	3.4	0.330
	4 times or more a week	45.4	27.9	7.7	
3. Meat and fish, including low-meat dishes	not every day	59.2	32.6	4.2	0.007*
	every day	42.3	21.5	3.6	
4. Animal fats	not every day	52.1	31.2	4.8	0.803
	every day	53.7	29.4	4.1	
5. Vegetable fats, including hydrogenated fats	not every day	62.3	30.5	4.1	0.001*
	every day	40.2	24.6	3.9	
6. Raw fruit and vegetables	not every day	58.7	29.0	4.4	0.083
	every day	48.0	30.4	4.3	
7. Crisps and other similar products	≤ 3 times a month	53.3	32.7	4.6	0.905
	once a week or more often	52.6	27.2	4.1	
8. Vegetable or fruit juice	≤ 3 times a week	53.8	29.7	4.2	0.772
	4 times or more a week	52.0	30.7	4.6	
9. Potatoes	≤ 3 times a week	53.8	31.9	3.8	0.675
	4 times or more a week	50.8	25.1	4.9	
10. Legumes	never	49.4	30.0	4.2	0.214
	I consume	57.1	29.9	4.5	
11. Cereal products and associated products	not every day	57.5	34.7	6.9	0.385
	every day	51.4	28.3	3.4	
12. Sugar and sweets	not every day	43.4	31.7	6.2	0.056
	every day	56.6	28.8	3.5	
13. Soft drinks	≤ once a week	58.4	31.2	4.4	0.062
	2 times or more a week	46.9	27.9	4.2	
14. Alcoholic beverages	≤ 3 times a month	62.8	30.5	4.4	0.001*
	once a week or more often	42.5	26.1	3.8	
15. Other beverages	not every day	73.1	25.0	8.3	0.034*
	every day	50.9	29.9	3.2	

Student's *t* test for independent samples for women and men in relation to API (data presented as percentage). * statistically significant; *M* – mean; *SD* – standard deviation; *SEM* – standard error of the mean.

analysis showed that within the group of females there was a higher percentage of sextants with CPI 2 and a lower percentage with CPI 0 in comparison with males (p = 0.004).

Association between the frequency of consumption of food products and the clinical dental parameters

The API of the female participants depended on the consumption of meat and fish (p = 0.005), vegetable fats (p = 0.001) and cereal products (p = 0.022). Females who consumed these products on a daily basis had a lower API. Males who ate raw fruit and vegetables (p = 0.034) and cereal products (p = 0.016) every day had lower API values, while those who consumed sugar or sweets on a daily basis had higher API values (p = 0.042). When females and males were analyzed as one group, results of the Student's t test for independent samples revealed statistically significant changes in the API with regard to the consumption of the following products: meat, fish, vegetable fats, and alcoholic and non-alcoholic beverages (Table 1).

The BoP index of female participants depended on the consumption of vegetable fats (p = 0.01) and was lower when these were consumed daily. The same indicator for males depended on the consumption of raw fruit and vegetables (p = 0.001) as well as alcoholic beverages (p = 0.046). Males who ate raw fruit and vegetables on a daily basis had a lower BoP index in comparison with those who consumed them more rarely (p = 0.001), and those who drank alcohol less than once a week also had a lower BoP. Concerning BoP for males and females (combined), the Student's t test for independent samples revealed statistically significant results in regard to the consumption of the following products: milk and dairy products, raw fruit and vegetables, and juice (vegetable or fruit; Table 2).

Table 2. Association between the frequency of consumption of various products and bleeding on probing (BoP)

Consumption of food products		*M*	*SD*	*SEM*	*p*-value
1. Milk and dairy products	not every day	23.7	17.4	2.3	0.032*
	every day	16.1	15.7	2.5	
2. Eggs	≤ 3 times a week	21.3	16.9	1.9	0.304
	4 times or more a week	16.0	17.7	4.9	
3. Meat and fish, including low-meat dishes	not every day	21.3	15.8	2.0	0.570
	every day	19.2	19.2	3.2	
4. Animal fats	not every day	19.6	16.6	2.5	0.613
	every day	21.3	17.5	2.4	
5. Vegetable fats, including hydrogenated fats	not every day	23.3	18.0	2.4	0.063
	every day	16.7	15.0	2.4	
6. Raw fruit and vegetables	not every day	26.1	18.4	2.8	0.003*
	every day	15.7	14.2	2.0	
7. Crisps and other similar products	≤ 3 times a month	19.4	16.5	2.3	0.504
	once a week or more often	21.8	17.8	2.7	
8. Vegetable or fruit juice	≤ 3 times a week	23.8	17.5	2.5	0.046*
	4 times or more a week	16.8	15.8	2.4	
9. Potatoes	≤ 3 times a week	21.1	16.9	2.0	0.592
	4 times or more a week	19.0	17.6	3.5	
10. Legumes	never	20.3	17.6	2.5	0.882
	I consume	20.8	16.6	2.5	
11. Cereal products and associated products	not every day	18.9	16.4	3.3	0.583
	every day	21.1	17.3	2.1	
12. Sugar and sweets	not every day	16.3	14.7	2.9	0.138
	every day	22.1	17.7	2.1	
13. Soft drinks	≤ once a week	21.6	17.5	2.5	0.532
	2 times or more a week	19.4	16.7	2.5	
14. Alcoholic beverages	≤ 3 times a month	18.8	13.8	2.0	0.307
	once a week or more often	22.4	19.9	2.9	
15. Other beverages	not every day	29.9	16.2	5.4	0.084
	every day	19.6	16.9	1.8	

Student's t test for independent samples for women and men in relation to BoP (data presented as percentage). * statistically significant.

Students who consumed raw fruit and vegetables on a daily basis had a lower DMFT score than those who consumed them less frequently (p = 0.042), while eating crisps more than once a week was associated with a higher DMFT (p = 0.012). Daily consumption of cereal products led to a higher DMFT in both females (p = 0.043) and males (p = 0.018). With regard to the DMFT score for males and females (combined), the Student's t test for independent samples showed statistically differences in relation to the consumption of raw fruit and vegetables, crisps and cereal products (Table 3).

The χ^2 test for the female participants showed no statistically significant differences in dental erosion based on the frequency of consumption of any of the investigated products. Among the male participants, the presence of dental erosion depended on the consumption of meat, fish (p = 0.024), and fruit and vegetable juices (p = 0.004). Dental erosion occurred more frequently in students who consumed meat and fish daily, and juices at least 4 times a week. With regard to males and females (combined), the presence of dental erosion depended solely on the consumption of alcoholic beverages. Those who drank alcohol more often than once a week were less likely to have erosive defects (p = 0.046).

Association between body mass components and the clinical dental parameters

Bleeding on probing and DMFT depended on BMI (p = 0.02, p = 0.04) and were higher in overweight or obese individuals in comparison with those with normal weight. The mean BoP in participants of proper weight was 18.9%, as compared to 30.3% in the case of overweight or obese students. The DMFT score in students with the

Table 3. Association between the frequency of consumption of various products and DMFT

Consumption of food products		*M*	*SD*	*SEM*	*p*-value
1. Milk and dairy products	not every day	10.1	5.2	0.7	0.738
	every day	9.7	4.0	0.6	
2. Eggs	≤ 3 times a week	9.9	4.7	0.5	0.945
	4 times or more a week	10.0	4.9	1.4	
3. Meat and fish, including low-meat dishes	not every day	9.6	4.2	0.5	0.323
	every day	10.5	5.4	0.9	
4. Animal fats	not every day	10.5	5.1	0.8	0.303
	every day	9.5	4.4	0.6	
5. Vegetable fats, including hydrogenated fats	not every day	10.3	4.9	0.7	0.413
	every day	9.4	4.5	0.7	
6. Raw fruit and vegetables	not every day	11.4	4.8	0.7	0.004*
	every day	8.6	4.3	0.6	
7. Crisps and other similar products	≤ 3 times a month	8.6	4.0	0.6	0.003*
	once a week or more often	11.4	5.0	0.7	
8. Vegetable or fruit juice	≤ 3 times a week	10.1	4.9	0.7	0.751
	4 times or more a week	9.8	4.5	0.7	
9. Potatoes	≤ 3 times a week	9.8	4.4	0.5	0.655
	4 times or more a week	10,3	5,5	1,1	
10. Legumes	never	10.4	4.7	0.7	0.290
	I consume	9.4	4.7	0.7	
11. Cereal products and associated products	not every day	7.5	4.1	0.8	0.002*
	every day	10.8	4.6	0.5	
12. Sugar and sweets	not every day	10.1	5.1	1.0	0.839
	every day	9.9	4.6	0.6	
13. Soft drinks	≤ once a week	9.7	4.6	0.7	0.671
	2 times or more a week	10.1	4.8	0.7	
14. Alcoholic beverages	≤ 3 times a month	10.2	4.7	0.7	0.512
	once a week or more often	9.6	4.7	0.7	
15. Other beverages	not every day	10.1	5.1	1.7	0.897
	every day	9.9	4.7	0.5	

Student's t test for independent samples for women and men in relation to the DMFT index. * statistically significant; DMFT – D – decayed, M – missing, F – filled, T – teeth.

proper body weight amounted to 9.5, as compared to 12.3 for overweight and obese participants.

With regard to male participants, a statistically significant relationship was observed between the API index on the one hand, and waist measurement (p = 0.009) and skin-fat fold thickness over the triceps brachii muscle (p = 0.022) on the other hand. Likewise, only in males did waist measurement (p = 0.021) and FM% (p = 0.039) have any significant influence on BoP. These were positive correlations.

Discussion

In the present study, we examined oral health of young students in relation to dietary habits and nutritional status. The limitations of the study were the age of the participants (the study group consisted only of students), a modest sample size and the absence of a control group.

The DMFT score was lower for those females and males who consumed raw fruit and vegetables on a daily basis. According to Trzcionka and McDowell, in order to protect oneself against dental caries, it is important to consume products containing polyphenols, of which raw fruit and vegetables (apples in particular) are the main sources.[11] Another important factor in preventing dental caries are the physical characteristics of an individual's diet.[11] Hard consistency of food has a positive effect on the self-cleaning capacity of the oral cavity. The cariogenic effect of nutrition stems from, among other things, the consumption of soft foods – mushy, glutinous foods, which favor the build-up of dental plaque in retention places and generally worsen hygiene conditions in the oral cavity.

The current results showed that the consumption of crisps and cereal products had a negative impact on hard dental tissue. Likewise, Johansson et al. identified crisps as products associated with an increased incidence of dental caries.[5] A study by Monteagudo et al. showed that the consumption of cereal products was associated with a lower incidence of dental caries.[6] Additionally, Trzcionka and McDowell claimed that cariostatic properties can only be identified in raw cereal grains – on account of the phosphorane present in them.[11]

Our observations are in accordance with the results of other reports, namely that the main factor responsible for the occurrence of erosive lesions is the consumption of low pH foods. The results of a study by Waszkiel showed that 30% of the respondents with dental erosion consumed citrus juice several times a day, while 20% did so several times a week. Moreover, 70% of persons with erosions ate fruit.[12] The current results showed that dental erosions occur more frequently in students who consumed meat and fish on a daily basis. This contradicts observations made by Herman that vegetarians are more likely to suffer from enamel erosion – 39% in comparison with 24% in the control group.[13] Unhealthy dietary habits, such as the consumption of stimulants and supplements, and alcohol abuse, are among the risk factors for non-carious lesions.[10] However, we found a lower incidence of erosion among students who more often drank alcoholic beverages.

Al-Zahrani noted the positive effects that dairy products have on periodontal tissue.[14] According to our results, the consumption of dairy products had a positive effect on oral health – the BoP index for male and female participants combined was lower in those individuals who consumed dairy products on a daily basis. These results are in line with the findings of Dietrich et al., who reported that supplementation with vitamin D reduces the susceptibility of gums to inflammation.[15] Likewise, we found that the consumption of raw fruit and vegetables and juice had a positive effect on the structure of the periodontium (lower BoP). These are major sources of vitamin C. Kuzmanova et al. observed lower levels of vitamin C in the plasma of patients with periodontitis in comparison with a control group.[16]

We found that female students who consumed vegetable fats on a daily basis had lower BoP values as compared with the average values for this indicator. Vegetable oils are the main source of omega-3 unsaturated fatty acids, which have, among other things, anti-inflammatory properties, and which the human body is unable to synthesize independently.[8]

The current data also indicates that the consumption of alcoholic beverages by males has a negative effect on oral health and results in a higher BoP index as compared to the average values for this indicator. Tezal et al. showed a statistically significant linear relationship between the quantity of alcoholic beverages consumed and the severity of periodontitis.[17] The harmful mechanisms involved in alcohol consumption may depend on its direct inhibitory effect on bone metabolism as well as on the toxic action of osteoblasts.[18]

We found lower API values in young female students who consumed meat, fish, vegetable fats, and cereal products daily. Young men who consumed raw fruit and vegetables and cereal products on a daily basis also had lower API values in comparison to the average values for this indicator. Higher API values in male participants were associated with the daily consumption of sugar and sweets.

A number of studies have also confirmed the positive impact of wholegrain products on oral health. According to Merchant et al., consumption of such food reduces the risk of periodontitis.[19] There has been an increase in the prevalence of periodontitis among young people aged 18–25 years, a trend associated with the addition of sugar to foods.[20] In our study, more than half of those surveyed (62.1%) consumed refined sugar every day and had a higher API. Baumgartner et al. asserted that an increase in the supply of refined sugar results in increased gum bleeding.[21]

The results of the present study showed that the BoP and DMFT indices depended on BMI and were higher in students with an unsuitable body mass. No correlation was found between API and BMI. These outcomes are partly

convergent with a study conducted by Konopka et al., who observed a correlation between BMI, API and BoP.[22] The API indicates the effectiveness of cleaning of interdental spaces. Poorer hygiene causes bacterial plaque to settle, which may lead to the development of gingivitis and, subsequently, chronic periodontitis.

Our results show that the parameters of fatty tissue in the body correlate with oral tissue health. In the case of male participants, the greater the waist measurement, the higher the BoP and API indices. The API of the study participants was affected by the skin-fat fold thickness over the triceps brachii muscle, while BoP was shaped by FM%. In both cases, the greater the values of these parameters, the worse the health of the periodontal tissue. Other authors have singled out an increase in body mass and adipose tissue content in the body as factors that favor and exacerbate the course of chronic periodontitis.[1,23–26] According to Salekzamani et al., patients with periodontitis have greater waist measurements in comparison with healthy individuals and patients with gingivitis.[23] According to Benguigui et al., the plaque index and the presence of deep periodontal pockets are statistically associated with an increase in BMI.[24] In their own study, Suvan et al. showed that a higher BMI may be regarded as a factor explaining the poorer response of certain patients to non-surgical periodontal treatment.[25] Among patients with an increased BMI, Konopka et al. observed higher API and BoP, predisposing these individuals to the onset of periodontitis.[22] Ekuni et al. came to similar conclusions in a study on Japanese students and, according to their results, the higher the BMI, the higher CPI values.[26]

Our results show that the consumption of sugar, sweets and alcoholic beverages had a negative impact on periodontal tissues. Eating crisps and cereal products increased caries, and consumption of sugar, sweets and alcoholic beverages had a negative impact on periodontal tissue health. Dental erosion was associated with the consumption of fruit, vegetables, meat, fish, and alcoholic beverages.

Conclusions

The consumption of unhealthy products has a negative impact on dental and periodontal tissue health. Finally, poor dietary habits may have a harmful influence on selected clinical and anthropometric parameters. Further research is warranted to systematize the function of macro- and micro-nutrients in relation to periodontal tissues and overall oral health.

Ethics approval and consent to participate

This study protocol was approved by the Ethics Committee of Jagiellonian University, Kraków, Poland (approval No. KBET/77/B/2014). Informed consent was provided by all study participants.

Data availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Consent for publication

Not applicable.

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