Poor diet predicts periodontal disease development in 11-year follow-up study

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Abstract

Objective: To study whether diets based on the Nordic food culture and dietary recommendations are related to periodontal disease development.

Methods: The data were based on the Health 2000 and 2011 Surveys (BRIF8901). The participants were aged 30 – 49 in 2000, periodontally healthy, without diabetes or rheumatoid arthritis. Analyses were made in the total study population (n=240) and among non-smokers (n=193) in 2011. Periodontal condition was determined in a clinical examination and the number of teeth with deepened (≥ 4 mm) periodontal pockets in 2011 was used as an outcome. The diet was measured using a validated food frequency questionnaire and the quality of the diet using the Baltic Sea Diet Score (BSDS) and the Recommended Finnish Diet Score (RFDS) in 2000. Incidence rate ratios (IRRs) and 95% confidence intervals (CIs) were estimated using Poisson regression models.

Results: Low scores (indicating poor diet) in both the BSDS and the RFDS were associated with the development of deepened periodontal pockets. Among non-smokers, the associations between low dietary scores and the number of teeth with deepened periodontal pockets were stronger than among the whole study population.

Conclusions: Among middle-aged adults, poor-quality diet appears to be associated with the development of periodontal disease.

Introduction

The mouth is not a sterile environment and histological inflammation is constantly present in the gingival tissues. As the amount of bacteria increases, the inflammation also becomes clinically observable.[1] Gingival inflammation progresses in susceptible patients to periodontitis, which is characterized by loss of connective tissue and alveolar bone loss. The essential question is which factors affect the inflammatory response in a way that it leads the development and progression of periodontal disease.

The inflammatory response and subsequent periodontal disease development are partly genetically regulated, but the disease progression is dependent on lifestyle choices, including for example oral hygiene, smoking habits and weight control.[2, 3] Recently, it has been suggested that diet plays a role in maintaining periodontal health.[4,5]

Recent studies suggest that low intake of some nutrients, such as vitamins[6-8], omega-3 polyunsaturated fatty acids[9-11], antioxidants[12], other micronutrients [6,8], dietary fibre[13], high intake of saturated fats[14] and added sugars[15], are associated with poor periodontal condition. In addition to single foods or nutrients, nutritional research has recently focused also on the whole diet. Evidence from cross-sectional whole diet studies[16,17] as well as an RCT[18] suggests that a healthy diet is associated with periodontal health.

At the moment, there is a lack of evidence on the role of the whole diet in periodontal disease development. The aim of this study was to examine how adherence to diets based on the Nordic food culture and dietary recommendations predicts periodontal disease development.

Methods

Data came from the Health 2000 and 2011 Surveys organized by the Finnish Institute for Health and Welfare (THL). Information on the number of teeth with deepened periodontal pockets was obtained from 1,029 individuals both in 2000 and 2011. They all had filled in a food frequency questionnaire (FFQ) in 2000. Of them, participants with diabetes (n=86) were first excluded, then participants with rheumatoid arthritis (n=22), and then participants aged 50 years or older (n=334) leaving n=587. Finally, only those who had no teeth with deepened (≥ 4 mm) periodontal pockets in

2000 were included (n=240). Of them, supplementary analysis was done for those reported to be non-smokers in 2011 (n=193) to control the confounding effect of smoking thoroughly.

Both the Health 2000 and 2011 Surveys were approved by the Ethical Committee for Epidemiology and Public Health of the Hospital District of Helsinki and Uusimaa and informed consent was obtained from each participant. This manuscript meets the criteria stated at the STROBE-guidelines.

Clinical oral health examination

In 2000 and 2011, a dentist used a WHO periodontal probe to measure the depths of the periodontal pockets with a 20 g force on every teeth except wisdom tooth and tooth remnants [19,20]. The periodontal pockets were measured on four surfaces of each tooth: the distobuccal, buccal, mesiolingual and lingual surfaces. Measurements were registered: ”pocket <4 mm”, ”pocket 4–5 mm” or ”pocket ≥6 mm”. Only the deepest pocket per tooth was recorded. For the analyses, the latter two categories were combined. The number of teeth with a pocket depth of ≥4 mm was used as the outcome.

The validity and reliability of periodontal pocket depth measurements were evaluated during the Health 2000 Survey. At the baseline, the percent agreement for pocket depth measurements between the reference dentist and the field dentists was 77% (κ-value 0.41)[19] and the repeatability among the field dentists showed a κ-value of 0.83.[21]

Dietary variables

A validated FFQ was used to measure the diet of the participants over the previous 12 months.[22,23]. It included 128 food items and frequencies of food consumption that ranged in nine categories from never or rarely to six or more times per day. The amount of food consumed was estimated by multiplying fixed portion sizes with frequencies of consumption and this information was converted into food, ingredients and nutrient intake by using Fineli®, a Finnish food consumption database.[24]

Two scores were used to measure the quality of the diet. The Baltic Sea Diet Score (BSDS) [25] was based on a Nordic food culture and complied with dietary recommendations and it included only healthy foods produced in the Nordic countries. The Recommended Finnish Diet Score (RFDS) [26]

was based on Finnish dietary recommendations and included not only local but also non-local components such as oranges. In the scores, the foods and nutrients were categorized as being either positive (healthy) or negative (unhealthy).

The positive components in the BSDS were fruits and berries (apples, pears and berries); vegetables (leafy vegetables, cucumber, tomatoes, peas, cabbages and roots, excluding potato); cereals (rye, oats and barley); low-fat milk (low-fat and fat-free milk); fish (salmon and freshwater fish); and fat ratio (the ratio of polyunsaturated fatty acids (PUFA) to saturated fat (SFA) and trans-fatty acids). The negative components in the BSDS were red meat (beef, pork, processed meat products and sausage); total fat intake as a percentage of the total energy intake (E%); and alcohol (ethanol intake).

The positive components in the RFDS were fruits (apples, citruses and other fruits and berries); vegetables (fruit vegetables, leafy vegetables, roots, cabbages, legumes, mushrooms, excluding potato); the ratio of white meat (poultry, fish and fish products) to red and processed meat (beef, pork, lamb, sausage, meat products, game and offal); rye, which was used to represent dietary fibre and is the most common source of fibre in Finland; and the ratio of PUFA to SFA and trans-fatty acids. The negative components in the RFDS were salt (g/day), sucrose (E%) and alcohol (E%).

In both scores, each component was given from 0 to 3 points according to the quartiles of consumption, except for alcohol in the BSDS, which was given from 0 to 1 point (one point was given if the ethanol intake per day was <20 g for men and <10 g for women, otherwise zero points were given). The overall score ranged between 0 and 25 points in the BSDS and 0 and 24 in the RFDS. In the analyses, both scores were used as continuous variables and categorized into tertiles. Low scores indicated a poor diet and high scores a healthy diet.

Potential confounding variables

Education, smoking, dental attendance pattern and use of non-steroidal anti-inflammatory drugs (NSAID) were asked during the interview. Education was categorized into basic, intermediate and higher education. Those with no formal vocational training or upper secondary education were classified as having basic education. Those who had completed vocational training or passed the matriculation examination were considered as having intermediate education. Those with higher education had completed a degree or diploma in higher vocational institutions, polytechnics and

universities. Smoking was categorized as daily, occasional and no smoking. The dental attendance pattern was categorized as having attended a regular check-up either in 2000 or 2011 or in both years or in neither of these years. The use of medications in the past seven days was asked verbally and then checked from prescriptions or packages. The medicines were further classified according to the anatomical therapeutic chemical classification system.

Use of dietary supplements was based on the FFQ and it was used as a dichotomous variable (regular use *vs*. no use).

Level of physical exercise was estimated to be optimal when the participants in a questionnaire reported exercising for ≥30 minutes during their leisure time at least four times a week and walked or cycled for ≥30 minutes a day on the way to work, adequate when the participants reported exercising for ≥30 minutes during their leisure time at least four times a week or walked or cycled for ≥30 minutes a day on the way to work, uncertain when the participants reported exercising for ≥30 minutes during their leisure time 2 to 3 times a week and walked or cycled for <30 minutes a day on the way to work, and inadequate when the participants reported exercising for ≥30 minutes during their leisure time once a week or less and walked or cycled for <30 minutes a day on the way to work.

Weight and height, as well as high-sensitivity C-reactive protein (hs-CRP), were measured during the clinical health examination. Body mass index (BMI) and hs-CRP were used as continuous variables.

The presence of dental plaque was observed during the clinical oral health examination using the modified Silness and Löe method.[27] In 2000, on one surface of three teeth: the buccal surface of the most posterior tooth on the upper right side; the lingual surface of the most posterior tooth on the lower left side and the buccal surface of tooth 33. The presence of visible plaque was registered as no, in gingival margins and also elsewhere. The highest value of the indicator teeth was used to describe the level of oral hygiene. Parallel measurements resulted in κ-value 0.36 (58% agreement), and the repeat measurements in κ-value 0.79. [19,21] In 2011, the presence of dental plaque was measured on the buccal side of every tooth, except for wisdom teeth, and it was registered as plaque per tooth or no plaque.

Statistical methods

Due to the count data and the skewed distribution of teeth with deepened periodontal pockets in the sample, Poisson regression was used to estimate incidence rate ratios (IRR) and 95% confidence intervals (CIs). The models were adjusted for age, gender, level of education, BMI, use of supplements, plaque and total energy intake (kJ) in 2000; CRP, smoking (not in the model of non-smokers), physical exercise, use of NSAID and plaque in 2011 and changes in BMI and dental attendance pattern in years 2000 and 2011 (combined variable). The number of teeth in 2011 was used as an offset variable in the models. Nutrient intake variables (except alcohol E%) were corrected using the residual method before fitting the regression models.[28]

SAS statistical package, version 9.4, PROC GENMOD, Cary NC, USA, was used to statistical analyses.

Results

The basic characteristics of the study populations are presented in Table 1. There were more daily smokers and people with inadequate oral hygiene among those who developed deepened periodontal pockets during the follow-up than among those who remained periodontally healthy (Table 1).

Table 2 presents the basic characteristics and potential confounding variables according to the tertiles of the BSDS and the RFDS. The average number of teeth with ≥4 mm deepened periodontal pockets in 2011 was 3.2 for the lowest tertiles of the BSDS, 3.4 for the middle tertile of the BSDS and 2.5 for the highest tertile of the BSDS. The corresponding numbers for the tertiles of the RFDS were 3.3, 3.3 and 2.4, respectively. (Table 2).

Low scores in the BSDS and the RFDS were associated with a higher number of teeth with deepened (≥4 mm) periodontal pockets in 2011 (Table 3). IRR for the continuous BSDS was 0.94, (95% CIs 0.92, 0.96) and for the RFDS 0.91 (95% CI 0.88, 0.94).

Among non-smokers in 2011, the associations between low scores of the BSDS and the RFDS and the number of teeth with deepened periodontal pockets in 2011 were stronger than in the whole study population. IRR for the continuous BSDS variable was 0.85 (95% CIs 0.82–0.88) and for the RFDS it was 0.74 (95% CIs 0.71–0.77) (Table 3).

Discussion

The main finding of this study was that a poor-quality diet was associated with periodontal pocket formation during the 11-year follow-up period. This is in line with earlier studies where the progression of disease has been examined in relation to food groups or a combination of nutrients either alone or combined with periodontal treatment. [29] For example, in a study performed among 70-year-old people [30], dark green and yellow vegetables were inversely associated and cereals, nuts and seeds, sugar, sweeteners and confectioneries were positively associated with periodontal disease events during a six-year follow-up. In another study [31], the consumption of fruits and vegetables and the intake of β–carotene, vitamin C, α-tocopherole, eicosapentaenoic acid and docosahecsaenoic acid were associated with enhanced periodontal healing after scaling and root planing in a group of 34 to 90-year-old non-smokers with chronic periodontitis. The beneficial role of anti-inflammatory diet was also shown in an intervention study. [18]

To our best knowledge, the present study is the first observational study where the whole diet was examined in relation to periodontal disease development. Previously, whole diets based on North American dietary recommendations have been studied in two cross-sectional studies which found that low quality diet was associated with a higher risk of periodontal disease[16,17]. The findings of the present study are more or less in line with the above-mentioned studies and also with the findings of our earlier studies using the Health 2000 data.[32,33]

Single components of the BSDS and the RFDS have been suggested to affect the inflammatory response in different ways. It is known, for example, that polyunsaturated omega-3 fatty acids are precursors for anti-inflammatory molecules, such as lipoxins, maresins, resolvins and protectins, which play an important role during the resolution of inflammation.[34] It is also known that high energy intake from sugars and saturated fats accelerate the production of oxygen-free radicals that leads to increased oxidative stress in the body [35] while, on the other hand, diet including antioxidants from fruits, vegetables and berries protect against oxidative stress. [36]

Both periodontitis and nutrition are related to socio-behavioural aspects.[37] This was also seen in these data because smoking, visiting the dentist irregularly and a lower level of education, for example, were more common among those who had low dietary scores than among those with high

scores. In order to take into account the effect of these factors, multivariate models were used. However, residual confounding related to these factors or unmeasured attitudes towards health behaviours may exist. Unlike health habits, it is worth noting that the number of teeth or tooth loss during 11 years did not essentially differ between tertiles in the BSDS or in the RFDS. This can be interpreted that no essential biases related to the number of teeth or tooth loss during the follow-up exist.

One important question is whether smoking had any effect on the findings. To control the confounding effect of smoking thoroughly, we performed also an analysis among non-smokers. This analysis showed that the associations between low scores of the BSDS and the RFDS and the number of teeth with deepened (≥4 mm) periodontal pockets at the follow-up were stronger than among the whole study population. This suggests, although not unexpectedly, that the association between diet and periodontal condition in the whole study population is confounded by smoking.

Another question is whether smoking modifies the association between the diet and the periodontal disease development, i.e. whether smokers benefit to a greater of lesser degree from a healthy diet than non-smokers. Regrettable, it was not possible to perform an analysis among smokers due to the low number of smokers in these data and thus we cannot compare the strength of the association between smokers and non-smokers. This means that we cannot exclude the possibility that true effect modification related to smoking exists.

The association between the BSDS and the number of teeth with deepened (≥4 mm) periodontal pockets was not completely linear. One explanation could be the composition of the index: the same score may be composed of completely different components of the index and the associations of different components, for example vegetables, whole grain or alcohol were not studied separately in this study. Naturally, the small number of participants may also have caused chance findings.

In this study, dietary exposure was measured once at the beginning of the study. Although people usually do not suddenly change their diets [38], it remains uncertain whether participants followed the same diet also during the follow-up period. The conception that diets are quite permanent is also supported by a study that was based on a nationally representative sample of the Finnish adult population. [39] That study showed that changes in dietary habits between the years 2000 and 2011 have been small. Also, another Finnish study, made in an adult population aged 25–75 years with a seven-year follow-up, reported that adherence to the healthy Nordic Diet (BSDS) did not essentially

change during the follow-up period. [40] In addition, the non-experimental nature of this study can be considered to be a weakness. This means that before making any inferences of causality between diet and periodontal disease development, these findings need to be confirmed by interventional studies. These could include promotion of a healthy diet based on dietary recommendations as part of other lifestyle instructions. In addition, the role of a diet could be studied in relation to periodontal healing.

The findings of this study made among middle-aged Finnish adults support the conception that poor-quality diet is associated with an increased risk to develop periodontal disease.

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Table 1. Basic characteristics of the study population by the outcome (number of teeth with ≥ 4 mm deep periodontal pockets in 2011).

	All	Participants with number of teeth with ≥4 mm deep periodontal pockets in 2011	
	(n=240)	None (n=114)	≥1 (n=126)
		n (%)	
Gender			
Male	84 (35)	33 (29)	51 (40)
Female	156 (65)	81 (71)	75 (60)
Level of education in 2000			
Basic	29 (12)	11 (10)	18 (14)
Intermediate	61 (25)	30 (26)	31 (25)
Higher	150 (63)	73 (64)	77 (61)
Dental attendance pattern			
Regularly in 2000	23 (10)	8 (7)	15 (12)
Regularly in 2011	33 (15)	13 (12)	20 (17)
Regularly in 2000 and 2011	127 (56)	63 (59)	64 (53)
No regular pattern (missing n=12)	45 (20)	23 (21)	22 (18)
Presence of dental plaque in 2000			
None	114 (48)	69 (61)	45 (36)
On the gingival margin	115 (48)	42 (37)	73 (58)
Elsewhere on the teeth	11 (5)	3 (3)	8 (6)
Smoking in 2000			
Daily	40 (17)	9 (8)	31 (25)
Occasionally	19 (8)	11 (10)	8 (6)
No smoking	181 (75)	94 (82)	87 (69)
in 2011			
Daily	31 (13)	10 (9)	21 (17)
Occasionally	14 (6)	6 (5)	8 (6)
No smoking (missing n=2)	193 (81)	97 (86)	96 (77)
Physical activity in 2000			
Optimal	7 (3)	4 (4)	3 (2)
Adequate	62 (26)	27 (24)	35 (28)
Uncertain	83 (35)	46 (40)	37 (29)
Inadequate	88 (37)	37 (32)	51 (40)
in 2011			
Optimal	10 (4)	3 (3)	7 (6)
Adequate	63 (27)	33 (29)	30 (24)
Uncertain	91 (38)	48 (43)	43 (34)
Inadequate (missing n=3)	73 (31)	28 (25)	45 (36)
Use of supplements in 2000			
Yes	47 (20)	22 (19)	25 (20)
No	193 (80)	92 (81)	101 (80)
Use of non-steroidal anti-inflammatory drugs in 2000			
Yes	80 (33)	37 (32)	43 (34)
No	137 (57)	66 (58)	71 (56)
Information missing	23 (10)	11 (10)	12 (10)

in 2011			
Yes	18 (8)	8 (7)	10 (8)
No	220 (92)	105 (93)	115 (92)
Information missing	-	1 (1)	1 (1)
		Mean (SD [1])	
Body Mass Index			
in 2000	24.8 (3.8)	24.7 (4.2)	25.0 (3.4)
in 2011	26.1 (4.6)	25.9 (4.9)	26.3 (4.3)
Hs-CRP [2]			
in 2000	1.5 (3.5)	1.4 (3.1)	1.7 (3.8)
in 2011	2.4 (5.0)	2.5 (5.8)	2.2 (4.2)
Number of teeth			
in 2000	26.5 (5.3)	26.4 (5.9)	26.5 (4.8)
in 2011	26 (5.3)	26.1 (5.9)	25.9 (4.7)
Number of teeth with deepened (≥ 4 mm) periodontal pockets			
in 2000	0 (0)	0 (0)	0 (0)
in 2011	3.0 (4.2)	0 (0)	5.7 (4.3)
BSDS [3] in 2000	12.9 (4.1)	13.3 (4.3)	12.6 (3.8)
RFDS [4] in 2000	12.0 (3.5)	12.5 (3.7)	11.5 (3.3)

[1] Standard deviation, [2] High-sensitivity C-reactive protein, [3] Baltic Sea Diet Score, [4] Recommended Finnish Diet Score

Table 2. Basic characteristics of the study population (n=240) by tertiles of the Baltic Sea Diet Score (BSDS) and the Recommended Finnish Diet Score (RFDS) (the higher the score the healthier the diet)

	BSDS			RFDS		
	Tertiles (range of score)					
	Low (3-10)	Middle (11-14)	High (15-23)	Low (2-10)	Middle (11-13)	High (14-20)
	n=72	n=75	n=93	n=82	n=72	n=86
	n (%)					
Gender						
Male	28 (39)	28 (37)	28 (30)	37 (45)	26 (36)	21 (24)
Female	44 (61)	47 (63)	65 (70)	45 (55)	46 (64)	65 (76)
Level of education in 2000						
Basic	7 (10)	11 (15)	11 (12)	12 (15)	7 (10)	10 (12)
Intermediate	21 (29)	20 (27)	20 (22)	23 (28)	17 (24)	21 (24)
Higher	44 (61)	44 (59)	62 (67)	47 (57)	48 (67)	55 (64)
Dental attendance pattern						
Regularly in 2000	6 (9)	9 (13)	8 (9)	10 (13)	7 (10)	6 (7)
Regularly in 2011	9 (13)	11 (16)	13 (14)	12 (15)	8 (12)	13 (16)
Regularly in 2000 and 2011	36 (52)	39 (57)	52 (58)	37 (47)	41 (60)	49 (60)
No regular pattern (missing n=12)	18 (26)	10 (14)	17 (19)	19 (24)	12 (18)	14 (17)
Presence of dental plaque in 2000						
None	28 (39)	38 (51)	48 (52)	37 (45)	30 (42)	47 (55)
On the gingival margin	39 (54)	32 (43)	44 (47)	40 (49)	40 (56)	35 (41)
Elsewhere on the teeth	5 (7)	5 (7)	1 (1)	5 (6)	2 (3)	4 (5)
Smoking in 2000						
Daily	16 (22)	17 (23)	7 (8)	18 (22)	15 (21)	7 (8)
Occasionally	5 (7)	5 (7)	9 (10)	3 (4)	8 (11)	8 (9)
No smoking	51 (71)	53 (71)	77 (83)	61 (74)	49 (68)	71 (83)
in 2011						
Daily	13 (18)	13 (18)	5 (5)	14 (17)	10 (14)	7 (8)
Occasionally	3 (4)	6 (8)	5 (5)	4 (5)	5 (7)	5 (6)
No smoking (missing n=2)	56 (78)	55 (74)	82 (89)	64 (78)	56 (79)	73 (86)
Physical activity in 2000						
Optimal	1 (1)	0 (0)	6 (6)	1 (1)	3 (4)	3 (3)
Adequate	15 (21)	23 (31)	24 (26)	19 (23)	19 (26)	24 (28)
Uncertain	20 (28)	23 (31)	40 (43)	25 (30)	23 (32)	35 (41)
Inadequate	36 (50)	29 (39)	23 (25)	37 (45)	27 (38)	24 (28)
2011						
Optimal	4 (6)	2 (3)	4 (4)	3 (4)	2 (3)	5 (6)
Adequate	17 (24)	19 (26)	27 (30)	24 (29)	14 (19)	25 (30)
Uncertain	28 (39)	29 (39)	34 (37)	25 (30)	36 (50)	30 (36)
Inadequate (missing n=3)	23 (32)	24 (32)	26 (29)	30 (37)	20 (28)	23 (28)
Use of supplements in 2000						
Yes	14 (19)	6 (8)	27 (29)	13 (16)	15 (21)	19 (22)
No	58 (63)	69 (92)	66 (71)	69 (84)	57 (79)	67 (78)

Use of non-steroidal anti-inflammatory drugs in 2000						
Yes	22 (31)	28 (37)	30 (32)	27 (33)	25 (35)	28 (33)
No	43 (60)	41 (55)	53 (57)	49 (60)	39 (54)	49 (57)
Information missing	7 (10)	6 (8)	10 (11)	6 (7)	8 (11)	9 (10)
in 2011						
Yes	3 (4)	10 (14)	5 (5)	5 (6)	5 (7)	8 (9)
No	69 (96)	64 (86)	87 (95)	77 (94)	66 (93)	77 (91)
BSDS						
Low	72 (100)	(0)	(0)	51 (62)	18 (25)	3 (3)
Middle	0 (0)	75 (100)	(0)	27 (33)	27 (38)	21 (24)
High	0 (0)	(0)	93 (100)	4 (5)	27 (38)	62 (72)
RFDS						
Low	51 (71)	27 (36)	4 (4)	82 (100)	0 (0)	0 (0)
Middle	18 (25)	27 (36)	27 (29)	0 (0)	72 (100)	0 (0)
High	3 (4)	21 (28)	62 (67)	0 (0)	0(0)	86 (100)
			Mean (SD [1])			
Body Mass Index						
2000	24.8 (4.3)	24.8 (3.4)	24.9 (3.7)	24.5 (3.6)	25.2 (3.9)	24.8 (3.8)
2011	26.4 (4.9)	25.4 (3.7)	26.6 (5.0)	25.6 (4.3)	26.6 (4.8)	26.3 (4.6)
Hs-CRP [2]						
in 2000	1.7 (3.5)	1.6 (4.3)	1.4 (2.6)	1.4 (3.3)	2.0 (4.8)	1.3 (2.2)
in 2011	2.5 (6.3)	2.3 (5.3)	2.3 (3.5)	2.4 (6.1)	1.9 (2.0)	2.7 (5.7)
Number of teeth						
in 2000	26.8 (4.1)	26.5 (5.6)	26.2 (6.0)	26.5 (4.8)	26.5 (5.5)	26.5 (5.7)
in 2011	26.4 (4.1)	26.1 (5.6)	25.7 (5.8)	26.1 (4.7)	25.9 (5.5)	26.1 (5.6)
Number of teeth with deepened (≥4 mm) periodontal pockets						
in 2000	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
in 2011	3.2 (4.7)	3.4 (4.6)	2.5 (3.5)	3.3 (4.9)	3.3 (4.1)	2.4 (3.6)
BSDS	8.1 (1.9)	12.5 (1.2)	17.0 (2.0)	9.4 (2.8)	12.9 (2.9)	16.3 (3.0)
RFDS	9.3 (2.9)	11.5 (2.8)	14.5 (2.5)	8.1 (1.8)	12.1 (0.8)	15.7 (1.5)

[1] Standard deviation, [2] High-sensitivity C-reactive protein

Table 3. Incidence rate ratios (IRR) and 95% confidence intervals (95% CI) for the Baltic Sea Diet Score (BSDS) and the Recommended Finnish Diet Score (RFDS) in 2000 (the higher the score the healthier the diet) number of teeth with deepened (≥4 mm) periodontal pockets in 2011 as an outcome.

ALL					
	BSDS			**RFDS**	
	IRR (95% CI)			**IRR (95% CI)**	
	Unadjusted (n=240)	**Adjusted*** (n=225)		**Unadjusted** (n=240)	**Adjusted*** (n=225)
Continuous	**0.90** (0.88–0.92)	**0.95** (0.93–0.98)	**Continuous**	**0.89** (0.87–0.91)	**0.96** (0.92–0.99) p=<0.001
Tertiles (range of score)			**Tertiles** (range of score)		
I tertile (3-10) n= 72	**1.94** (1.63–2.31)	1.23 (0.93–1.63)	**I tertile (**2–10) n= 82	**1.95**(1.60–2.32)	**1.49** (1.12–1.99)
II tertile (11–14) n= 75	**0.78** (0.65–0.94)	**2.26** (1.70–2.99)	**II tertile (**11–13) n= 72	1.10 (0.92–1.33)	1.14 (0.86–1.51)
III tertile (15–23) n= 93	ref.	ref.	**III tertile (**14–20) n= 86	ref.	ref.
NON-SMOKERS in 2011					
	Unadjusted (n=193)	**Adjusted*** (n=183)		**Unadjusted** (n=193)	**Adjusted*** (n=183)
Continuous	**0.92** (0.90–0.94)	**0.90** (0.87–0.93)	**Continuous**	**0.93** (0.90–0.96)	**0.78** (0.74–0.81)
Tertiles (range of score)			**Tertiles** (range of score)		
I tertile (4-10) n=64	1.20 (0.98–1.47)	1.09 (0.79–1.52)	**I tertile (5-10)** n= 59	**1.34 (**1.10–1.64)	**5.75** (4.13–8.01)
II tertile (12-14) n= 45	**0.63** (0.50–0.78)	**2.55** (1.84–3.53)	**II tertile (11-13)** n= 57	**0.57** (0.45–0.72)	1.15 (0.83–1.61)
III tertile (15-23) n= 84	ref.	ref.	**III tertile (14-20)** n= 77	ref.	ref.

The number of teeth in 2011 was used as an offset variable.

* **Year 2000**: age, gender, level of education, body mass index (BMI), use of supplements, plaque, total energy intake (kJ) ; **year 2011**: plaque, physical activity, smoking (not in the model of non-smokers), High-sensitivity C-reactive protein, use of non-steroidal anti-inflammatory drugs; **years 2000 and 2011**: BMI (change), dental attendance pattern (combined variable).