

Dental status, diet and cardiovascular risk factors in middle-aged people in northern Sweden

Ingegerd Johansson², Per Tidehag^{1,3},
Vivan Lundberg⁴ and
Göran Hallmans¹

Departments of ¹Nutritional Research,
²Cariology, and ³Prosthodontics, University of
Umeå, Umeå, Department of Medicine,
⁴Kalix Hospital, Kalix, Sweden

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Abstract – The aim of the present study was to compare the dietary intake and the levels of traditional cardiovascular (CVD) risk factors in edentulous middle-aged individuals and individuals of the same age and sex who still had natural teeth. The study was performed within the framework of the MONICA-project. Population registers were used to sample randomly 1287 men and 1330 women aged 25–64 yr. Data were collected from a mailed questionnaire, blood analyses, registrations of blood pressure and anthropometric measures. The estimated daily energy intake did not differ between the two groups, but edentulous men and women ate more sweet snacks compared to those who still had teeth. Edentulous men also ate less fruits, vegetables and fibre and edentulous women ate more fat than dentates. Edentulous men and women were more obese and had lower serum HDL-cholesterol concentrations than those with remaining teeth. Edentulous women also had significantly higher concentrations of total cholesterol and triglycerides in serum than dentate women. Edentulous men and women were more often regular smokers, but not snuff users, than dentates of the same age and sex. Thus, the presence of two or more cardiovascular risk factors was more common in edentulous individuals than in those who still had natural teeth. In summary, these results support the hypothesis that edentulous middle-aged individuals have a more unfavourable risk factor profile for CVD. Counselling on balanced dietary habits and non-smoking given by dental personnel to orally diseased patients – recommendations given to improve resistance to dental caries or periodontitis – might therefore improve general health and possibly also improve risk factors for CVD.

Key words: CVD; teeth; diet; MONICA study

Dr. Per Tidehag, Department of Nutritional Research, University of Umeå, 901 87 Umeå, Sweden

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Disease patterns in industrialised countries differ markedly from those in less affluent communities. Non-communicable diseases including atherosclerosis (1, 2), diabetes (3) and dental caries (4) are more prevalent in industrialized nations. As a society becomes more affluent, disease patterns alter towards a more "westernized" type (5).

Dental caries and periodontitis, which lead to tooth loss, are caused by micro-organisms, but life style factors including dietary habits, oral hygiene and compliance with prophylactic programmes, modify disease progression. Patients with

cardiovascular (9) or cerebral (10) infarction have been reported to have poorer dental status than control subjects. Chronic oral infection was suggested to be associated with infarction (9, 10). However, the existence of common factors for the development of infarction and dental disease could not be excluded. Epidemiological studies show correlation between atherosclerosis and age and gender but also with factors related to life style, including dyslipidaemias, obesity, smoking, dietary habits (6, 7) and physical activity (8). We have recently found that adolescents with a high prevalence

of caries had a dietary composition (11) and a medical status (12) often claimed to be related to an increased risk of developing cardiovascular disease. They had a higher average daily intake of energy originating from fat and lower daily fibre intake (11), were more obese, and had a higher blood pressure than caries-free adolescents (12). The number of daily sucrose intakes or percentage of the energy provided by sucrose did not differ between the caries-active and the caries-free groups (11).

The aim of the present study was to investigate dietary intake in a group of

edentulous middle-aged individuals, and assess whether they had a more unfavourable profile of factors associated with increased risk of developing cardiovascular disease than individuals who still had natural teeth. The study was performed within the framework of the MONICA (Multinational Monitoring of Trends and Determinants in Cardiovascular Disease) study which was initiated by the World Health Organization to screen cardiovascular risk factors in 39 randomly selected population samples in 26 nations over a 10-yr period (13).

Methods

Study population – The subjects included in the present study were participants in the northern Sweden MONICA study. Surveys were made from 15th January to 15th April in 1986 and 1990 in the provinces of Norrbotten and Västerbotten in northern Sweden. Continuously updated population registers were used to select randomly 2000 individuals aged 25–64 yr in 1986 and 2000 in 1990. The survey area, which corresponds to the area of England and Wales, has a total middle-aged population of 262 000 persons. Each year 250 men and 250 women in every 10-yr age group (25–34, 35–44, 45–54, 55–64 yr) were selected and invited. The invitation was repeated once. Of the 2000 individuals invited, 1625 participated in 1986 and 1583 in 1990.

The study was approved by the Ethics Committee for Human Experiments at the University of Umeå, Sweden.

Non-participants The reason for non-attendance was obtained from 207 (56.7%) of the 375 non-respondents in 1986 and from 203 (49.4%) of 422 non-respondents in 1990. More than half of the interviewed non-participants were not interested in medical assessment. Other reasons for non-participation were: not possible to contact, temporary residence outside the screening area, or hospitalised or too ill to participate. Less than 1% had died after selection. Comparisons between participants and non-participants did not reveal any major systematic differences (14, 15).

Dietary registration Consumption frequencies of a variety of 82 food items were reported on a nine-level scale, ranging from never eaten to eaten four or more times per day (16). The questionnaire included eight questions on the

consumption frequency of various types of fats, nine on milk and dairy products, seven on bread and cereals, none on fruit, vegetables and root fruits and eight on sugar containing snacks and soft drinks. Five questions on spirit, wine and beer consumption were included in a list of beverages. The remaining 36 questions recorded potato, rice, pasta, meat and fish intake. The reported consumption frequencies were converted to number of intakes per day and the nutrient intake was estimated in standard portions (16).

The list of food items was reduced to 49 items in 1990. The present evaluation of dietary intake was therefore restricted to the individuals included in 1986.

Medical registration – The participants received a mailed questionnaire which included questions on medical history, dietary, physical and smoking habits, and psycho-social situation. At the medical examination, which took place after at least a 4-h fast, the questionnaire was returned, blood pressure and anthropometric measurements registered and a venous blood sample drawn. Serum concentrations of total and HDL-cholesterol and triglycerides were analysed by enzymatic methods using commercial kits (Boehringer Mannheim GmbH, Mannheim, Germany). Serum triglycerides were only assessed in overnight fasted participants in 1990 (cf. Table 2). Systolic and diastolic blood pressures were measured with the subject seated using the random zero technique (17). Details of the standardised procedures and methods have been described elsewhere (14, 15).

Evaluation of dental status – Two questions on dental status were included in the questionnaire. Three alternatives were given for each question: 1) Do you only have your natural teeth? 2) Do you have natural teeth and a removable partial denture? 3) Do you wear full dentures? These questions were answered separately for the maxilla and mandible.

Statistics Computerised data handling was approved by the National Computer Data Inspection Board, Sweden. The Statistical Analysis System (SAS release 6.03 edition 1988; SAS Institute Inc., Cary, North Carolina, USA) was used for basic statistical analysis.

The association between loss of teeth and various dietary variables and traditional CVD risk factors were analysed in two ways. Firstly, the differences between

age-adjusted means and their SE were calculated and tested with Student's *t*-test for men and women separately. The means and measures of variation were standardised for age using analysis of covariance in the GLM procedure in SAS (18). Adjustment for study year did not affect the results further. The chi-square-test was used to compare numbers of dentate and edentulous individuals with hypertension or with different numbers of risk factors. All tests were two-tailed and *P*-values below 0.05 were considered statistically significant. Secondly, the risk of being edentulous was evaluated for different levels (quintiles) of dietary exposure or values of CVD risk factors taking the lowest quintile as the reference category. Multiple logistic regression analysis (19) was used to control for confounding factors. Factors that are likely to influence the exposure-disease relationship under study were taken into account. We 1) adjusted for age (additional adjustment for education level did not have any major influence on the results) and 2) simultaneously included all variables that in step 1 had a significant increasing or decreasing effect. This was done to find the relative impact of each variable. Odds ratios with their 95% confidence limits are presented.

Results

The overall response rate in the northern Sweden MONICA study was 81.3% in 1986 and 79.2% in 1990. All respondents had answered the questions on dental status, but the number of participants who had answered other questions varied. The results are presented for data merged for the 2 yr but similar results were found when data were analysed separately for 1986 and 1990.

The number of participants with total loss of teeth (full denture in both maxilla and mandible) was 415 and 2202 claimed to have at least some natural teeth (Table 1). The remaining 591 participants had a full denture in one jaw or at least one partial denture. These 591 participants were not included in the statistical analysis. The number and percentage of edentulous participants were higher in 1986 than in 1990 in all groups (Table 1). Only one man, and no women, aged 25–34 yr had complete tooth loss (Table 1). The youngest age group was therefore excluded and groups with complete tooth loss

Table 1. Distribution of participants by dental status in the MONICA study 1986 ($n=1625$) and 1990 ($n=1583$). Numbers in parentheses refer to the percentage of the age-group or the gender

Age group	Men						Women					
	Dentate		Partial denture ^a		Edentulous		Dentate		Partial denture ^a		Edentulous	
	1986	1990	1986	1990	1986	1990	1986	1990	1986	1990	1986	1990
25-34 yr	169	160	5	7	1 (0.6%)	0 (0%)	170	174	17	3	0 (0%)	0 (0%)
35-44 yr	161	184	41	13	10 (5%)	2 (1%)	169	186	29	18	8 (4%)	2 (1%)
45-54 yr	133	133	54	49	38 (17%)	21 (10%)	125	143	49	49	38 (18%)	17 (8%)
55-64 yr	60	88	66	77	85 (40%)	42 (20%)	56	91	57	57	84 (43%)	67 (31%)
Total	523	565	166	146	134 (16%)	65 (8%)	520	594	152	127	130 (16%)	86 (11%)

^a at least one partial denture or a full denture in one jaw.Table 2. Age-adjusted odds ratios and their (95% confidence intervals) for separate dietary variables and CVD risk factors. The arrows indicate the trend in the risk through the quintiles (\rightarrow =no, \uparrow =increasing, \downarrow =decreasing)

	Men (quintiles)				Women (quintiles)			
	1st	4th	5th (high)	Trend	1st	4th	5th (high)	Trend
Energy ^a	1.00	0.48 (0.23-1.00)	0.59 (0.29-1.20)	\rightarrow	1.00	1.36 (0.72-2.54)	1.23 (0.65-2.31)	\rightarrow
Fat ^a	1.00	0.44 (0.20-0.95)	0.70 (0.34-1.40)	\rightarrow	1.00	1.55 (0.73-3.26)	2.43 (1.17-5.05)	\uparrow
Fibre ^a	1.00	0.68 (0.33-1.40)	0.41 (0.20-0.86)	\downarrow	1.00	0.75 (0.35-1.58)	0.82 (0.39-1.73)	\rightarrow
Fruit ^a	1.00	0.57 (0.27-1.14)	0.27 (0.13-0.56)	\downarrow	1.00	0.56 (0.26-1.21)	0.53 (0.25-1.13)	\rightarrow
Vegetables ^a	1.00	0.28 (0.15-0.67)	0.18 (0.08-0.38)	\downarrow	1.00	0.38 (0.18-0.83)	0.40 (0.19-0.85)	\downarrow
Sweet snacks ^a	1.00	1.67 (0.80-3.48)	2.55 (1.22-5.32)	\uparrow	1.00	2.12 (1.01-4.46)	2.52 (1.20-5.30)	\uparrow
Cholesterol ^b	1.00	0.98 (0.55-1.75)	1.27 (0.72-2.23)	\rightarrow	1.00	1.07 (0.56-2.05)	2.34 (1.25-4.38)	\uparrow
HDL-Cholesterol ^b	1.00	0.43 (0.25-0.74)	0.34 (0.18-0.62)	\downarrow	1.00	0.39 (0.22-0.72)	0.35 (0.20-0.62)	\downarrow
Triglycerides ^c	1.00	3.35 (0.73-8.58)	2.61 (1.98-6.34)	\uparrow	1.00	2.42 (0.60-9.87)	11.1 (3.1-39.4)	\uparrow
BMI ^b	1.00	1.19 (0.66-2.14)	2.07 (1.17-3.63)	\uparrow	1.00	1.85 (0.99-3.46)	3.44 (1.87-6.32)	\uparrow
Waist-hip ratio ^b	1.00	1.66 (0.92-3.00)	2.38 (1.34-4.22)	\uparrow	1.00	4.40 (2.34-8.30)	5.98 (3.19-11.2)	\uparrow

^a dietary data were obtained only in 1986 (total $n_{\text{men}}=523$ and total $n_{\text{women}}=520$). ^b data from 1986 and 1990 (total $n_{\text{men}}=1088$ and total $n_{\text{women}}=1114$). ^c only analysed in 1990 in overnight fasted individuals (total $n_{\text{men}}=272$ and total $n_{\text{women}}=305$).

or natural teeth were compared for 35-64-yr-olds.

The prevalences of edentatitas were similar for men and women in both study years (Table 1), but loss of teeth was strongly associated with increasing age (Table 1) and level of education. Male and female participants, with elementary school had odds ratios with (95% CI) for edentatitas of 2.83 (1.57-5.08) for men and 2.87 (1.67-4.94) for women, respectively compared to men and women with more than elementary school.

In 35-44, 45-54, and 55-64-yr-olds, 75.4%, 65.4% and 56.9%, respectively, had answered all questions in the food frequency list in 1986. In all, 29 men and 11 women with more than 10 missing questions were excluded from estimation of daily intake of energy, fat and fibre. As could be seen (Table 2) an increasing risk for edentatitas was found through the quintiles for both men and women by increasing intake of sweet snacks or decreasing intake of vegetables. Men with low intake of fruit or fibre had also higher risk to be edentulous than those with a high intake, and women with high

intake of fat had increased risk. A comparison between the age-adjusted mean intakes for the two groups is shown in Table 3. As could be seen in Table 3 the estimated daily energy intake did not differ between edentulous and dentate participants, but edentulous men and women had a higher daily average intake of sweet snacks. Edentulous men also had a significantly lower average intake of fruit and vegetables and edentulous women higher intake of fat than the corresponding dentate group (Table 3).

Elevated blood pressure was defined as a diastolic blood pressure ≥ 95 mm Hg or a systolic blood pressure ≥ 160 mm Hg and/or intake of anti-hypertensive drug(s). The age-adjusted odds ratios for edentatitas was similar in participants with normal blood pressure and those with a high systolic or diastolic blood pressure (data not shown). However, the age-adjusted odds ratios to be edentulous increased for both sexes by increasing quintiles of BMI, waist-hip ratio and serum concentration of triglycerides (Table

Table 3. Comparison of dietary variables in dentate and edentulous middle-aged people in northern Sweden in 1986. Data are presented as mean \pm SE adjusted for age

	Men ^a			Women ^a		
	Dentate	Edentulous	P-value ^b	Dentate	Edentulous	P-value ^b
Energy, MJ/day ^c	9.0 \pm 0.2	8.8 \pm 0.3	NS	4.7 \pm 0.1	5.0 \pm 0.1	NS
Fat, g/day ^c	83.8 \pm 1.7	82.7 \pm 2.9	NS	44.6 \pm 1.0	50.3 \pm 1.6	<0.01
Fat, E% ^c	34.2 \pm 0.3	34.5 \pm 0.5	NS	35.2 \pm 0.4	37.0 \pm 0.6	<0.05
Fibre, g/day ^c	20.4 \pm 0.5	18.4 \pm 0.8	<0.05	11.7 \pm 0.3	11.1 \pm 0.5	NS
Fruit ^d	1.2 \pm 0.1	0.9 \pm 0.1	<0.01	1.5 \pm 0.1	1.3 \pm 0.1	NS
Vegetables ^d	1.1 \pm 0.1	0.8 \pm 0.1	<0.01	1.5 \pm 0.1	1.3 \pm 0.1	NS
Sweet snacks ^d	2.7 \pm 0.1	3.4 \pm 0.2	<0.01	1.8 \pm 0.1	2.5 \pm 0.2	<0.001

^a dietary data were obtained only in 1986 (total $n_{\text{men}}=523$ and total $n_{\text{women}}=520$). ^b tested with a two-tailed Student's *t*-test. ^c estimated daily intake. ^d servings per day.

2). The odds ratios to be edentulous decreased for both sexes by increasing serum concentration of HDL-cholesterol (Table 2). A comparison of traditional CVD risk factor levels in edentulous and dentate participants is presented in Table 4.

The use of tobacco was compared be-

tween participants with or without natural teeth. "Regular smokers" were defined as those who smoked one cigarette or more per day, or had a weekly use exceeding 5 g pipe-tobacco or five cigars. Those who used snuff at least once daily were considered "regular snuff dippers". "Non-tobacco users" were defined as

those who did not smoke or use snuff (20). The number of regular smokers was significantly higher in all age groups of edentulous men and women compared to their respective control group (data not shown). Regular use of snuff did not differ between dentate and edentulous men and women. Regularly smoking men and women had significantly higher risk to be edentulous than non-smokers (non-tobacco users/snuff dippers). The odds ratios (95% CI) were for men 2.32 (1.57–3.45) and for women 2.02 (1.36–2.99).

When all variables found to affect the risk to be edentulous (cf. Table 2) were included into the regression model simultaneously (Table 5) age, education and intake of fruits and vegetables contributed significantly to explain the increased risk in men, whereas age, education, intake of fat, vegetables and sweet snacks, BMI, total cholesterol, and HDL-cholesterol contributed in women. BMI and waist-hip ratio are both measures of obesity and therefore only BMI was included in the model. Triglyceride values were not included due to the low number of analysed samples. The number of variables where the values exceeded cut-off values defined by WHO as risk levels for CVD (21) were compared in edentulous and dentate participants. Thus, values, of total cholesterol >6.5 mmol/l, elevated blood pressure as described above, and BMI ≥ 27 kg/m², and regular smoking were scored as risk values. Individuals with one or no risk factors were more common among dentate individuals than among edentulous ones (Fig. 1), and two or more risk variables were more common in edentulous individuals.

Table 4. Comparison of cardiovascular risk factors in dentate and edentulous middle-aged people in northern Sweden. Data are presented as mean \pm SE adjusted for age

	Men ^a			Women ^a		
	Dentate	Edentulous	P-value ^b	Dentate	Edentulous	P-value ^b
Cholesterol ^c	6.49 \pm 0.04	6.55 \pm 0.09	NS	6.34 \pm 0.04	6.71 \pm 0.09	<0.001
HDL-cholesterol ^c	1.22 \pm 0.01	1.11 \pm 0.02	<0.001	1.50 \pm 0.001	1.36 \pm 0.03	<0.001
Triglycerides ^c	1.76 \pm 0.07	1.69 \pm 2.55	NS	1.32 \pm 0.05	1.84 \pm 0.11	<0.001
BMI ^d	25.8 \pm 0.1	26.7 \pm 0.3	<0.01	25.0 \pm 0.2	26.8 \pm 0.3	<0.001
Waist-Hip ^e	0.94 \pm 0.002	0.96 \pm 0.005	<0.001	0.83 \pm 0.003	0.87 \pm 0.005	<0.001

^a data from 1986 and 1990 (total $n_{\text{men}} = 1088$ and total $n_{\text{women}} = 1114$). ^b tested with a two-tailed Student's *t*-test. ^c mmol/l. ^d kg/m². ^e circumference ratio.

Table 5. Logistic regression of age, education, diet and CVD risk factors simultaneously on dental status (teeth/no teeth)

	Men (<i>n</i> = 472)			Women (<i>n</i> = 475)		
	Odds ratio	95% CI	P for β -coeff	Odds ratio	95% CI	P for β -coeff
Age	4.44	3.04–6.49	***	4.50	3.36–7.75	***
Education	2.63	1.49–4.63	***	2.86	1.64–4.97	***
Fat		not in model		1.24	1.02–1.50	*
Fibre	0.97	0.79–1.20	NS		not in model	
Fruits	0.81	0.66–0.99	*		not in model	
Vegetables	0.82	0.67–1.00	*	0.80	0.66–0.97	*
Sweet	1.17	0.97–1.41	NS	1.22	1.00–1.48	*
Cholesterol		not in model		1.26	1.02–1.55	*
HDL-Cholesterol	0.83	0.67–1.03	=0.08	0.88	0.72–1.07	*
BMI	1.13	0.94–1.35	NS	1.34	1.09–1.64	**
Smoking	1.17	0.70–1.96	NS	1.64	0.93–2.90	=0.09

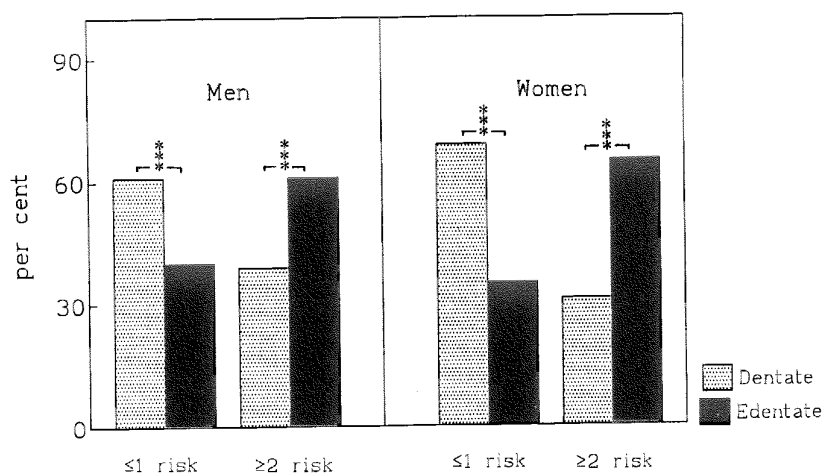


Fig. 1. Percentage of men and women with ≤ 1 or ≥ 2 risk factors for cardiovascular disease by dental status in 55–64-yr-olds.

Discussion

In the present study, which was conducted in an area with a high incidence of cardiovascular disease (14), dietary intake, medical status, and tobacco use were compared in groups of middle-aged individuals with total tooth loss or remaining natural teeth. It was found that beside high age, low level of education, low intake of vegetables and low level of HDL-cholesterol in serum, increased the risk for edentatitas in both sexes. On the group level edentulous men and women also had a higher average daily intake of sweet snacks, were more obese and more

frequently were regular smokers than the respective dentate group. However, these variables did not have a consistent effect for the genders in the multiple regression analyses. Further, edentulous individuals more often had two or more factors at levels considered unfavourable for developing cardiovascular disease compared to dentate sex and age matched groups. Our findings support the hypothesis that individuals with high levels of dental disease have more unfavourable levels of risk factors for developing atherosclerotic diseases (9–12, 22, 23).

The participants in the study were randomly selected from updated population registers. The participation rate was 81.3% in 1986 and 79.2% in 1990. Thus, the participants were representative of the northern Swedish, middle-aged population in 1986 and 1990. Dental status was classified as total tooth loss, remaining natural teeth only, and an intermediate status, based on two questions in the questionnaire. The validity of these questions was not assessed but we found an expected decrease in prevalence of toothlessness between the two survey occasions and an increase with age. The prevalence of toothlessness was 17% in 1986 and 9% in 1990 in 45–54-yr-olds, and 41% in 1986 and 26% in 1990 in 55–64-yr-olds. These data for 1990 agree with the prevalence of toothlessness of 5% in 50-yr-olds and 30% in 65-yr-olds found in a population based study on oral health performed in 1990 in the province of Västerbotten (24).

There is a suggestion that poor dietary habits in terms of high energy and fat intake, especially saturated fatty acids, low fibre, vitamin C and E, and carotenoids (7) may enhance development of CVD. We found that edentulous men and women had a lower intake of vegetables and that edentulous men also had a lower intake of fruit than dentates. This is in accordance with HALLING *et al.* (25) who reported that edentulous women had a lower consumption of fresh vegetables and fruits than those with teeth (25). Our study has not examined whether the finding of the lower intake of fruits or vegetables and higher intake of sweets were the cause or the result of tooth loss. However, individuals rarely change their dietary habits unless they are instructed to do so, and new, well-fitting dentures (26, 27) or osseo-integrated teeth (28) did not improve dietary habits merely as a result

of improved chewing ability. It therefore seems likely that the reported dietary habits in the edentulous participants reflect their past dietary habits. An association between CVD and dental status is not fully understood and the present study design does not allow any conclusion on causality but merely on covariations between these variables. Variations in lifestyle and social situation, among which dietary and smoking habits are included, may explain some covariation in tooth loss and the number of unfavourable CVD risk factors but this must be confirmed in studies where the outcome variable is measured in a more differentiated way, e.g. as number of teeth.

We found support for the hypothesis that middle-aged individuals with tooth loss have a more unfavourable risk factor profile for CVD. Further support may be found in a Finnish study (22) and two Swedish studies (11, 12) reporting a relationship between dental caries, BMI, fat and fibre intake in adolescents. Three other studies in adults show that patients with myocardial (9, 23) or cerebral infarction (10) had poorer dental status than controls. In our study, edentulous participants more often had two or more risk factors associated with atherosclerosis than dentate controls. Preventive measures in adolescents and young adults with high activities of dental caries or periodontitis frequently include sucrose restriction, general dietary advice, and advice to stop smoking. This study suggest that counselling on balanced dietary habits and non-smoking given by dental personnel to orally diseases patients – recommendations given to improve resistance to dental caries or periodontitis – could also improve general health and possibly also improve risk factors for CVD. This may be an advantage since young subjects may be difficult to motivate to alter their lifestyle – stop smoking or change dietary habits – in order to influence the development of CVD as they perceive the benefit as remote or difficult to prove.

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