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Total Dietary Fiber, and Selected Vegetable, Fruit, Legume and Cereal Fiber Intake and Risk of Heart Attack in Periodontitis Subjects

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Abstract:

Background: Epidemiological studies have found an association between periodontal disease and coronary artery disease(Arbes, Slade et al. 1999; Beck, Elter et al. 2001; Genco, Offenbacher et al. 2002), and have even implicated periodontal disease as a risk factor(Arbes, Slade et al. 1999; Beck, Elter et al. 2001), however have not proven causality(Hujoel, Drangholt et al. 2000). Although dietary amounts, sources, and types (soluble versus insoluble) of fiber have been shown to reduce the risk of heart attack (Liu, Buring et al. 2002; Negri, Vecchia et al. 2003), this author is unaware of studies that have examined the association between food sources of dietary fiber and heart attack risk in subjects with periodontitis.

This study was designed to determine whether total dietary fiber and fiber from different plant sources (vegetables, fruits, legumes, or cereals) modified self-reported HA risk, as well as acute-phase inflammatory responses in subjects with periodontitis using NHANES III data.

Objectives: The objective of this study was to investigate the association between total dietary fiber intake levels, and selected vegetables, fruits, legumes, and cereal fiber intake and the risk of self-reported history of heart attack (HA) in periodontitis subjects using data available in the Third National Health and Nutrition Examination Survey (NHANES III).

Materials and Methods: Adult participants in NHANES III were used in this study. Zero to thirty three (0-33) percent of sites with periodontal attachment loss > 3 mm was considered a healthy periodontium, while greater than thirty three percent (>33) of sites with periodontal attachment loss of > 3 mm as periodontitis. The outcome variable was the self-reported history of HA. Total dietary fiber, and monthly selected vegetable, fruit, legume and cereal consumption were divided into low and adequate levels. Data was analyzed by Kruskal-Wallis, ANOVA and multivariate analyses using SPSS ®. $P<0.05$ was used to reject the null hypothesis.

Results: Individuals with periodontitis, that consumed low levels of the selected vegetables and fruits had a significantly increased risk of self-reported HA for: low total dietary fiber intake

levels(P<0.005); low levels of selected vegetables - low broccoli and any other vegetables(P<0.01); Brussels sprouts, carrots, cabbages, spinach and tossed salads(P<0.05), and low selected fruits – citrus fruits, peaches/nectarines and any other fruits(P<0.05), adjusting for confounders of both diseases and energy (Kcal). Adjusting the model further for serum antioxidants, dietary cholesterol and other fat intake maintained a significantly higher HA risk for: low total dietary fiber intake levels(P<0.05); low levels of selected vegetables - low broccoli, spinach(P<0.05) and any other vegetables(P=0.05); but significantly increased HA risk with low all-bran cereal(P<0.05). Serum CRP and creatinine, and plasma fibrinogen, were significantly affected by fiber quantity and source in periodontitis versus healthy periodontium subjects, and in periodontitis and healthy periodontium subjects individually(P<0.05)

Conclusions: It is theorized that subjects with periodontitis that consume inadequate levels of total dietary fiber, and inadequate fiber from selected vegetables, fruits, legumes, and cereals are likely to increase their risk of heart attack.

Keywords: Dietary Fiber, Periodontitis , Heart Attack

Background:

Numerous previous prospective (Morris, Marr et al. 1977; Kromhout, Bosschieter et al. 1982; Kushi, Lew et al. 1985; Khaw and Barrett-Connor 1987; Fehily, Yarnell et al. 1993), epidemiological (Martinez-Gonzalez, Fernandez-Jarne et al. 2002) and observational studies (Liu, Buring et al. 2002; Martinez-Gonzalez, Fernandez-Jarne et al. 2002; Negri, Vecchia et al. 2003) have suggested that dietary fiber intake protects against myocardial infarction, or heart attack (HA), but most studies have been unable to distinguish the independent effects of dietary fiber from other beneficial food constituents of high fiber foods and sources of fiber. Recommended dietary fiber intakes are not being met(Alaimo, McDowell et al.), because intakes of good sources of dietary fiber, fruits, vegetables, whole and high-fiber grain products, and legumes are low (Marlett and Cheung 1997; Marlett, McBurney et al. 2002).

Several studies have demonstrated that dietary preferences are altered with tooth loss (Krall, Hayes et al. 1998; Walls, Steele et al. 2000; Hung, Willett et al. 2003; Nowjack-Raymer and Sheiham 2003), and it has also been suggested that edentulous subjects may have an increased heart attack risk, due to their inability to chew fibrous foods (Johanson, Tidehag et al. 1994).

Epidemiological studies have found an association between periodontal disease and coronary artery disease(Arbes, Slade et al. 1999; Beck, Elter et al. 2001; Genco, Offenbacher et al. 2002), and have even implicated periodontal disease as a risk factor(Arbes, Slade et al. 1999; Beck, Elter et al. 2001), however have not proven causality(Hujoel, Drangholt et al. 2000). Acknowledged risk factors for heart attack are also risk factors for periodontal disease(Grossi and Genco 1998). Although dietary amounts, sources, and types (soluble versus insoluble) of fiber have been shown to reduce the risk of heart attack (Liu, Buring et al. 2002; Negri, Vecchia et al. 2003), this author is unaware of studies that have examined the association between food sources and amounts of dietary fiber and heart attack risk in subjects with periodontitis.

This study was designed to determine whether total dietary fiber intake levels and fiber from different plant sources (vegetables, fruits, legumes, or cereals) modified self-reported HA risk, as well as acute-phase inflammatory responses in subjects with periodontitis using NHANES III data.

Materials and Methods:

Data for this study was obtained from NHANES III, conducted from 1988 to 1994, which was designed to provide estimates of the health status of the United States' civilian, non-institutionalized population aged two months and over (Ezzati, Massey et al. 1992). For this analysis, three public use data files – household adult ((DHHS) 1996a), examination ((DHHS) 1996a), and laboratory ((DHHS) 1996b) were obtained in CD-ROM and merged into one data file. This study was limited to individuals eighteen years of age +. The independent variable of interest was the percent of periodontal sites per subject with attachment loss (PAL) of > 3 millimeters (mm). Periodontal examinations were conducted in the mobile examination centers by six calibrated dentists trained in the use of epidemiological indices for oral health and are described elsewhere (Arbes, Slade et al. 1999). For this study, extent scores (Carlos, Wolfe et al. 1986), representing the percent of sites per subject with attachment loss of 3 mm or greater, were calculated and categorized into two levels

Zero to thirty three (0-33) percent of sites with PAL of > 3 mm was considered normal, while greater than thirty three (>33) percent of sites with PAL > 3 mm was defined as periodontitis. The threshold of 3 mm was used to increase the likelihood that attachment loss was the result of disease and not measurement error. This grouping was consistent with other studies reporting NHANES III data (Arbes, Slade et al. 1999). The analysis excluded persons who were edentulous.

Another outcome variable was the "self-reported history of heart attack". The administration of food-frequency questionnaires and a detailed 24-hour dietary recall was used to record food consumption. Monthly total dietary fiber (g/day) intake, and selected monthly vegetable, and cereal consumption was calculated and divided into low or adequate levels.

Table 1. Consumption levels of selected vegetables, fruits, legumes, and cereals, including fiber content.

Selected Food	Monthly Consumption Level (servings) Low ≤	Adequate >	Total Dietary Fiber (grams)	Soluble Fiber (grams)	Insoluble Fiber (grams)
Selected Vegetables					
Broccoli	5.2	5.2	2.7	0.3	2.4
Brussels sprouts	3.3	3.3	3.3	0.2	2.8
Carrots	8.0	8.0	2.1	0.2	1.9
Cabbages	4.5	4.5	1.2	0.1	1.1
Spinach	4.5	4.5	2.0	0.5	1.5

Tossed Salad	10.0	10.0	1.0		
Any other Veget.	12.2	12.2	3.0	0.2	2.8
Selected Fruits					
Citrus Fruits	7.4	7.4	2.0	0.5	1.5
Melons	2.8	2.8	0.9	0.1	0.8
Peaches/Nectarines	4.9	4.9	2.0		
Any other fruits	15.8	15.8	2.6	0.3	2.3
Selected Legumes					
Beans	9.3	9.3	6.6	1.5	5.1
Selected Cereals					
All-Bran	2.2	2.2	13.5	2.0	11.5
Total, etc.	1.6	1.6	3.0	0.2	2.8
All other cold	12.2	12.2	1.1	0.1	1.0
Hot	3.3	3.3	4.4	1.7	2.7
Total Dietary Fiber	14.5	14.5			

Non-fasting, venous blood was collected and analyzed for serum C-reactive protein (CRP), fibrinogen (FIB), and creatinine (CRTN) levels (DHHS 1996).

Data was analyzed using SPSS® version 10.1. Group comparisons were made using Kruskal-Wallis, ANOVA, multivariate general linear models using a Bonferroni adjustment, and multivariate logistic regression to calculate crude odds ratios. Established risk factors for periodontal disease and HA risk were selected covariables. The covariables were age, race, gender, body mass index (BMI), smoking history, a self-reported history of diabetes (self-reported by "Has the doctor ever told you that you have diabetes?"), hypertension, socio-economic status [poverty income ratio (unimputed income)], education level (years), serum carotene, folate, vitamins E and C. Furthermore, in order to determine if this effect was due to exogenous antioxidants derived from selected vegetables, fruits, legumes, and cereal consumption, this researcher also controlled for other serum anti-oxidants (lutein/zeaxanthin, cryptoxanthin, and lycopene); and dietary cholesterol, fat, and Kilocalorie (Kcal) intake in the multinomial logistic regression model. $P<0.05$ was used to reject the null hypothesis.

Results:

Baseline Findings

Subjects with periodontitis had risk factors including demographics, smoking, medical conditions, inflammatory biomarkers, serum antioxidants, and dietary intake. When compared with healthy subjects, periodontitis subjects significantly younger and male ($P<0.05$); had significantly higher body mass index waist circumference to hip circumference ratio ($P<0.001$) and significantly lower serum folate levels ($P<0.05$). Individuals with a history of HA also had risk factors including demographics, smoking, medical conditions, inflammatory markers and antioxidant intake. When compared with individuals reporting no history of HA, individuals with

a history of HA were less educated and poorer ($P<0.05$), and had significantly lower serum β-carotene levels ($P<0.05$).

Table 2. Baseline demographics, medical conditions, blood chemistry, and serum anti-oxidants.

Baseline Characteristics		No Perio. (13,001)	Yes Perio. (2,017)	No Heart Attack (16,660)	Yes Heart Attack (840)
Demographics		Mean±SEM		Mean±SEM	
Age, y		47.4 ± 0.2	45.9 ± 0.6*	47.5±0.2	47.8±0.7
Male, %		46.7	62.3*	48.8	47.3
Race, %					
	Caucasian	86.6	13.4	95.3	4.7
	Afr.Amer.	84.4	15.6	95.2	4.8
	Other	86.5	13.5	95.2	4.8
Education Level, years		10.84±0.04	10.66±0.11	10.86±0.03	9.71±0.14*
Poverty Index		235.0±2.1	245.7±5.5	238.8±1.4	227.2±6.0*
Heart Attack Risk Factors					
Systolic B.P., mm Hg		118.52±0.21	119.01±0.57	118.38±0.18	117.30±0.90
Diastolic B.P., mm Hg		69.99±0.14	68.73±0.38	68.71±0.12	67.92±0.64
Pulse Rate, beats/min		76.44±0.13	75.90±0.34	75.61±0.11	75.24±0.49
Diabetes History, % yes		8.1	7.1	8.1	7.2
Body Mass Index		26.38±0.05	27.25±0.12†	23.54±0.05	23.79±0.22
Waist to Hip Ratio		.889±.001	.964±.002†	.908±.001	.907±.003
Smoking: Packs/day		1.23±0.09	1.01±0.16	1.20±0.05	1.42±0.29
Current Smoker, % yes		51.7	48.4	51.0	50.2
Serum Levels		Blood Chemistry			
C-Reactive Protein(mg/dL)		0.44±0.01	0.42±0.02	0.42±0.01	0.42±0.02
Fibrinogen (mg/dL)		318.9±1.4	319.6±4.0	317.7±1.2	321.9±5.5
Creatinine		1.066±.004	1.083±.014	1.068±.003	1.057±.010
Triglycerides		132.2±1.5	133.9±3.5	133.1±1.3	136.0±5.4
Cholesterol		193.2±0.5	192.4±1.2	194.1±0.4	194.3±1.6
Low Density Lipoproteins		122.9±0.7	124.0±1.8	124.3±0.6	124.0±2.4
High Density Lipoproteins		132.2±1.5	133.9±3.5	51.7±0.1	51.3±0.5
WBC Count		7.38±0.02	7.45±0.06	7.37±0.02	7.35±0.08
Serum Level		Antioxidants			
Serum β-Carotene(µg/dL)		519.4±8.8	535.8±21.5	435.4±6.2	402.6±23.8*
Serum Tocopherol(µg/dL)		9.53±0.10	8.02±0.18	8.29±0.07	8.21±0.25
Serum Vitamin C(mg/dL)		.763±.005	.756±.013	.753±.004	.744±.018
Serum Folate(ng/mL)		7.16±0.06	6.80±0.14*	6.83±0.05	6.60±0.16

Lycopene((µg/dL)	22.19±0.11	22.18±0.28	22.00±0.09	22.03±0.39
Cryoptanxthin(µg/dL)	11.08±0.08	10.87±0.19	10.81±0.07	10.84±0.28
Luteinizin/Zeanxanthin(µg/dL)	22.11±0.13	21.78±0.27	22.27±0.11	22.52±0.44

*P<0.05, **P<0.01, ΨP<0.005, †P<0.001.

Individuals with periodontitis consumed significantly less total dietary fiber than individuals with healthy periodontium (P<0.05). Individuals that "self-reported" a history of HA consumed significantly more melons, any other vegetables, and any other fruits (P<0.05), but significantly less beans (P<0.05), than individuals who did not report a history of HA.

Table 3. Baseline of selected vegetables, fruits, legumes, and cereals in subjects with and without periodontitis, and subjects with and without "self-reported" heart attack.

Baseline Dietary Consumption Levels	No Perio. (13,001)	Yes Perio. (2,017)	No Heart Attack (16,660)	Yes Heart Attack (840)
Fiber Sources	Mean±SEM		Mean±SEM	
Level of Dietary Consumption				
Total Dietary Fiber (g/day)	16.89±0.20	15.81±0.49*	15.19±0.13	14.80±0.58
Selected Vegetables				
Broccoli	5.29±0.39	6.03±1.18	5.01±0.22	4.60±0.96
Brussels Sprouts	3.61±0.43	3.93±1.18	3.05±0.23	3.23±0.95
Carrots	8.34±0.42	8.81±1.19	7.72±0.22	8.38±0.98
Cabbages	4.68±0.43	5.38±1.18	4.25±0.24	4.54±0.96
Spinach	4.39±0.39	5.79±1.36	4.37±0.25	4.17±0.96
Tossed Salad	10.23±0.41	9.99±1.00	9.73±0.24	10.72±1.37
Any Other Vegetables	12.32±0.13	12.00±0.36	12.20±0.09	13.11±0.39*
Selected Fruits				
Citrus Fruits	7.45±0.14	7.28±0.31	7.35±0.09	7.79±0.40
Melons	2.81±0.07	2.66±0.17	2.80±0.05	3.22±0.23*
Peaches/Nectarines	5.39±0.48	4.80±0.98	4.69±0.25	5.49±0.99
Any Other Fruits	16.45±0.48	16.47±0.45	15.46±0.26	18.26±1.06*
Selected Legumes				
Beans, Lentils, Peas, Etc.	9.29±0.44	10.17±1.21	9.12±0.26	6.90±1.00*
Selected Cereals				
All Bran	2.38±0.24	2.18±0.63	2.00±0.19	2.73±1.12
Total, etc.	1.62±0.24	0.96±0.47	1.62± 0.19	2.78±1.11
All Other Cold	12.34±0.44	13.23±1.24	12.40± 0.39	10.79±1.52
Hot	3.24±0.27	3.99±0.87	3.16± 0.21	3.41±1.54

*P<0.05.

Periodontitis and Inflammatory Biomarkers

Relationships between low and adequate total dietary fiber, and selected vegetables, fruits, legumes, and cereals, in individuals with periodontitis and healthy periodontium were explored using a Bonferroni adjustment of the data.

Table 4. Relationship between selected monthly vegetable, fruit, legume, and cereal levels, and total dietary fiber levels, and serum C-reactive protein (CRP), fibrinogen, and creatinine levels, Mean±SEM using a multivariate general linear model.

Selected Food	Consumption Level	Biomarker Mean(SEM)	No Perio	Yes Perio
Total Dietary Fiber (g/day)	Low	C-Reactive Protein	.613±.103	1.293±.254[S]
	High		.487±.105	.315±.272*
	Low	Fibrinogen	316.2±8.8	365.1±21.7[S]
	High		305.3±9.0	281.3±23.2*
	Low	Creatinine	1.16±0.03	1.31±0.07[S]
	High		1.13±0.03	1.03±0.07*
Selected Vegetables				
Monthly Broccoli Consumption	Low	C-Reactive Protein	.566±.088	.990±.222[S]
	High		.525±.157	.414±.368
	Low	Fibrinogen	310.8±18.8	344.3±18.8
	High		314.9±13.3	275.6±31.1
	Low	Creatinine	1.16±0.02	1.22±0.06
	High		1.09±0.04*	1.06± 0.10
Monthly Brussels Sprouts Consumption	Low	C-Reactive Protein	.569±.089	.792±.228
	High		.517±.154	.941±.348
	Low	Fibrinogen	314.5±7.5	319.9±19.3
	High		303.3±29.6	340.3±29.6
	Low	Creatinine	1.16±0.02	1.12±0.06
	High		1.11±0.04	1.31±0.09[S]
Monthly Carrots Consumption	Low	C-Reactive Protein	.547±.097	.336±.286
	High		.571±.123	1.219±.250[S]
	Low	Fibrinogen	308.9±8.3	316.1±24.6
	High		316.5±10.5	333.6±21.5
	Low	Creatinine	1.13±0.03	1.19±0.08
	High		1.18±0.03	1.17±0.07
Monthly Cabbages Consumption	Low	C-Reactive Protein	.576±.082	.993±.217[S]
	High		.435±.204	.324±.393
	Low	Fibrinogen	312.8±7.0	339.7±18.4
	High		305.6±17.3	280.9±33.4
	Low	Creatinine	1.13±0.02	1.19± 0.06
	High		1.22±0.05*	1.14±0.11
Monthly	Low	C-Reactive Protein	.526±.037	.610±.093
	High		.549±.080	.652±.216

Spinach Consumption	Low	Fibrinogen	310.2±3.9	320.1±9.7
	High		309.6±8.5	346.3±22.7 ^{S}
	Low	Creatinine	1.14±0.01	1.13±0.03
	High		1.08±0.03*	1.42±0.07*, ^{S}
Monthly Any Other Vegetables Consumption	Low	C-Reactive Protein	.491±.101	.380±.286
	High		.640±.115	1.186±.250*, ^{S}
	Low	Fibrinogen	308.9±8.6	288.7±24.4
	High		315.5±9.8	354.5±21.3 ^{S}
	Low	Creatinine	1.16±0.03	1.21±0.08
	High		1.13±0.03	1.15±0.07
Monthly Tossed Salad Consumption	Low	C-Reactive Protein	.543±.040	.539±.106
	High		.503±.060	.755±.142 $^{=}$
	Low	Fibrinogen	310.2±4.2	315.2±11.2
	High		308.9±6.3	340.3±15.0 ^{S}
	Low	Creatinine	1.14±0.01	1.18±0.04
	High		1.09±0.02	1.16±0.05 $^{=}$
Selected Fruits				
Monthly Citrus Fruit Consumption	Low	C-Reactive Protein	.484±.040	.658±.106 ^{S}
	High		.627±.059	.542±.142
	Low	Fibrinogen	304.9±4.2	317.5±11.1
	High		321.2±6.2	336.1±14.9
	Low	Creatinine	1.14±0.01	1.13±0.04
	High		1.10±0.02*	1.25±0.05*, ^{S}
Monthly Melons Consumption	Low	C-Reactive Protein	.570±.087	.958±.213 ^{S}
	High		.507±.165	.352±.425
	Low	Fibrinogen	313.6±7.4	334.0±18.1
	High		305.4±14.0	294.0±36.2
	Low	Creatinine	1.16±0.02	1.18±0.06
	High		1.10±0.04 $^{=}$	1.18±0.11
Monthly Peaches & Nectarines Consumption	Low	C-Reactive Protein	.554±.083	.773±.218
	High		.567±.201	1.046±.395
	Low	Fibrinogen	310.3±7.0	318.0±18.5
	High		320.4±10.1	352.4±33.5
	Low	Creatinine	1.16±0.22	1.11±0.06
	High		1.07±0.05	1.39±0.10*
Monthly Any Other Fruit Consumption	Low	C-Reactive Protein	.473±.089	1.019±.220 ^{S}
	High		.770±.143*	.336±.365*
	Low	Fibrinogen	305.0±7.6	340.2±18.7 ^{S}
	High		329.1±12.2	287.0±31.0*
	Low	Creatinine	1.17±0.02	1.16±0.06
	High		1.09±0.04*	1.21±0.10

Selected Legumes				
Monthly Beans Consumption	Low	C-Reactive Protein	.591±086	.601±.220
	High		.427±.166	1.484±.365 [S]
	Low	Fibrinogen	315.7±7.3	318.5±18.9
	High		297.1±14.2	346.8±31.3
	Low	Creatinine	1.14±0.02	1.15±0.06
	High		1.16±0.05	1.26±0.10

Multivariate general linear model with a Bonferroni adjustment for gender, race, age, BMI, smoking status, diabetes history, hypertension, socioeconomic status, education level, serum carotene, folate, vitamins E and C, cryptoxanthin, lutein/zeanxanthin, lycopene, and total Kcal, dietary choleserol and fat intake.

*P<0.05.

[S]There are only significant differences between the high and low fiber, selected vegetables, fruits, and selected legumes in the "yes" periodontal disease subjects. [s]<0.05.

When analyses were restricted to individuals with periodontitis, low total dietary fiber intake levels and any other fruit consumption were significantly associated with higher CRP (P<0.05), while low monthly any other vegetable (P<0.05) consumption was significantly associated with lower CRP (P<0.05); low total dietary fiber intake levels, broccoli, and any other fruit consumption were significantly associated with higher levels of plasma fibrinogen (P<0.05); low total dietary fiber were significantly associated with higher serum creatinine (P<0.05) and low spinach and peaches/nectarines were significantly associated with lower serum creatinine (P<0.05);, after using a Bonferroni adjustment of the data (Table 4). When analyses were restricted to individuals with healthy periodontium, low monthly any other fruit consumption were significantly associated with lower serum CRP (P<0.05); and low monthly broccoli, spinach, citrus fruit, and any other fruit was significantly associated with higher serum creatinine levels (P<0.05), while low cabbages consumption was significantly associated with lower serum creatinine (P<0.05).

When analyses were separated for low versus adequate total dietary fiber intake levels, and selected monthly vegetables, fruits, legumes, and cereals consumption in individuals with periodontitis versus individuals with healthy periodontium, significant increases were seen in: 1) serum CRP for low total dietary fiber, low monthly broccoli, adequate carrots, low cabbages, adequate any other vegetables, low citrus fruits, low melons, and low other fruit, and adequate beans consumption (P<0.05); 2) plasma fibrinogen for low total dietary fiber intake levels, low monthly broccoli, adequate spinach, adequate any other vegetables, adequate tossed salads consumption (P<0.05); 3) significant increases were seen in serum creatinine for low total dietary fiber, and adequate monthly Brussels sprouts, spinach, citrus fruits, and peaches/nectarines consumption (P<0.05), after using a Bonferroni adjustment of the data.

Table 5. Risk Ratios (RRs) for heart attack associated with periodontitis and healthy periodontium, and selected monthly vegetables, fruits, legumes and cereal consumption, and total dietary fiber intake levels.

	Relative Risk for "Self-Reported" Heart Attack Yes vs No No (5.2%) Yes (94.8%) RR(95% CI)			
Periodontal Status	No		Yes	
Level of Consumption	Low	Adequate	Low	Adequate
Food Selection				
Total Dietary Fiber	1.00(Ref)	1.24(0.89,1.73)	2.14(1.33,3.44)‡	1.13(0.59,2.17)
Selected Vegetables				
Broocoli	1.00(Ref)	1.18(0.80,1.76)	1.72(1.15,2.58)†	0.66(0.21,2.12)
Brussels sprouts	1.00(Ref)	1.18(0.81,1.73)	1.56(1.02,2.39)*	1.59(0.76,3.34)
Carrots	1.00(Ref)	1.19(0.85,1.67)	1.68(1.05,2.67)*	1.51(0.81,2.82)
Cabbages	1.00(Ref)	1.02(0.64,1.63)	1.56(1.04,2.34)*	1.26(0.50,3.18)
Spinach	1.00(Ref)	1.22(0.80,1.86)	1.64(1.10,2.46)*	1.11(0.40,3.09)
Any Other Vegets	1.00(Ref)	1.21(0.87,1.70)	1.86(1.17,2.96)†	1.31(0.69,2.50)
Tossed Salad	1.00(Ref)	0.81(0.56,1.17)	1.57(1.02,2.42)*	1.05(0.50,2.18)
Selected Fruits				
Citrus Fruits	1.00(Ref)	0.82(0.57,1.18)	1.58(1.02,2.45)*	1.09(0.54,2.20)
Melons	1.00(Ref)	0.98(0.67,1.43)	1.51(0.74,3.02)	1.50(0.98,2.33)
Peaches/Nectarines	1.00(Ref)	1.53(1.03,2.28)*	1.60(1.06,2.42)*	1.82(0.78,4.28)
Any Other Fruits	1.00(Ref)	1.54(1.10,2.15)*	1.77(1.11,2.83)*	1.76(0.94,3.28)
Selected Legumes				
Beans	1.00(Ref)	0.59(0.37,0.94)*	1.48(0.97,2.24)	1.07(0.49,2.34)
Selected Cereals				
All Bran	1.00(Ref)	2.14(0.38,12.10)	4.09(0.87,19.22)	----
Total	1.00(Ref)	1.94(0.34,10.96)	4.01(0.85,18.86)	----
All Other Cold	1.00(Ref)	0.78(0.14,4.38)	2.98(0.51,17.33)	2.29(0.24,22.04)
Hot	1.00(Ref)	1.13(0.20,6.31)	2.70(0.47,15.54)	4.22(0.42,42.27)

Adjusted for age, race, gender, BMI, serum carotene, serum vitamin E, serum vitamin C, smoking status, history of diabetes, socioeconomic status, and education level, and total kilcalorie intake. *P<0.05, †P<0.01, ‡P<0.005.

Periodontitis and Self-Reported Heart Attack Risk

Multivariate logistic regression for individuals with periodontitis and individuals with healthy periodontium, stratified for low and adequate levels are shown in table 5. Various dose-response relationships were explored. Individuals with periodontitis, showed a significant relationship self-reported HA risk and: low total dietary fiber (RR, 2.14: 95% CI, 1.33-3.44 (P<0.005)); low broccoli (RR, 1.72: 95% CI, 1.15-2.58 (P<0.01) and low any other vegetables (RR, 1.86: 95% CI, 1.17-2.96(P<0.01)); low Brussels sprouts (RR, 1.56: 95% CI, 1.02-2.39(P<0.05)), low carrots (RR, 1.68: 95% CI, 1.05-2.67 (P<0.05)), low peaches/nectarines (RR, 1.60 CI, 1.06-2.42

(P<0.05)) and any other fruits (RR, 1.77: 95% CI, 1.11-2.83 (P<0.05)) consumption, adjusting for demographic, medical, and lifestyle factors, and total energy (Kcal) intake (Table 5). Further adjustment for additional confounders for both periodontitis and HA, such as serum antioxidants, dietary cholesterol and other fat intake, the dose-response relationship statistically decreased between HA risk and: low total dietary fiber intake levels (RR, 1.85: 95% CI, 1.05-3.26 (P<0.05)); low broccoli (RR, 1.65: 95% CI, 1.02-2.67 (P<0.05)), and low any other any other vegetables (RR, 1.73: 95% CI, 1.00-2.98 (P=0.05)); and remained the same for low any other fruits (RR, 1.57: 95% CI, 0.91-2.73 (P<0.05)); but was increased for low level of All-Bran cereal consumption (RR, 4.88: 95% CI, 1.07-23.60 (P<0.05)).

Table 6. Risk Ratios (RRs) for heart attack associated with localized and/or generalized periodontitis and healthy periodontium, and total dietary fiber intake levels, and selected monthly vegetables, fruits, legumes and cereal consumption.

	Relative Risk for "Self-Reported" Heart Attack Yes vs No No (5.2%) Yes (94.8%) RR(95% CI)			
Periodontal Status	No		Yes	
Level of Consumption	Low	Adequate	Low	Adequate
Food Selection				
Total Dietary Fiber	1.00(Ref)	1.05(0.71,1.54)	1.85(1.05,3.26)*	1.10(0.53,2.26)
Selected Vegetables				
Broccoli	1.00(Ref)	1.23(0.78,1.94)	1.65(1.02,2.67)*	0.97(0.30,3.15)
Brussels sprouts	1.00(Ref)	1.06(0.67,1.66)	1.38(0.82,2.31)	1.84(0.82,4.11)
Carrots	1.00(Ref)	1.14(0.76,1.69)	1.36(0.77,2.42)*	1.83(0.95,3.56)
Cabbages	1.00(Ref)	0.83(0.48,1.45)	1.41(0.87,2.28)	1.48(0.52,4.19)
Spinach	1.00(Ref)	1.29(0.80,2.09)	1.62(1.01,2.61)*	1.09(0.33,3.55)
Any Other Vegets	1.00(Ref)	1.28(0.86,1.89)	1.73(1.00,2.98)	1.48(0.69,3.17)
Tossed Salad	1.00(Ref)	0.89(0.58,1.37)	1.56(0.94,2.59)	1.07(0.46,2.52)
Selected Fruits				
Citrus Fruits	1.00(Ref)	0.74(0.48,1.14)	1.42(0.85,2.39)	1.17(0.53,2.60)
Melons	1.00(Ref)	1.11(0.72,1.72)	1.59(0.97,2.62)	1.24(0.49,3.15)
Peaches/Nectarines	1.00(Ref)	1.27(0.79,2.06)	1.52(0.93,2.46)	1.59(0.56,4.51)
Any Other Fruits	1.00(Ref)	1.33(0.90,1.97)	1.57(0.91,2.73)*	1.72(0.83,3.53)
Selected Legumes				
Beans	1.00(Ref)	0.72(0.43,1.20)	1.47(0.90,2.40)	1.07(0.42,2.71)
Selected Cereals				
All Bran	1.00(Ref)	1.05(0.11,9.71)	4.88(1.07,23.60)*	----
Total	1.00(Ref)	0.92(0.10,8.52)	4.75(0.98,23.00)	----
All Other Cold	1.00(Ref)	0.47(0.04,4.11)	5.17(0.83,32.21)	1.94(0.20,18.80)

Hot	1.00(Ref)	1.13(0.20,6.31)	2.70(0.47,15.54)	4.22(0.42,42.27)

Adjusted for age, race, gender, BMI, smoking status, history of diabetes, socioeconomic status, and education level, and serum folate, vitamin C, beta-carotene, vitamin E, cryptoxanthin, lutein/zeanxanthin, lycopene, cholesterol, fat, and total KCal intake. *P<0.05, †P<0.01, ‡P<0.005.

Individuals with healthy periodontitis, showed a significant increase in self-reported HA risk and: adequate peaches/nectarines (RR, 1.53: 95% CI, 1.03-2.28 (P<0.05)) and adequate any other fruits (RR, 1.54: 95% CI, 1.10-2.15 (P<0.05)) consumption; but a significant decrease in self-reported HA risk and adequate beans consumption (RR, 0.59: 95% CI, 0.37-0.94 (P<0.05)) adjusting for demographic, medical, and lifestyle factors, and total energy (Kcal) intake (Table 5). Further adjustment for additional confounders for both periodontitis and HA, such as serum antioxidants, made the risk for HA non-significant at different total dietary fiber intake levels, selected vegetables, fruits, legumes, and cereal consumption levels (Table 6).

Individuals with periodontitis that consumed adequate total dietary fiber, broccoli, spinach, tossed salads, citrus fruits, and beans had their risk of HA return to toward normal levels (RR,0.40-3.09), however this decrease was not significant when compared to individuals with periodontitis that consumed low levels of these foods (Tables 6).

Discussion:

Periodontitis is a chronic inflammation of the supporting tissues of the teeth and affects 75% of the adults in the United States(Genco, Offenbacher et al. 2002). Bacteria within dental plaque are a major factor for the initiation and progression of periodontal disease. Periodontopathic bacteria produce lipopolysaccharides (LPS), which initiate a synthetic cascade of proinflammatory cytokines, which have both local and systemic effects. These effects include activation of monocytes/macrophages, increasing the number of neutrophils and the plasma concentrations of fibrinogen and other coagulation factors, alterations in lipid metabolism, and enhancement of the synthesis of acute phase proteins such as C-reactive protein (CRP), fibrinogen, interleukin-6 (IL-6), and TNF-alpha(Loos, Craandijk et al. 2000; Slade, Offenbacher et al. 2000). Acknowledged risk factors for heart attack (obesity, diabetes, smoking, hypertension, elevated acute-phase inflammatory and vascular responses, serum lipid and cholesterol concentrations) are also risk factors for periodontal disease(Grossi and Genco 1998).

Associations have been found between cardiovascular diseases and elevated acute-phase response of serum C-reactive protein (Furuichi, Shimotsu et al. 2003; Kaysen and Kumar 2003; Sano, Tanaka et al. 2003; Uehara, Nomura et al. 2003), fibrinogen (Lowe 2001; Acevedo, Foody et al. 2002; Engstrom, Stavenow et al. 2003), and creatinine (Walsh, O'Donnell et al. 2002; Kaysen and Kumar 2003; Mann, Dulau-Florea et al. 2003); as well as associations between periodontal disease incidence, severity (Ebersole, Cappalli et al. 1999; Slade, Offenbacher et al. 2000; Noack, Genco et al. 2001) and possibly therapy (Ide, McPartlin et al. 2003), suggesting these serum biomarkers to be the possible link between periodontal disease to elevated cardiovascular risk (Wu, Trevisan et al. 2000; Glurich, Grossi et al. 2002; Craig, Yip et al. 2003; Slade, Ghezzi et al. 2003).

Dietary amounts, sources, and types (soluble versus insoluble) of fiber have been shown to reduce the risk of heart attack (Liu, Buring et al. 2002; Negri, Vecchia et al. 2003). Emphasis on dietary and lifestyle factors is one of the approaches currently advocated to prevent coronary artery disease(s). Epidemiologic studies have shown protective effects of dietary fiber on coronary artery disease (Morris, Marr et al. 1977; Kromhout, Bosschieter et al. 1982; Kromhout, Bosschieter et al. 1984; Kushi, Lew et al. 1985; Khaw and Barrett-Connor 1987; Fehily, Yarnell et al. 1993; Humble, Malarcher et al. 1993; Pietinen, Rimm et al. 1996; Rimm, Ascherio et al. 1996), while others suggested that this protection may be mediated by improvements in hemostasis with fiber intake (Fehily, Milbank et al. 1982; Bonan, Hellstein et al. 1994). Cross-sectional and prospective studies suggest that elevated CRP, fibrinogen, and creatinine are associated with ischemic heart disease (Wilhelmsen, Svardsudd et al. 1984; Meade, Brozovic et al. 1986; Hamsten, Walldius et al. 1987; Kannel, Wolf et al. 1987; Ernst and Resch 1993; Matts, Karnegis et al. 1993; Meade, Ruddock et al. 1993; Heinrich, Balleisen et al. 1994; Walsh, O'Donnell et al. 2002; Mann, Dulau-Florea et al. 2003) (Berk, Weintraub et al. 1990; Maseri, Biasucci et al. 1996; Mendall, Patel et al. 1996; Ridker, Buring et al. 1999; Ridker, Hennekens et al. 2000; Ridker, Rifai et al. 2000; Liuizzo and Rizello 2001). Others have proposed that these markers may be elevated due to undiagnosed chronic infectious processes, and consequently their pro-inflammatory properties may increase the existing inflammatory activity in plaque-associated lesions in coronary arteries and prejudice cardiac events (Maseri, Biasucci et al. 1996).

Higher levels of dietary fiber consumption has been shown to reduce serum CRP (King, Egan et al. 2003). Studies have shown dietary fiber consumption has a positive effect on blood lipids, factor VII coagulant activity, (Marckmann, Sandstrom et al. 1993; Marckmann, Raben et al. 2000), plasminogen activator inhibitor type 1 (Marckmann, Sandstrom et al. 1993; Djousse, Ellison et al. 1998), insulin levels (Ludwig, Pereira et al. 1999), and fibrin network structure (Veldman, Nair et al. 1997); while the effects on plasma fibrinogen have been controversial (Fehily, Milbank et al. 1982; Marckmann, Sandstrom et al. 1993; Djousse, Ellison et al. 1998; Marckmann, Raben et al. 2000).

The results of this study provide evidence of a relationship between periodontitis subjects with low total dietary fiber, and low levels of selected monthly vegetables, fruits, legumes, and cereal consumption, and a significantly elevated risk of HA when compared to periodontitis subjects that consumed adequate total dietary fiber intake and selected fiber-containing vegetables, fruits, and legumes. Fiber levels in individuals with healthy periodontium were not significantly associated with the risk of HA, when adjusting for all risk factors, including serum antioxidants, dietary cholesterol and fat and total caloric intake. Inflammatory markers, serum CRP, plasma fibrinogen, and serum creatinine, were significantly associated with different levels of total dietary fiber, and selected vegetables, fruits, and legumes ($P<0.05$), in individuals with periodontitis versus individuals with healthy periodontium ($P<0.05$). The findings of this study did show evidence of significant dose-response relationships between total dietary fiber, and selected vegetables, fruits, and legumes, and serum CRP, plasma fibrinogen, and serum creatinine, in the periodontitis subjects; and also demonstrated a significantly increased risk of HA with low total dietary fiber and selected vegetables, fruits, legumes and cereals. A positive relationship was found between low fiber and HA risk in periodontally involved subjects.

In the present study this researcher also observed significant associations between periodontitis and serum CRP similar to those reported in other studies (Loos, Craandijk et al. 2000). He also observed significant associations between CRP, fibrinogen, and creatinine and different total dietary fiber intake levels, and selected monthly vegetable, fruit, and legume consumption, in individuals with periodontitis ($P<0.05$). In the statistical analyses, he controlled for serum antioxidants, and dietary cholesterol and fat, and total kilocalorie intake, all of which are affected by dietary fiber (Vahouney, Tombes et al. 1980; Jenkins, Wolever et al. 1993). Fiber is mainly supplied by vegetables, fruits, legumes, cereal and whole grains, which contain many other beneficial substances (high levels of vitamin A, vitamin C, vitamin E, folate, potassium, bioflavonoids (especially quercetin), and phytosterols). Evidence from experimental studies suggests that soluble fiber can be absorbed by the body, and can affect intestinal cholesterol and macronutrient absorption and hepatic lipid metabolism (Vahouney, Tombes et al. 1980; Jenkins, Wolever et al. 1993).

Taken together, the data confirm evidence that periodontitis may have systemic sequelae: serum levels of CRP, fibrinogen, and creatinine are elevated in the blood of individuals with periodontitis. Furthermore CRP levels, fibrinogen and creatinine levels were reduced in individuals with adequate fiber intake when compared to indidivuals with low fiber intake levels, independent of the source. This researcher theorizes that periodontitis elevated the risk of HA, and that higher fiber reduced this risk.

A diet adequate in fiber-containing foods is also usually rich in micronutrients and non-nutritive ingredients (e.g., antioxidants, phytoestrogens) that have additional health benefits, such as earlier satiety. Thus, the statistical analyses included; in addition to age, gender, race, smoking status, diabetes history, hypertension, socioeconomic status, education level, body mass index, and waist to hip ratio; serum levels of antioxidants, and dietary cholesterol and fat, and Kilocalorie intake. In addition, total cholesterol and LDL-cholesterol levels are lowered and risk of fatal myocardial infarction is lowered when a low fiber diet is replaced isoenergetically by a high fiber diet (Marckmann, Raben et al. 2000). When nutrients are considered as co-factors or co-variables, energy adjustments should be made in the interpretation of the relative risks across each model used. When nutrients were categorized into different levels, the residual and the nutrient density models, which gave similar results, yielded statistically more significant tests for relative risks than did the standard and partition models.

Fruits, vegetables, legumes, and whole grain products are the best sources of fiber and are important components of the diet (Martinez-Gonzalez, Fernandez-Jarne et al. 2002). Dietary fiber can be separated into two basic types based on its properties and effects on the body. These two types are insoluble and soluble fiber. Insoluble fibers, such as cellulose, hemicellulose, and lignin: 1) do not dissolve in water; 2) are found in foods such as wheat bran, whole grains, and vegetables; and 3) absorb water and increase the intestinal bulk, which helps the intestine function properly. Soluble fibers, such as gum and pectin: 1) dissolve in water and are found in beans, oats, barley, and some fruits and vegetables; and 2) may play a role in lowering blood cholesterol and in regulating the body's use of sugar. Different plant foods contain different amounts of soluble fiber in relation to insoluble fiber. In our study, adequate legumes (which contain a higher amount of soluble fiber in relation to insoluble fiber and total fiber) consumption by individuals with healthy periodontium showed a significant decrease in HA risk

($P<0.05$), while the other selected vegetables, fruits, and cereals (which contain a lower level of soluble fiber in relation to insoluble and total fiber) did not show this decrease in HA risk.

The association between types of fiber and nonfatal acute myocardial infarction has been examined (Negri, Vecchia et al. 2003), and it was shown that soluble fiber, and fruit fiber significantly reduced the risk of nonfatal acute myocardial infarction, more than insoluble fiber. High intake of total fiber, total insoluble fiber, and vegetable fiber reduced the risk of nonfatal acute myocardial infarction but not significantly; while high intake of cereal fiber tended to increase HA risk slightly. Though an inverse association between fiber intake and HA risk appears established, the causality of this association is still open to debate. Cereal fiber derives chiefly from refined grains, and this may explain the lack of protection by this type of fiber. It has been reported that dietary fiber decreased the risk of first acute myocardial infarction by up to 86% (Martinez-Gonzalez, Fernandez-Jarne et al. 2002), and coronary artery disease by 30% (Martinez-Gonzalez, Fernandez-Jarne et al. 2002), however giving patients/subjects dietary fiber advice had no clear effect on coronary or all-cause mortality (Ness, Hughes et al. 2002).

Conclusion: The current observations may explain the epidemiological links between a specific vegetables, fruits, legumes, and cereals, and fit the generalized hypothesis that good dietary habits and proper choice of nutrients consumed reduces the risk of cardiovascular diseases in individuals with periodontitis

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