

Association between Diet Quality and Periodontitis in Korean Population

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Objectives: The aim of this study was to examine the association between the diet quality and periodontitis for Korean population.

Methods: The total number of participants in the KNHANES was 7,943. Periodontitis was defined as Community Periodontal Index. Diet quality was evaluated using the Korean Healthy Eating Index (KHEI) following adequacy, moderation, and balance components.

Results: The lowest KHEI total score was associated with periodontitis and severe periodontitis. Especially, lower fruit intake was associated with periodontitis, while lower have breakfast, lower total fruits, meat fish, eggs, and beans intake, and lower carbohydrate and fat energy balance were associated with severe periodontitis.

Conclusions: Diet quality had a more significant effect on severe periodontitis than on periodontitis. It is necessary to pay attention to diet quality to better oral health.

Keywords Diet quality, Epidemiologic study, Healthy Eating Index, KNHANSE, Periodontitis

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I. Introduction

Periodontitis is a multifactorial chronic inflammatory disease involving destruction of the tissues surrounding and supporting the teeth [1]. According to the Global Burden of Disease study [2], oral conditions are consistently remain a substantial population health issues, showing that social inequality still exists and 796 million suffer from severe periodontitis worldwide. Previous epidemiological studies have reported that periodontal disease is associated with various systemic diseases [3] and also affects mortality, and quality of life [4].

Periodontitis is a non-communicable disease such as cardiovascular disease, diabetes mellitus, cancer, and it shares social determinants and common risk factors (smoking, obesity, and nutrition deficiencies) with non-communicable diseases (NCDs) [5]. Especially, there are evidence from association studies that nutritional aspects and periodontitis [6]. Previous evidence that have focused on nutrient intake and food choices have found an association between nutrient deficiencies and periodontitis [6], but few studies have evaluated the overall diet quality in dentistry [7,8]. It is noteworthy that in the updated systematic

review and meta-analysis, high-quality diets were associated with a significant reduction in the risk of all-cause mortality and cancer mortality [9], major chronic diseases [10].

The United States Department of Agriculture first developed the HEI (Healthy Eating Index) based on a food-based approach rather than a nutrient-based approach [11]. The HEI is a tool of diet quality as described by the main dietary recommendations of the Dietary Guidelines [11]. Also, the HEI is a national screening and monitoring tool to assess the overall dietary quality applicable to a large general population [12]. The KHEI (Korean Healthy Index) was developed in 2015 and has been annually used in the Korea National Health and Nutrition Examination Survey (KNHANES) to evaluate compliance with dietary recommendations [12].

Although there have been several studies on HEI and various systemic diseases [9,10,13], a meaningful research on dietary quality using the HEI and periodontitis are difficult to find the evidence. The study of HEI and periodontitis was the three epidemiological study that reported by a community-based sample of 13,920 US Hispanics [7], NHAENS III [14], and random sample of 340 adults [15]. Although Park reported on diet quality and periodontitis among Koreans, it did not

adjust for systemic diseases that were highly correlated with these two variables, and detailed analysis of diet quality items was not sufficient.

This study hypothesized that diet quality, as measured by HEI and periodontitis a representative Korean population. This study aimed to evaluate the distribution of the KHEI according to the periodontal status and to determine whether the periodontitis is associated with dietary quality using the KHEI and KHEI 14 components as observed in a representative general population.

II. Materials and Methods

1. Study participants

The KNHANES is a study periodically conducted by the Korea Centers for Disease Control and Prevention (KCDC) using a complex, stratified, multistage, and probability-cluster design of a representative sample of the non-institutional Korean citizens [16]. The survey included a health interview, a nutrition survey, and a oral and general health examination survey. Detailed information regarding the sampling methods, study design, process is available in several reports [16]. The national survey was approved by the institutional review board of the KCDC (2013-07CON-03-4C in 2013 and 2013-12EXP-03-5C in 2014). Since 2015, The KNHANES has been conducted without the deliberation of the institutional review board, which corresponds to research conducted by the government for public welfare in accordance with the Bioethics Act. All participants provided voluntarily written informed consent.

The total number of participants in the KNHANES 2013-2015 was 22,948. Since the information on the KHEI was only responded to aged ≥ 19 , participants aged years < 19 years were excluded from analyses ($n=1,574$). Participants excluded from the analysis were as follows: (1) incomplete response to the 24-hour dietary recall data, (2) unexamined periodontal status evaluation, and (3) missing information for the various confounders. After that, the final sample included 7,943 adult participants (2,875 males and 5,073 females) and 15,005 participants were excluded.

2. Assessment of periodontitis

Calibrated dentists performed the full-mouth oral examinations on participants. Periodontal health status was assessed using a community periodontal index (CPI) according to the World Health Organization guideline [17]. Ten index teeth were selected for the periodontal examination as follows: the first and second molars in each posterior sextant, the upper right incisor in the upper middle sextant, and the lower left central incisor in the lower middle sextant [17]. If none of the index teeth was present in a sextant qualifying for the examination, all of the remaining teeth in that sextant were examined and the highest score was recorded as the score for that sextant [17]. The periodontal health status was evaluated the five CPI scores, which was recorded as 0 (normal), 1 (gingival bleeding), 2 (calculus), 3 (shallow periodontal pocket of 3.5-5.5mm), and 4 (deep periodontal pocket of 5.5mm or more)[17]. For the analyses, the periodontal status level was divided into two periodontitis case definitions as follows [18]: (1) non-periodontitis (CPI = 0 to CPI = 2) versus periodontitis (CPI ≥ 3), (2) no severe periodontitis (CPI = 0 to CPI = 3) versus severe periodontitis (CPI = 4).

3. Assessment of Korean Healthy Eating Index (KHEI)

Dietary assessment was obtained from 24-hour recall methods that was administered by a face-to face trained interviews. The KHEI was developed as a standardized assessment tool. The KHEI is a tool [19] for evaluating overall diet quality by scoring system the degree of adherence to dietary guidelines for healthy Korean through Dietary guidelines [20], Health Plan 2020 [21], and Dietary reference intake [22] for Koreans. The components of the KHEI were selected based on current scientific evidence and dietary guidelines.

The KHEI contains 14 components adding up to 100 points, with higher scores indicating better quality diet: 8 adequacy components (having breakfast, mixed grains intake, total fruits intake, fresh fruits intake, total vegetables intake, vegetables intake excluding Kimchi and pickled vegetables intake, meat, fish, eggs and beans intake, and milk and milk products intake), 3 moderation components (percentage of energy from saturated

fatty acid, sodium intake, percentage of energy from sweets and beverages), and 3 balance components (percentage of energy from carbohydrate, percentage of energy intake from fat, and energy intake). Each component had a range of 0 to 5 or 0 to 10 points and the total score ranges from 0 to 100. The detailed scoring system on components of KHEI is described in KNHANES report [19]. For the analyses, the KHEI total scores and KHEI 14 components scores were categorized into tertiles (1st tertile: 15.86 - 59.90, 2nd tertile: 59.91 - 71.26, 3rd tertile: 71.27 - 99.82).

4. Assessment of potential confounders

The health examination and medical interview was used to obtain potential confounders including age, sex, income, education, dental visits, high-risk alcohol consumption, smoking status, hypertension, obesity, and diabetes mellitus.

Income was categorized into quintiles (<20%, 20-39%, 40-59%, 60-79%, \geq 80%) and education level was categorized into five groups according to the degree of education. Smoking status was divided into three groups: never smoker, former smoker, and current smoker. Dental visits were identified by asking if they had visited a dentist regular examination during the past year. High-risk alcohol consumption is defined as more than 7 glasses of males and 6 glasses of females more than twice a week. This information determined by frequency and amount of drinking the participants during the last year. Hypertension was defined as systolic blood pressure \geq 140mmHg or diastolic blood pressure \geq 90mmHg or being medicated for hypertension. Body mass index (BMI) was used to define obesity. BMI was calculated by dividing weight in kilograms by the square of height in meters. Obesity was defined as a BMI \geq 25.0 kg/m². Diabetes mellitus was defined as having a fasting glucose level $>$ 126mg/dL or taking medication for diabetes.

5. Statistical analysis

Analyses for complex sample design was performed according to the guidelines for the use of KNHANES. The dependent variable was periodontitis and the independent variable was KEHI. Descriptive characteristics by periodontitis case definitions

(CPI \geq 3 and CPI = 4) were reported as weighted percentage and standard error using chi-square test. Total score of KHEI was used as continuous variable and summarized the crude and adjusted mean and standard by periodontal status. To assess the association between KHEI total scores (tertile) and periodontitis, adjusted odds ratios (OR) and confidence intervals (95% CIs) were calculated in a sequential multivariate logistic models. Model 1 was adjusted for demographic factor such as age and sex. Model 2 was adjusted for all variables in Model 1 plus socioeconomic variables including income and education. Model 3 was adjusted for all variables in Model 2 plus oral and health behaviors variables, including dental visits, high-risk drinking, and smoking. Model 4 was adjusted for all the above-mentioned variables plus systemic health status, including hypertension, obesity, and diabetes mellitus. Multivariate logistic regression analyses were then applied in order to assess the association between each KHEI components and periodontitis adjusting for the same confounders. All analyses were performed using a statistical program.

III. Results

Table 1 shows the characteristics of the study participants according to the periodontitis case definitions (CPI \geq 3 and CPI = 4). The prevalence rate of periodontitis defined as CPI \geq 3 was 28.6%, while the prevalence rate of severe periodontitis defined as CPI = 4 was 8.5%. Basic characteristics according to the periodontitis case definitions were quite similar ($P < 0.001$), except for income, dental visits, and high risk alcohol consumption.

Table 2 demonstrates the distribution of KHEI total score according to the periodontitis definition. Unlike the unadjusted mean value, the adjusted means for KHEI scores relatively lower in participants with periodontitis and severe periodontitis than in normal ($P = 0.003$ for periodontitis, $P = 0.014$ for severe periodontitis).

The total score of KHEI tertiles were consistently associated with the two periodontitis case definitions in the sequential logistic models throughout the adjustment process (Table 3).

<Table 1> Characteristics of the study participants according to the periodontal status (N=7,943)

Variables	Total n	CPI ≥ 3		P-value*	CPI = 4		P-value*
		No periodontitis	Periodontitis		No severe periodontitis	Severe periodontitis	
		(n=5,452)	(n=2,491)		(n=7,201)	(n=742)	
Age (years)							
20-29	865	23.2 (0.9)	2.9 (0.5)	<0.001	19.0 (0.8)	0.6 (0.4)	<0.001
30-39	1231	22.9 (0.9)	10 (0.9)		20.4 (0.7)	6.1 (1.2)	
40-49	1447	20.1 (0.7)	21.4 (1.1)		20.3 (0.6)	22.3 (2.3)	
50-59	1682	17.4 (0.6)	31.4 (1.2)		20.2 (0.6)	34.2 (2.4)	
≥60	2718	16.4 (0.6)	34.3 (1.2)		20.1 (0.7)	36.8 (2.2)	
Gender							
Male	2870	43.2 (0.8)	53.1 (1.1)	<0.001	44.7 (0.7)	60.1 (1.9)	<0.001
Female	5073	56.8 (0.8)	46.9 (1.1)		55.3 (0.7)	39.9 (1.9)	
Income							
I (<20%)	1493	18.2 (0.8)	20.8 (1.1)	0.111	18.8 (0.7)	20.5 (1.9)	0.142
II (20-39%)	1616	20.1 (0.8)	20.5 (1.1)		20.4 (0.7)	18.6 (2.0)	
III (40-59%)	1608	20.9 (0.8)	19.7 (1.1)		20.7 (0.7)	18.2 (1.8)	
IV (60-79%)	1635	20.4 (0.8)	20.9 (1.0)		20.2 (0.7)	24.4 (2.0)	
V (≥80%)	1591	20.4 (0.9)	18.1 (1.1)		19.9 (0.9)	18.3 (1.9)	
Education							
Primary school	1819	11.4 (0.5)	25.0 (1.1)	<0.001	14.4 (0.5)	24.8 (2.0)	<0.001
Middle school	850	7.4 (0.4)	13.0 (0.8)		8.4 (0.4)	15.3 (1.4)	
High school	2697	39.9 (0.9)	35.0 (1.2)		38.9 (0.8)	33.9 (2.4)	
College	2577	41.4 (1.0)	27.1 (1.3)		38.3 (0.9)	26 (2.1)	
Dental visits							
No	5581	69.6 (0.8)	70.4 (1.2)	0.450	69.7 (0.7)	71.8 (1.9)	0.298
Yes	2362	30.4 (0.8)	29.6 (1.2)		30.3 (0.7)	28.2 (1.9)	
High-risk alcohol consumption							
No	6011	68.4 (0.8)	69.4 (1.2)	<0.001	68.7 (0.7)	68.2 (2.1)	0.830
Yes	1932	31.6 (0.8)	30.6 (1.2)		31.3 (0.7)	31.8 (2.1)	
Smoking status							
Never	5289	64.3 (0.8)	49.9 (1.1)	<0.001	61.8 (0.7)	42.2 (2.1)	<0.001
Former	1380	17.1 (0.6)	22.7 (1.0)		18.1 (0.5)	26 (1.9)	
Current	1274	18.6 (0.7)	27.4 (1.1)		20.1 (0.6)	31.9 (2.2)	
Hypertension							
No	5578	80.6 (0.7)	62.4 (1.2)	<0.001	76.9 (0.6)	59.2 (2.1)	<0.001
Yes	2365	19.4 (0.7)	37.6 (1.2)		23.1 (0.6)	40.8 (2.1)	
Obesity							
No	5257	68.8 (0.8)	58.8 (1.1)	<0.001	66.8 (0.7)	56.7 (2.2)	<0.001
Yes	2686	31.2 (0.8)	41.2 (1.1)		33.2 (0.7)	43.3 (2.2)	
Diabetes mellitus							
No	7059	93.9 (0.4)	83.6 (0.9)	<0.001	92.2 (0.7)	77.9 (2.2)	<0.001
Yes	884	6.1 (0.4)	16.4 (0.9)		7.8 (0.7)	22.1 (2.2)	

* Obtained from chi-square test.

Data are presents as weighted percentage and standard error.

Bold denotes statistical significance at p<0.05.

<Table 2> Distribution of the KHEI total scores according to the periodontal status (N=7,943)

Variables	CPI ≥ 3		P-value	CPI = 4		P-value
	No periodontitis	Periodontitis		No severe periodontitis	Severe periodontitis	
	(n=5,452)	(n=2,491)		(n=7,201)	(n=742)	
KHEI total score (14 item)						
Unadjusted mean and SE	63.48 (0.26)	64.15 (0.31)	0.069*	63.66 (0.23)	63.74 (0.53)	0.882*
Adjusted mean and SE	61.70 (0.37)	60.68 (0.42)	0.003[†]	61.51 (0.36)	60.21 (0.55)	0.014[†]

* Data were presented as unadjusted mean and standard error by t-test

[†] Data were presented as adjusted mean and standard error adjusting for age, gender, income, education, dental visits, high-risk alcohol consumption, smoking, hypertension, obesity, and diabetes mellitus by general linear model.

Bold denotes statistical significance at p<0.05.

<Table 3> Association of KHEI scores with periodontitis/severe periodontitis

Variable	No periodontitis	Periodontitis/ Severe Periodontitis	Odds ratio (95% CI)			
			Model 1	Model 2	Model 3	Model 4
Outcome variable: CPI ≥ 3 (periodontitis)						
KHEI scores (tertiles)						
I (lowest)	1835	810	1.48 (1.27/1.75)	1.37 (1.17/1.61)	1.28 (1.09/1.51)	1.27 (1.08/1.50)
II	1770	878	1.18 (1.02/1.37)	1.13 (0.97/1.31)	1.08 (0.93/1.26)	1.07 (0.93/1.25)
III (highest)	1847	803	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
<i>p-trend</i>			<0.001	<0.001	0.003	0.004
Outcome variable: CPI = 4 (severe periodontitis)						
KHEI scores (tertiles)						
I (lowest)	2395	250	1.51 (1.17/1.93)	1.44 (1.12/1.86)	1.33 (1.03/1.73)	1.32 (1.02/1.71)
II	2373	275	1.29 (1.03/1.62)	1.27 (1.01/1.60)	1.21 (0.96/1.53)	1.20 (0.95/1.51)
III (highest)	2433	217	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
<i>p-trend</i>			0.001	0.004	0.030	0.038

Model 1: adjusted for age and gender

Model 2: adjusted for age, gender, income, and education

Model 3: adjusted for age, gender, income, education, dental visits, high-risk alcohol consumption, and smoking

Model 4: adjusted for age, gender, income, education, dental visits, high-risk alcohol consumption, smoking, hypertension, obesity, and diabetes mellitus.

Total score of KHEI was inversely associated with periodontitis (1st tertile: OR = 1.48, 95% CI = 1.27 to 1.75, 2nd tertile: OR = 1.18, 95% CI = 1.02 to 1.37), showing a dose-response relationship (p-trend <0.001). The strength of association between total score of KHEI and periodontitis was slightly weakened but remained significant in fully adjusted model (OR = 1.27, 95% CI = 1.08 to 1.50 for 1st tertile, p-trend = 0.004). However, the link between the total score of KHEI and periodontitis disappeared in 2nd tertile of KHEI (OR = 1.07, 95% CI = 0.93 to 1.25).

Considering the results of severe periodontitis analyses, total score of KHEI was inversely associated with severe periodontitis

after controlling for age and sex (1st tertile: OR = 1.51, 95% CI = 1.17 to 1.93, 2nd tertile: OR = 1.29, 95% CI = 1.03 to 1.62), showing a dose-response relationship (p-trend <0.001). The strength of association was gradually decreased in the process of adjusting various confounders (OR = 1.32, 95% CI = 1.02 to 1.71 for 1st tertile, p-trend = 0.038). But second tertile of KHEI lost the significant association (OR = 1.20, 95% CI = 0.95 to 1.51).

Table 4 and Table 5 depict the association between the KHEI 14 components and periodontitis case definition. Periodontitis (CPI ≥ 3) was significantly associated with 8 KHEI components (have breakfast, mixed grains intake, total fruits intake, fresh

<Table 4> Association of KHEI components with periodontitis (CPI \geq 3)

KHEI components	No periodontitis	Periodontitis	OR (95% CI)	
			Model 1	Model 2
<i>Adquacy components</i>				
Have breakfast				
I (lowest)	691	240	1.31 (1.06/1.61)	1.15 (0.93/1.41)
II	1196	344	1.15 (0.95/1.38)	1.09 (0.90/1.31)
III (highest)	3565	1907	1.00 (ref)	1.00 (ref)
Mixed grains intake				
I (lowest)	1988	819	1.17 (1.01/1.37)	1.14 (0.97/1.34)
II	1677	771	1.13 (0.97/1.32)	1.12 (0.96/1.31)
III (highest)	1787	901	1.00 (ref)	1.00 (ref)
Total fruits intake				
I (lowest)	1544	819	1.58 (1.31/1.84)	1.36 (1.16/1.60)
II	1923	824	1.21 (1.04/1.42)	1.15 (0.98/1.34)
III (highest)	1985	848	1.00 (ref)	1.00 (ref)
Fresh fruit intake				
I (lowest)	2112	1011	1.40 (1.22/1.61)	1.25 (1.08/1.43)
II	702	334	1.20 (0.98/1.46)	1.15 (0.94/1.40)
III (highest)	2638	1146	1.00 (ref)	1.00 (ref)
Total vegetables intake				
I (lowest)	1895	752	1.03 (0.90/1.19)	0.99 (0.86/1.14)
II	1624	718	0.98 (0.85/1.12)	0.97 (0.84/1.11)
III (highest)	1933	1021	1.00 (ref)	1.00 (ref)
Vegetables intake excluding Kimchi and pickled vegetables				
I (lowest)	1850	776	1.03 (0.89/1.18)	0.97 (0.84/1.11)
II	1704	749	1.03 (0.90/1.19)	1.02 (0.89/1.18)
III (highest)	1898	966	1.00 (ref)	1.00 (ref)
Meat, fish, eggs and beans intake				
I (lowest)	1760	888	1.12 (0.97/1.29)	1.10 (0.93/1.25)
II	1656	739	0.96 (0.83/1.10)	0.96 (0.84/1.11)
III (highest)	2036	864	1.00 (ref)	1.00 (ref)
Milk and milk products intake				
I (lowest)	3094	1624	1.24 (1.08/1.42)	1.13 (0.99/1.31)
II	357	134	1.20 (0.88/1.62)	1.22 (0.90/1.64)
III (highest)	2001	733	1.00 (ref)	1.00 (ref)
<i>Moderation components</i>				
Percentage of energy from saturated fatty acid				
I	1592	505	0.89 (0.77/1.03)	0.88 (0.76/1.02)
II	3860	1986	1.00 (ref)	1.00 (ref)
Sodium intake				
I (lowest)	1807	841	0.95 (0.82/1.11)	0.97 (0.83/1.14)
II	1835	811	0.98 (0.84/1.14)	1.02 (0.87/1.19)
III (highest)	1810	839	1.00 (ref)	1.00 (ref)

<Table 4> Continued.

KHEI components	No periodontitis	Periodontitis	OR (95% CI)	
			Model 1	Model 2
Percentage of energy from sweets and beverages				
I	1051	395	0.99 (0.85/1.16)	0.95 (0.81/1.11)
II	4401	2096	1.00 (ref)	1.00 (ref)
<i>Balance of energy intake</i>				
Percentage of energy from carbohydrate				
I (lowest)	1751	1006	1.16 (1.00/1.35)	1.10 (0.94/1.28)
II	1764	773	1.01 (0.87/1.17)	0.99 (0.86/1.15)
III (highest)	1937	712	1.00 (ref)	1.00 (ref)
Percentage of energy intake from fat				
I (lowest)	1223	738	1.21 (1.04/1.41)	1.15 (0.99/1.34)
II	1078	529	1.09 (0.94/1.27)	1.06 (0.91/1.24)
III (highest)	3151	1224	1.00 (ref)	1.00 (ref)
Energy intake				
I (lowest)	1489	702	1.16 (1.01/1.33)	1.11 (0.96/1.28)
II	1239	527	0.99 (0.85/1.16)	0.96 (0.82/1.12)
III (highest)	2724	1262	1.00 (ref)	1.00 (ref)

Model 1: adjusted for age, gender

Model 2: adjusted for age, gender, income, education, dental visits, high-risk alcohol consumption, smoking, hypertension, obesity, and diabetes mellitus.

<Table 5> Association of KHEI components with severe periodontitis (CPI = 4)

KHEI components	No severe periodontitis	Severe periodontitis	OR (95% CI)	
			Model 1	Model 2
<i>Adquacy components</i>				
Have breakfast				
I (lowest)	852	79	1.56 (1.18/2.05)	1.39 (1.04/1.85)
II	1448	92	1.13 (0.86/1.47)	1.07 (0.82/1.40)
III (highest)	4901	571	1.00 (ref)	1.00 (ref)
Mixed grains intake				
I (lowest)	2554	253	1.09 (0.86/1.37)	1.08 (0.85/1.37)
II	2236	212	0.95 (0.76/1.19)	0.96 (0.76/1.20)
III (highest)	2411	277	1.00 (ref)	1.00 (ref)
Total fruits intake				
I (lowest)	2110	253	1.42 (1.12/1.79)	1.23 (0.96/1.56)
II	2491	256	1.36 (1.08/1.72)	1.29 (1.02/1.62)
III (highest)	2600	233	1.00 (ref)	1.00 (ref)
Fresh fruit intake				
I (lowest)	2810	313	1.31 (1.06/1.61)	1.16 (0.94/1.44)
II	935	101	1.22 (0.92/1.63)	1.17 (0.88/1.55)
III (highest)	3456	328	1.00 (ref)	1.00 (ref)
Total vegetables intake				
I (lowest)	2427	220	1.09 (0.86/1.37)	1.03 (0.82/1.30)
II	2133	209	1.03 (0.83/1.29)	1.03 (0.82/1.29)
III (highest)	2641	313	1.00 (ref)	1.00 (ref)

<Table 5> Continued.

KHEI components	No severe periodontitis	Severe periodontitis	OR (95% CI)	
			Model 1	Model 2
Vegetables intake excluding Kimchi and pickled vegetables				
I (lowest)	2396	230	1.09 (0.87/1.37)	1.04 (0.82/1.31)
II	2230	223	1.10 (0.88/1.37)	1.07 (0.86/1.34)
III (highest)	2575	289	1.00 (ref)	1.00 (ref)
Meat, fish, eggs and beans intake				
I (lowest)	2383	265	1.26 (1.01/1.56)	1.22 (0.97/1.52)
II	2149	246	1.28 (1.02/1.61)	1.29 (1.03/1.63)
III (highest)	2669	231	1.00 (ref)	1.00 (ref)
Milk and milk products intake				
I (lowest)	4215	503	1.24 (1.01/1.53)	1.15 (0.93/1.42)
II	459	32	1.19 (0.74/1.91)	1.20 (0.74/1.92)
III (highest)	2527	207	1.00 (ref)	1.00 (ref)
<i>Moderation components</i>				
Percentage of energy from saturated fatty acid				
I	1935	162	1.14 (0.89/1.46)	1.12 (0.88/1.44)
II	5266	580	1.00 (ref)	1.00 (ref)
Sodium intake				
I (lowest)	2388	260	0.85 (0.67/1.09)	0.87 (0.68/1.12)
II	2404	242	0.97 (0.76/1.25)	1.01 (0.79/1.30)
III (highest)	2409	240	1.00 (ref)	1.00 (ref)
Percentage of energy from sweets and beverages				
I	1324	122	0.98 (0.75/1.28)	0.92 (0.70/1.22)
II	5877	620	1.00 (ref)	1.00 (ref)
<i>Balance of energy intake</i>				
Percentage of energy from carbohydrate				
I (lowest)	2448	309	1.38 (1.09/1.75)	1.34 (1.06/1.70)
II	2300	237	1.15 (0.90/1.47)	1.13 (0.88/1.45)
III (highest)	2453	196	1.00 (ref)	1.00 (ref)
Percentage of energy intake from fat				
I (lowest)	1729	232	1.39 (1.11/1.75)	1.37 (1.09/1.71)
II	1448	159	1.06 (0.85/1.32)	1.03 (0.82/1.28)
III (highest)	4024	351	1.00 (ref)	1.00 (ref)
Energy intake				
I (lowest)	1988	203	0.99 (0.80/1.23)	0.94 (0.75/1.17)
II	1600	166	1.13 (0.88/1.45)	1.09 (0.85/1.40)
III (highest)	3613	373	1.00 (ref)	1.00 (ref)

Model 1: adjusted for age, gender

Model 2: adjusted for age, gender, income, education, dental visits, high risk alcohol consumption, smoking, hypertension, obesity, and diabetes mellitus.

fruit intake, milk and milk products intake, percentage of energy from carbohydrate, percentage of energy intake from fat, and energy intake) after controlling for age and sex. However, the

fully adjusted model, periodontitis showed a significant association with total fruits intake and fresh fruit intake (Table 4). Severe periodontitis (CPI = 4) was significantly associated with 7

KHEI components (have breakfast, total fruits take, fresh fruit intake, meat, fish, eggs and beans intake, milk and milk products intake, percentage of energy from carbohydrate, and percentage of energy intake from fat) after controlling for age and sex. In fully adjusted model, severe periodontitis is associate with 5 KHEI components (have breakfast, total fruits intake, fresh fruit intake, meat, fish, eggs and beans intake, percentage of energy from carbohydrate, and percentage of energy intake from fat) (Table 5).

IV. Discussion

In a representative general Korean population, the results indicate that total score of KHEI was slightly lower in participants with periodontitis ($CPI \geq 3$) and severe periodontitis ($CPI = 4$) than normal. These results also identified that lower diet quality, as measured by KHEI, was associated with periodontitis and severe periodontitis, independent of the effects of age, sex, income, education, dental visits, high-risk alcohol consumption, smoking status, hypertension, obesity, and diabetes mellitus. In fully adjusted models, the lowest dietary quality was only associated with periodontitis and severe periodontitis. In addition to total score of KHEI, KHEI 14 components showed the association between periodontitis and severe periodontitis. The results of this study are the study on KHEI and periodontitis in Korean and provide additional evidence for the effect of dietary quality as a risk factor for periodontitis.

The results of the present study are considerably consistent with the evidence of Salazar et al [6]. In 13,920 Hispanic/Latinos adults in the United States [6], higher AHEI scores were associated with lower odds of severe periodontitis. In fully adjusted models, the link between highest AHEI quartile and periodontitis was only remained significant. Bawadi et al [15]. reported that poor diet (HEI score < 50) showed associated with increased odds of periodontitis using a systematic random sample of 340 participants in Jordanian adults. Since the cut-off score of the HEI score was not agreed to an international standard, the present study used a continuous variable and KHEI tertiles among Korean population. The study of Bawadi et al

[15]. evaluated several periodontal parameters such as plaque index, gingival index, PPD, and CAL, but it is difficult to compare directly with our study using CPI. Alzahrani et al [14]. showed that cumulative effect of the three health-enhancing behaviors (recommended exercise, higher diet quality, healthy weight) was associated with lower periodontitis using data on 12,110 participants who participated in the NHANES III data. The health-enhancing behaviors used in this study are difficult to confirm the effect of each behavior.

To date, previous investigations [7,14,15] have shown that comprehensive diet quality is significantly associated with several periodontal indicators. In addition, our study has provided evidence for association with KHEI and severe periodontitis ($CPI = 4$) as well as periodontitis ($CPI \geq 3$). Considering that the strength of the link on severe periodontitis was slightly higher than that of periodontitis, these results suggest that lower diet quality may affect more exacerbate periodontitis.

Our findings showed an inverse association with several KHEI components of periodontitis and severe periodontitis. In terms of periodontitis analyses, participants with the lowest total fruits intake and fresh fruit intake had significantly higher odds of periodontitis than participants with the highest quartiles in the fully adjusted models. In contrast, severe periodontitis was associated with other components, showing a different pattern. The present findings do not consistent with Salazar's previous results [7]. Although periodontitis led to a change in fruit intake, severe periodontitis seems to show more pronounced results in percentage of energy from carbohydrate and fat. Periodontitis gradually exacerbates masticatory function and tooth loss over time, so it affects the overall nutritional status due to changes in dietary habits and food choices of in a way more fat and starch and less fruits and vegetable intake [24]. Also, because the current study differ from Salazar's periodontitis classification, interpretation should be taken with caution.

The results of this research can be explained in part by biological plausibility linking between KHEI and periodontitis. Periodontitis commonly share various risk factors with NCDs.[5] An unhealthy diet identified as a risk factor contributes to periodontitis as well as systemic inflammation burden [6,23]. Greater adherence to the dietary guidelines, as measured by HEI predicted lower

risk of major chronic disease including stroke, cancer, diabetes mellitus, and coronary heart disease [10]. Better diet quality may affect the formation of lower calculus deposits, which can lead to periodontal disease [24], and then such a diet may consequences to healthy periodontal status. Thus, medical and dental professional should encourage optimal dietary intake that meets the dietary recommendations on improvement of systemic and oral health. The relevant KHEI components need to be applied to actual diet counseling.

The results of our research should be carefully considered for interpretation. Although the present study provides additional evidence on the link between diet quality and periodontitis using Korea national data, it is a cross-sectional study that is difficult to infer causality. Moreover, when synthesizing research that diet quality differs among diverse race [7], specific analysis by sex and age group is required to determine whether there are differences. Future research are needed analyze how KHEI affects periodontitis using longitudinal study design.

Notwithstanding, this study has several strengths. The KHEI is a well-known comprehensive tool suitable for assessing diet quality in the large population rather than an individual level. This study is the result of using a representative population that can add a scientific evidence on a summary measure of the overall diet quality and periodontal status.

V. Conclusions

Our results demonstrated an inversely significant association between diet quality and periodontitis in nationally representative sample of Korean adult population.

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