



## Original Article

# Effect of dietary quality on periodontal diseases in Korean adults: the Korea National Health and Nutrition Examination Survey (2016-2018)

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## ABSTRACT

**Objectives:** This study investigated the relationship between the Korean healthy eating index (KHEI) and periodontal disease in the Korean adult population. **Methods:** The data used in the analyses were obtained from the seventh Korean National Health and Nutrition Examination Survey (2016–2018). Data were analyzed by chi-square tests and t-test. Multiple regression analysis was also performed to assess the association between KHEI and periodontal disease. Statistical significance was set at  $p < 0.05$ . **Results:** Multiple logistic regression analysis adjusted for socioeconomic variables showed that medical and health behavior variables were significantly related to the KHEI 1 ( $< 63.7$ , odds ratio [OR]: 1.23, 95% confidence interval [CI]: 1.03–1.46), KHEI 2 (63.7–79.9, OR: 1.14, 95% CI: 0.97–1.34), and risk for periodontal disease. **Conclusions:** The results showed a significant association between the KHEI and periodontal disease in the Korean adult population.

**Key Words:** Healthy eating index, Nutrients, Oral health, Periodontal disease

## Introduction

Healthy eating is an important determinant of the quality of life and is essential for healthy living [1]. Nutrients obtained from food help maintain good health and improve the quality of life by preventing diseases and delaying the onset of non-infectious diseases [2].

Carbohydrates, proteins, fat, and micronutrients constitute periodontal tissues and interact with immune cells that mediate immune responses against periodontal infections [3,4].

Healthy eating is a behavior in which an individual ingests nutrients needed by different body parts. As efforts are needed to assess and improve eating habits, the Korean Healthy Eating Index (KHEI) was developed to assess eating habits among Korean adults. The KHEI is a standardized assessment tool containing 14 items and is based on a national dietary guideline and scientific evidence regarding dietary changes and the dietary factors associated with chronic diseases [5].

International tools for assessing eating habits include the Healthy Eating Index (HEI) [6] and Dietary Quality Index (DQI) [7] in the United States and the Healthy Diet Indicator (HDI) [8] in Europe. Different countries use different tools that are catered to their domestic situations to assess eating habits. The KHEI, which was developed in Korea, has been used to examine the relationships between the number of teeth and dietary quality in Korean adults [9], predicted cardiovascular age and the KHEI in adults [10], and psychological pain [11].

A study examining the relationship between periodontal diseases and body mass index (BMI), participation in a recommended level of physical activity, and diet in Americans reported that health-promotion behaviors, including consuming high-quality meals,

could reduce the risk of periodontal diseases [12]. A study examining the impact of physical activity and eating habits on the risk of periodontal diseases among Jordanian adults reported that a poor diet increased the risk of periodontal diseases and suggested the need for additional research on dietary nutrients and periodontal diseases [13].

This study assessed the impact of dietary quality on the risk of periodontal diseases using the KHEI, a standardized dietary quality assessment tool. This study aimed to provide data regarding dietary regulation for the prevention and management of periodontal diseases.

## Methods

### 1. Participants

This cross-sectional study was conducted using raw data from the 7th Korea National Health and Nutrition Examination Survey (KNHANES) (2016–2018). The data were approved by the Institutional Review Board of the Korea Disease Control and Prevention Agency, and consent was obtained from all respondents (No.2018-01-03-P-A). The present study extracted data for 13,199 respondents aged  $\geq 19$  years and analyzed data for 12,680 of the respondents who underwent a periodontal tissue examination. Inconsistencies in total frequencies resulted from missing values.

### 2. Study tools

#### 1) Periodontal disease

The presence of periodontal disease, which was a dependent variable, was determined based on the Community Periodontal Index (CPI) proposed by the World Health Organization (WHO). Periodontal disease was deemed to not be present if the periodontal pocket depth was  $< 4$  mm (CPI 0–2) and was deemed present if the pocket depth was  $\geq 4$  mm (CPI 3–4).

#### 2) KHEI

The KHEI is calculated using data from the Food Frequency Questionnaire (FFQ) administered by an experienced dietician using the 24-recall method. The total scores range from 0 to 100, with higher scores indicating a healthier diet [5]. The KHEI consists of eight items for adequate consumption (breakfast, mixed grain, fruit, vegetables, protein, and dairy products), three items for moderate consumption (saturated fatty acids, sodium, and sweets), and three items for balanced consumption (carbohydrates, total fat, and energy).

Based on a previous study [12,13], a KHEI of  $\geq 80$  indicated high dietary quality. Using the mean KHEI of 63.7 among adults aged  $\geq 19$  years, who were the population group of interest in the present study, as a cut-off, the participants were categorized into three groups with the following KHEI ranges:  $< 63.7$  (KHEI 1), 63.7–79.9 (KHEI 2), and  $\geq 80.0$  (KHEI 3).

#### 3) Covariates

The study participants were adults aged  $\geq 19$  years. They were divided according to each variable of interest. The demographic factors included sex, age, household income, and education levels. Age was categorized as 19–29, 30–39, 40–49, 50–59, 60–69, and  $\geq 70$  years. For household income, the participants were divided into quartiles of mean monthly household equivalized income, which was calculated by dividing the mean monthly household income by the square root of the total number of household members, and categorized as low, middle-low, middle-high, and high. Education level was categorized as elementary school or less, middle school, high school, and university or more.

The medical factors included BMI and diabetes. The participants were classified as underweight (BMI  $< 18.5$  kg/m<sup>2</sup>), normal-weight (18.5–22.9 kg/m<sup>2</sup>), overweight (23–24.9 kg/m<sup>2</sup>), and obese ( $> 25$  kg/m<sup>2</sup>). The diabetes categories were fasting glucose  $\geq 126$  mg/dL, diagnosed with diabetes, taking diabetes medications, and receiving insulin injections.

The health behavior factors included smoking status, alcohol consumption, and daily toothbrushing frequency. The categories for smoking status were non-smoker and smoker. The categories for alcohol consumption were 'have never drunk' and 'have drunk'. The categories for daily toothbrushing frequency were  $\leq 1$ , 2, and  $\geq 3$  times.

### 3. Statistical analysis

All statistical analyses were conducted on adults  $\geq 19$  years of age while considering the complex sample design of the raw KNHANES data. Chi-squared tests were used to examine the relationship between the general characteristics and the presence of periodontal disease. T-tests were used to examine the relationship between the presence of periodontal disease and the 14 KHEI items. Logistic regression was used to examine the correlation between the KHEI and periodontal diseases.

The first logistic regression model (Model 1) was adjusted for demographic factors (sex, age, household income, and education level). Model 2 was adjusted for the demographic factors plus medical factors (BMI and diabetes). Model 3 was adjusted for the demographic factors, medical factors, and health behavior factors (smoking status, alcohol consumption, and daily toothbrushing frequency). The odds ratios (ORs) for periodontal disease and their 95% confidence intervals (CIs) were presented. All statistical analyses were performed using IBM SPSS statistics for windows, version 20.0 (IBM Corp., Armonk, NY, USA). A type 1 error rate of 0.05 was used.

## Results

### 1. Rates of periodontal disease and general characteristics

<Table 1> presents the rates of periodontal disease for the participants divided according to their general characteristics. Significant differences in the rates of periodontal disease were observed for all general characteristics. The rate of periodontal disease was higher among men (37.7%) than that in women and increased with age ( $p < 0.001$ ). The rate increased as household income and education level decreased ( $p < 0.001$ ), and with BMI. The rate was also higher if a participant was diabetic, was a smoker, and had a daily toothbrushing frequency of  $\leq 1$  time ( $p < 0.001$ ). The rates of periodontal disease were 29.1%, 32.5%, and 30.2% for the KHEI 1, KHEI 2, and KHEI 3 groups, respectively. The rate of periodontal disease was higher in the KHEI 2 group than those in the other KHEI groups ( $p = 0.007$ ).

### 2. Comparison of KHEI by the presence of periodontal disease

<Table 2> presents the KHEI of the periodontal disease and normal groups. The total KHEI, which is the sum of the scores for the 14 KHEI items, was higher in the periodontal disease group (64.49) than that in the normal group by 0.99. Compared to the periodontal group, the normal group had significantly higher scores for protein (7.15, 95% CI: 7.05–7.24), milk and dairy products (3.49, 95% CI: 3.35–3.63), carbohydrates (2.56, 95% CI: 2.50–2.62), and fat consumption (3.35, 95% CI: 3.29–3.40) ( $p < 0.001$ ).

### 3. Correlation between periodontal disease and KHEI

<Table 3> presents the results of the analysis of the correlations between periodontal disease and eating habits. The ORs for periodontal disease were calculated with respect to the KHEI 3 group (KHEI  $\geq 80$ ). Model 1, which was adjusted for demographic factors, predicted significantly high ORs of 1.31 (95% CI: 1.10–1.55) for KHEI 1 and 1.16 (95% CI: 1.00–1.36) for KHEI 2. Model 2, which was adjusted for demographic and medical factors, predicted a significantly high OR of 1.31 (95% CI: 1.11–1.56) for KHEI 1. Model 3, which was adjusted for demographic, medical, and health behavior factors predicted a significantly high OR of 1.23 (95% CI: 1.03–1.46) for KHEI 1.

**Table 1.** Characteristics of the study population stratified by periodontal disease

Characteristics	Division	Periodontal disease (CPI 3,4)				Total N	<i>P</i> <sup>*</sup>
		No		Yes			
		N	Weighted % (SE)	N	Weighted % (SE)		
Sex (N = 12,689)	Male	3,417	62.3 (0.9)	2,128	37.7 (0.9)	5,545	< 0.001
	Female	5,291	74.7 (0.9)	1,853	25.3 (0.9)	7,144	
Age (yrs) (N = 12,689)	19 - 29	1,501	96.0 (0.8)	61	4.0 (0.8)	1,562	< 0.001
	30 - 39	1,806	86.5 (0.8)	294	13.5 (0.8)	2,100	
	40 - 49	1,768	74.8 (1.2)	647	25.2 (1.2)	2,415	
	50 - 59	1,466	60.6 (1.3)	1,005	39.4 (1.3)	2,471	
	60 - 69	1,144	53.7 (1.4)	1,017	46.3 (1.4)	2,161	
	≥ 70	1,023	52.1 (1.5)	957	47.9 (1.5)	1,980	
Household income (N = 12,656)	Lower	1,331	57.9 (1.6)	1,009	42.1 (1.6)	2,340	< 0.001
	Median	4,563	69.4 (0.8)	2,069	30.6 (0.8)	6,632	
	Upper	2,796	76.8 (1.0)	888	23.2 (1.0)	3,684	
Education (N = 12,110)	≤ Elementary school	1,172	50.7 (1.5)	1,147	49.3 (1.5)	2,319	< 0.001
	Middle school	654	54.9 (2.0)	522	45.1 (2.0)	1,176	
	High school	2,827	72.4 (1.0)	1,134	27.6 (1.0)	3,961	
	≥ University or college	3,686	80.0 (0.9)	968	20.0 (0.9)	4,654	
BMI (N = 12,390)	Underweight	379	81.9 (2.0)	96	18.1 (2.0)	475	< 0.001
	Normal	3,523	75.0 (0.9)	1,210	25.0 (0.9)	4,733	
	Overweight	1,839	65.9 (1.3)	955	34.1 (1.3)	2,794	
	Obesity	2,760	64.1 (1.1)	1,628	35.9 (1.1)	4,388	
Diabetes (N = 12,689)	Absence	8,134	71.6 (0.8)	3,358	28.4 (0.8)	11,492	< 0.001
	Presence	574	48.0 (1.9)	623	52.0 (1.9)	1,197	
Smoking (N = 12,571)	Non-smoker	7,344	71.8 (0.8)	2,966	28.2 (0.8)	10,310	< 0.001
	Smoker	1,292	58.2 (1.4)	969	41.8 (1.4)	2,261	
Alcohol (N = 12,584)	Non-drinker	847	61.6 (1.6)	520	38.4 (1.6)	1,367	< 0.001
	Drinker	7,794	70.3 (0.8)	3,423	29.7 (0.8)	11,217	
Tooth brushing / day (N = 12,687)	≤ 1	611	56.06 (1.7)	470	43.93 (1.7)	1,081	< 0.001
	2	3,196	66.40 (1.0)	1,660	33.59 (1.0)	4,856	
	≥ 3	4,738	74.18 (0.8)	1,725	25.81 (0.8)	6,463	
KHEI score (N = 11,026)	< 63.7	3,720	70.9 (0.9)	1,612	29.1 (0.9)	5,332	0.007
	63.7 - 79.9	2,929	67.5 (1.0)	1,448	32.5 (1.0)	4,377	
	≥ 80.0	910	69.8 (1.6)	407	30.2 (1.6)	1,317	

\*by chi-square test

**Table 2.** Korean healthy eating index components of the participants according to periodontal disease

KHEI component (maximum)	Periodontal disease (CPI 3,4)				<i>p</i> <sup>*</sup>	
	No (ref)		Yes			
	Mean	95% CI	Mean	95% CI		
14 total score (100)	63.50	63.05 - 63.95	64.49	63.91 - 65.07	0.002	
Adequacy components						
Whole grains intake (5)	1.95	1.88 - 2.01	2.21	2.11 - 2.31	< 0.001	
Fruits intake including juice (5)	2.32	2.25 - 2.40	2.37	2.26 - 2.47	0.414	
Fruits intake excluding juice (5)	2.49	2.42 - 2.57	2.59	2.49 - 2.70	0.084	
Vegetables intake including Kimchi or pickles (5)	3.38	3.33 - 3.42	3.67	3.60 - 3.73	< 0.001	
Vegetables intake excluding Kimchi or pickles(5)	3.13	3.08 - 3.18	3.24	3.17 - 3.31	0.009	
Protein foods intake (10)	7.15	7.05 - 7.24	6.74	6.59 - 6.89	< 0.001	
Milk and dairy intake (10)	3.49	3.35 - 3.63	2.71	2.52 - 2.90	< 0.001	
Have breakfast (10) score						
(N = 11,026)	0	1,088 <sup>b</sup>	14.5 (0.5) <sup>c</sup>	356 <sup>b</sup>	10.2 (0.6) <sup>c</sup>	< 0.001 <sup>a</sup>
	3	924 <sup>b</sup>	12.3 (0.5) <sup>c</sup>	259 <sup>b</sup>	7.4 (0.5) <sup>c</sup>	
	6	932 <sup>b</sup>	11.8 (0.4) <sup>c</sup>	240 <sup>b</sup>	6.7 (0.5) <sup>c</sup>	
	10	4,615 <sup>b</sup>	61.3 (0.9) <sup>c</sup>	2,612 <sup>b</sup>	75.7 (0.9) <sup>c</sup>	
Moderation components						
Percentage of energy from saturated fatty acid (10)	7.24	7.12 - 7.35	8.29	8.15 - 8.43	< 0.001	
Sodium intake (10)	7.00	6.90 - 7.11	7.01	6.87 - 7.16	0.916	
Percentage of energy from sweets and beverages (10)	9.17	9.10 - 9.23	9.31	9.23 - 9.39	0.005	
Balance of energy intake						
Percentage of energy from carbohydrate (5)	2.56	2.50 - 2.62	2.13	2.05 - 2.22	< 0.001	
Percentage of energy intake from fat (5)	3.35	3.29 - 3.40	2.94	2.85 - 3.03	< 0.001	
Energy intake (5)	3.07	3.01 - 3.13	3.08	2.99 - 3.17	0.767	

<sup>\*</sup>by t-test complex sampling general linear model; CI: confidence interval; <sup>a</sup>by chi-square test; <sup>b</sup>Unweighted N; <sup>c</sup>Weighted % (SE)

**Table 3.** Multivariable association between Korean healthy eating index and periodontal disease (ref. no periodontal disease)

Variable	Model 1	Model 2	Model 3
	OR (95% CI)	OR (95% CI)	OR (95% CI)
KHEI 1	1.31 (1.10 - 1.55)**	1.31 (1.11 - 1.56)**	1.23 (1.03 - 1.46)*
KHEI 2	1.16 (1.00 - 1.36)*	1.16 (0.99 - 1.36)	1.14 (0.97 - 1.34)
KHEI 3	Reference	Reference	Reference

Data are presented as OR (95% CI). OR: odds ratio, CI: confidence interval; \**p*<0.05 and \*\**p*<0.01

Reference: no periodontal disease (0).

Explanatory variable: KHEI 1; <63.7, KHEI 2; 63.7-79.9, KHEI 3; ≥80.0

Model 1 adjusted for socioeconomic variables (sex, age, household income, and education level).

Model 2 adjusted for the same factors as model 1 plus medical variables (BMI and diabetes mellitus).

Model 3 adjusted for the same factors as model 2 plus health behavior variables (smoking, alcohol drinking, and toothbrushing).

## Discussion

This study analyzed the relationship between periodontal diseases and dietary quality among Korean adults using data from the 7<sup>th</sup> KNHANES. Models adjusted for various confounding variables predicted a significant correlation between periodontal diseases and dietary quality.

We observed significant differences in the rate of periodontal disease according to all demographic factors. The percentage of participants with a KHEI of 63.7–79.9 was high (32.5%) in the periodontal disease group <Table 1>. The mean total KHEI score across all 14 items was also 0.09 higher in the periodontal disease group than that in the normal group <Table 2>. Each KHEI item was selected based on scientific evidence, a dietary guideline, and dietary quality criteria; thus, monitoring the items based on how well or how poorly an individual consumes the corresponding food items is recommended rather than assessing the KHEI of a population as an absolute value [5]. The present study assessed 14 KHEI items. The normal group scored high on the items for adequate consumption, including protein and milk and dairy products ( $p<0.001$ ) <Table 2>.

Proteins are involved in immune responses against pathogens causing periodontal diseases [14] and are essential for patients with periodontal disease or periodontal inflammation. A Danish study reported that high fat consumption was inversely correlated with periodontal disease [15]. A domestic study examining the relationship between periodontal disease and nutrient intake in menopausal women also reported a decreased odds ratio for periodontal disease of 0.31 for women with high protein consumption, suggesting that protein consumption is closely associated with periodontal disease prevention [16].

A previous study suggested that the calcium contained in milk and fermented products can prevent periodontal diseases [17], with a low risk of periodontal diseases (20%) for the quintile of participants with the highest level of dairy product consumption [18]. In the present study, the normal group had significantly higher scores for protein and calcium, which were items with adequate consumption, supporting the previous findings. The normal group also scored higher on carbohydrates and fat, which were items with balanced consumption, compared to the periodontal disease group. High carbohydrate and sugar consumption are associated with dental caries and periodontal diseases. Moreover, saccharose is a disaccharide that forms dental plaques and creates an unfavorable oral environment that can contribute to the development of periodontal diseases [19].

National Health and Nutrition Examination Survey cohort data in the United States showed that high added sugar consumption increased the risk of periodontal diseases by 1.42-fold (95% CI: 1.08–1.85) [20]. Similarly, the odds ratio for periodontal diseases was 3.31 (95% CI: 1.90–5.77) among the top consumers of carbohydrates in Korea [16]. Thus, carbohydrate consumption must be reduced to prevent oral diseases such as periodontal diseases and dental caries. A previous study reported that reducing carbohydrate consumption through a 4-week diet plan resulted in a more than two-fold decreased risk of gingival infection and that different carbohydrates had different effects on periodontal diseases [21].

Saturated fatty acids can cause inflammatory responses, and excessive inflammation is a major cause of periodontal diseases. A Japanese study on saturated fatty acid consumption and periodontal findings reported an association between fat consumption and the progression of periodontal disease [22]. Since periodontal diseases may be highly associated with carbohydrate or fat consumption, dietary quality related to carbohydrates and fat should be considered for the prevention and management of periodontal disease.

The periodontal disease group scored higher than the normal group on some of the items for adequate, moderate, and balanced consumption. However, these results do not prove that these items are not associated with periodontal diseases. The Harvard School of Public Health reported that the Healthy Eating Index (HEI) was associated with a reduced risk of cardiovascular diseases and was not associated with the risk of cancer [23]. Another research team reported a strong correlation between the HEI and plasma levels of antioxidants, providing evidence of cancer prevention [24]. The relationships between different food products and periodontal diseases must be assessed through systemic analyses of individual HEI scores and their statistical significance.



In the present study, logistic regression adjusted for demographic, medical, and health behavior factors predicted an odds ratio for periodontal diseases of 1.23 for the KHEI 1 group. American and Jordanian studies on the relationship between HEI and periodontal diseases found that a high dietary quality positively affected periodontal disease prevention and management [12,13]. Consistent with these findings, our results also suggested that poor dietary quality affects periodontal diseases.

A study on the relationship between oral health and dietary quality in the elderly reported that individuals with poor oral health had poor dietary quality and low levels of nutrition intake. The authors also suggested that a chronic poor diet might be associated with future oral problems [25]. Since dietary quality affects systemic and oral health as well as eating habits, dietary quality must be managed. The results of this study demonstrate that low dietary quality affects periodontal diseases and suggest the need to develop education programs aimed at improving the consumption of individual food items.

The present study could not elucidate the direct causal relationship between dietary quality and periodontal diseases. Despite this limitation, the study is meaningful as it used a more comprehensive approach than the traditional approach of assessing the impact of individual nutrients or food products on diseases to assess the risk of periodontal diseases and dietary quality. A longitudinal study on dietary quality and periodontal diseases is warranted. In conclusion, this study identified an association between dietary quality and periodontal diseases and found that poor dietary quality was significantly associated with an increased risk of periodontal diseases.

## Conclusions

This study analyzed data from the 7th KNHANES (2016-2018) to examine the relationship between periodontal disease and the KHEI used to assess the dietary quality among Korean adults aged  $\geq 19$  years. The major results were as follows:

1. The normal group scored high on protein, milk and dairy products, carbohydrates, and fat consumption ( $p < 0.001$ ).
2. Multiple logistic regression was performed after adjusting for demographic, medical, and health behavior factors to examine the correlation between periodontal disease and the KHEI. The odds ratio for periodontal diseases was 1.23 (95% CI: 1.03-1.46) for the KHEI 1 group and 1.14 (95% CI: 0.97-1.34) for the KHEI 2 group with respect to the KHEI 3 group.

These results demonstrated a relationship between periodontal diseases and dietary quality. Education programs to prevent and manage periodontal diseases and improve dietary quality are needed.

## Conflicts of Interest

The author declared no conflict of interest.

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# 한국 성인의 식생활의 질이 치주질환에 미치는 영향: 국민건강영양조사 제7기(2016-2018) 자료 활용

## 초록

**연구목적:** 본 연구는 국내의 19세 이상의 성인을 대상으로 식생활의 질이 치주질환에 미치는 영향을 파악하고자 수행되었다. **연구방법:** 국민건강영양조사의 제7기(2016-2018) 자료를 이용하였으며 성인 대상자 중 치주조직 검사를 실시한 12,689명을 대상으로 분석을 실시하였다. 치주질환 유병여부에 따른 일반적 특성과 식생활 평가지수(KHEI) 세부점수 자료는 교차분석과 t-test를 실시하였다. 식생활의 질에 따른 치주질환 간의 연관성을 평가하기 위해 다변량 로지스틱 회귀분석을 실시하여 검정하였다. 통계적 유의수준은 0.05로 설정하였다. **연구결과:** 인구사회학적요인, 의학적 요인 및 건강행태에 대한 요인을 보정한 후 다변량 로지스틱 회귀분석을 실시한 결과 KHEI 3 식생활평가의 상위 점수자에 비해 KHEI 1 평균점수 이하의 군에서 치주질환 승산비가 1.23배(95% CI: 1.03-1.46)으로 증가하였으며, KHEI 2 평균점수에서 80점 미만인 군에서는 1.14배(95% CI: 0.97-1.34)로 나타났다. **결론:** 식생활의 질 수준이 치주질환에 영향을 줄 수 있는 것으로 나타났다. 따라서 치주질환 예방과 관리를 위해 식생활에 대한 질을 높이기 위한 교육과 프로그램이 마련되어야 할 것으로 보인다.

**색인:** 구강건강, 식생활평가지수, 영양소, 치주질환