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The Association Between Vitamins A, E and Periodontal Disease: Using the 7th National Health and Nutrition Survey Data (2016-2018)

Ji-Ryang Kim[1†] , Jae-Hyun Kim[2†] , Jong-Hwa Jang[3]

[1]Ph.D. graduate student, Dept. of Public Health, Graduate School of Dankook University (201002698@hanmail.net), First Author
[2]Assistant professor, Dept. of Health Administration, College of Health Science, Dankook University (jaehyun@dankook.ac.kr), First Author
[3]Professor, Dept. of Dental Hygiene, College of Health Science, Dankook University (jhj@dankook.ac.kr), Corresponding Author
[†] These authors contributed equality to this work.

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ABSTRACT

This study aimed to examine and understand the association between the periodontal disease and content of vitamins A and E in the blood components by sex. Of the 16,489 participants of the 7th KNHANES (2016-2018) examination, the data of the final 4,478 people who underwent the oral examination were used. The data were collected through the self-administered interview questionnaire and examination, and the demographic characteristics, general blood tests, and the community periodontal index (CPI index) were measured, while the periodontal disease was determined to be CPITN 2 or higher. The association between vitamins A and E and the periodontal disease was analyzed by the multiple sample chi-square test and the multiple logistic regression analysis. The prevalence of the periodontal disease among the subjects turned out to be 27.5%. The association between gender vitamins and the periodontal disease analyzed by controlling the sociodemographic characteristics and blood components was 2.42 times lower (OR: 2.42, CI: 1.20-4.87) as the vitamin A content increased by 1st quantile among the men, and as for women, as the vitamin E content increased by 1st quantile, it decreased by 1.02 times (OR: 1.02, CI: 1.00-1.04). In conclusion, it was suggested that an adequate intake of vitamin A for men and vitamin E for women can help promote and maintain the periodontal health.

1. Introduction

The prevalence of the periodontal disease among the adults aged 19 years or older in Korea has been reported to be 23.4% from 2016 through 2018, and the periodontal disease is known to be the main cause of loss of teeth, particularly among the adults aged 35 years or older (Lee & Kim, 2015). Periodontal disease is a chronic inflammatory disease where the periodontal ligament

and alveolar bone are incrementally lost due to the inflammation of the tissues around the teeth by bacteria (Won & Ha, 2014). If it becomes severe, it can cause a loss of teeth, and it can also affect the face, pronunciation, and diet, thereby causing the quality of life to decline (Lee et al., 2013). The causes of the periodontal disease are known to be dental plaque, poor oral care, smoking, drinking, stress, systemic disease, and nutrition (Kim, 2011; Jung et al., 2013; Yoon et al., 2002; Jo et al., 2016; Hwang & Kim, 2018), among which, nutrition in particular is closely related to the oral health. The oral cavity plays a role in enabling the nutrients to be absorbed into the body first through mastication and swallowing when food is ingested (Paek et al., 2015), and when the teeth are lost due to the periodontal disease, the masticatory ability declines and the nutrient intake may be negatively affected, further resulting in a low-nutrition condition (Hwang & Kim, 2018). If the low-nutrition condition persists, immunity decreases and it can affect not only oral health but also the occurrence of various diseases (Hwang & Kim, 2018).

Among the various nutrients that play such an important role in maintaining the oral health, vitamins have been found to be highly related to the oral cavity, such as scurvy and acute necrotizing ulcerative gingivitis (Kim et al., 2016). Vitamins A and E act as the antioxidants to help prevent the oxidative damages caused by the active oxygen generated in the body (Jeong et al., 2016), and it has been reported that the recovery of gum health is faster when consumed in large quantities (Najeeb et al., 2016). Furthermore, a vitamin A deficiency could cause enamel hypoplasia and weakened immunity (Daum wikipedia, 2020), and a vitamin E deficiency is known to cause damages to the blood vessel and cell membrane functions (Jeong et al., 2016). In a study which used the National Health and Nutrition Examination Survey (NHANES) of the United States for analysis, it was claimed that the periodontal disease is more likely to occur when the vitamin A and vitamin E intake is reduced (Luo et al., 2018).

However, as for the previous studies of the periodontal disease in Korea, the studies on vitamins C and D are primarily conducted (Kim et al., 21016; Kim & Hwang, 2018; Paek &, Lee, 2014; Baek et al., 2009), and the studies on the vitamins A and E are inadequate.

The Korea National Health and Nutrition Examination Survey (KNHANES) is a large scaled nationwide fact finding survey, and the representativeness and reliability for the data on the health and nutritional level of the people are guaranteed. Hence, using the KNHANES data of the 7th period (2016-2018) to prevent the periodontal disease among the Korean adults to enhance the perception of oral care and prepare measures to promote the periodontal health, the vitamins A and E were examined with the periodontal disease for their association, and it is sought to examine and understand the sex differences.

2. Materials and Methods

2.1 Study design

This study is a cross-sectional study which analyzed the association between the vitamins A and E and the periodontal disease using the 7th KNHANES. The first and second years (2016-2017)

of the 7th KNHANES were exempted from deliberation by the Research Ethics Review Committee of the Korea Centers for Disease Control and Prevention as they were directly conducted by the state for the public welfare according to the Bioethics Safety Act, and the 3rd year (2018) was reviewed for the research ethics in consideration of the collection of human derivatives and the provision of raw data to a third party, etc. (IRB No. 2018-01-03-P-A).

2.2 Study participants

As the KNHANES is an open data[18], the subjects are selected by a composite sample where the proportional distribution method and the systematic sampling method are applied on a phased in basis. The data for the 7th period (2017-2018) used for this study were all household members aged 1 year or older among about 4,416 households nationwide from January 2016 through December 2018. To extract a representative sample, the most recent population and housing census data available at the time of the sample design were used as the basic extraction frame, and the declared prices of multi family housing properties was added to use the latest information that can reflect the current population characteristics, whereby the basic extraction frame was supplemented and the population inclusion rate was enhanced. As for the sampling method, a two-stage stratified colony sampling method was used with the survey district and household as the primary and secondary sampling units, and the extraction frame was stratified based on dong/eup/myeon and housing type (general house and apartment), while the area ratio and household head's educational ratio were used as the implicit stratification criteria. There were 192 survey districts, and 23 sample households were selected by using the systematic sampling method among the households excluding foreign households and facilities such as nursing homes, prisons, and military within the sample survey districts.

As for the research participants, the oral examination data were used during the examination, and 4,478 people the participants excluding 12,011 people with the data of missing value out of a total of 16,489 people.

2.3 Variables and measurement

The key independent variables were vitamins A and E, which were measured by general blood tests, and the data measured by the participants of the households selected through the household member identification survey visited the mobile examination center were used. The dependent variable was the periodontal disease, which was measured by oral examination, and using the community periodontal index (CPI index), CPI 0 was healthy, CPI 1 was gingivitis, and CPI 2 or higher as defined for the periodontal disease of this study. As for the number of lost teeth, 28 teeth were subjected, excluding the third molars, and was obtained by combining the carious and non-carious teeth, and the unerupted teeth and unrecorded teeth were not included.

As for the control variable, the trained investigators in accordance with the KNHANES test guidelines obtained consent from the participants to participate in the study voluntarily, and conducted an interview survey with the structured self-administered questionnaire questions. As for the demographic variables, area (Seoul, metropolitan city and others), gender (male and women), age (19

years old or younger, 20-29, 30-39, 40-49, 50-59, 60-69, 70 years old or older), income (low, low to middle, middle to high, and high), education (elementary school graduate or lower, junior high school, high school, and university graduate or higher), marital status (married and single), and the subjective health condition (good, average, poor) as a variable related to the health condition was included for the analytical model.

2.4 Statistical analysis

The frequency analysis was used to determine the general characteristics of the population and the prevalence of the periodontal disease, and to analyze as to whether the general characteristics and vitamins A and E were related to the prevalence of the periodontal disease, the multiple sample Chi-square test and the multiple logistic regression analysis were used. For the data analysis, the SAS 9.4 version of the statistical package was used.

3. Results

3.1 Prevalence of the periodontal disease according to general characteristics

Table 1 illustrates the general characteristics of the participants and the prevalence of the periodontal disease. As for the age of the participants with the periodontal disease, those aged 50-59 (30.9%) were the most, and there were more men than women (52.4%). In terms of their education level, high school graduates were the most at 30.3%, and as for the subjective health condition, those thinking average were the most at 52.0%. As for the age of the subjects without the periodontal disease, those aged 30-39 were the most at 19.3%, and those whose income is high were the most at 33.4%. Furthermore, as for the education level, those who are university graduates or higher were the most at 41.9%.

Table 1. General characteristics and the prevalence of the periodontal disease

Variables	Total		No		Yes	
	N	%*	N	%*	N	%*
Total	4478	100.0	3247	72.5	1231	27.5
Age						
≤ 19	442	8.9	439	12.2	3	0.2
20-29	516	12.3	491	16.1	25	2.4
30-39	760	16.1	655	19.3	105	7.7
40-49	822	17.8	598	18.4	224	16.3
50-59	888	20.9	519	17.1	369	30.9
60-69	602	13.7	326	10.5	276	22.4
≥ 70	448	10.3	219	6.5	229	20.1
Sex						
Male	2054	44.4	1369	41.3	685	52.4
Female	2424	55.6	1878	58.7	546	47.6

Variables	Total		No		Yes	
	N	%*	N	%*	N	%*
Region						
Seoul	916	22.1	719	23.4	197	18.8
City	1190	25.4	882	25.4	308	25.2
Etc.	2372	52.5	1646	51.2	726	56.1
Income						
Low	661	15.0	398	12.4	263	22.0
Mid-low	1068	23.4	746	22.6	322	25.7
Mid-high	1350	30.1	1023	31.6	327	26.0
High	1399	31.4	1080	33.4	319	26.0
Education						
≤ elementary school	811	17.8	481	13.9	330	27.9
Middle school	555	12.3	383	11.4	172	14.8
High school	1428	32.1	1036	32.8	392	30.3
≥ University	1684	37.8	1347	41.9	337	27.0
Marriage						
Married	3313	74.5	2164	67.3	1149	93.3
Unmarried	1165	25.5	1083	32.7	82	6.7
Subjective health						
Good	1445	31.8	1139	34.4	306	25.2
Average	2244	50.4	1598	49.7	646	52.0
Bad	789	17.8	510	15.9	279	22.7

%* = weighted %

3.2 Blood components according to whether the periodontal disease is prevalent

Table 2. Blood components and the prevalence of the periodontal disease

Variables	Total (n = 4478)		No (n = 3247)		Yes (n = 1231)	
	Mean	95% CI	Mean	95% CI	Mean	95% CI
Blood components						
Vitamin A	0.51	0.50-0.52	0.49	0.48-0.50	0.56	0.54-0.57
Vitamin E	13.23	12.93-13.53	12.72	12.45-12.99	14.56	13.84-15.26
Urea nitrogen	14.25	14.08-14.43	13.86	13.68-14.05	15.29	14.98-15.60
Creatinine	0.81	0.80-.81	0.79	0.78-0.80	0.84	0.82-0.85
White blood cell	6.25	6.18-6.31	6.14	6.07-6.21	6.53	6.41-6.65
Red blood cells	4.66	4.64-4.68	4.67	4.65-4.69	4.65	4.61-4.68
Platelets	264.00	261.81-266.19	266.21	263.75-268.67	258.19	253.84-262.53
High sensitivity C-reaction protein	1.09	1.03-1.15	1.04	0.97-1.11	1.24	1.11-1.36
Uric acid	5.12	5.08-5.17	5.11	5.06-5.17	5.15	5.07-5.24
Folic acid	7.30	7.18-7.43	7.28	7.13-7.42	7.37	7.17-7.58

CI = confidence interval

3.3 Association between vitamins A and E and the periodontal disease according to the all participants and sex

Table 2 illustrates the results of analyzing the association between the prevalence of the periodontal disease and vitamins A and E according to all participants and sex. As a result of the analysis of all participants, the prevalence of the periodontal disease decreased by 1.02 times as the 1st quintile increase in the vitamin E intake compared to the recommended amount demonstrated significant results (Odds Ratio (OR): 1.02, (Confidence Interval(CI)): 1.01-1.04, $p = 0.011$). The association of the periodontal disease according to general characteristics was higher among those aged 40-49 years than those aged 70 or older (OR: 0.43, CI: 0.30-0.62, $p < 0.001$), and among those aged 30-39 years (OR: 0.20, CI: 0.13-0.30, $p < 0.001$), and among those aged 20-29 (OR:0.08, CI:0.04-0.16, $p < 0.001$), and among those aged less than 19 (OR:0.01, CI:0.00-0.02, $p < 0.001$) in their respective order were rather more related to the prevalence of the periodontal disease. As for the education level, elementary school graduates were 2.46 times higher than university graduates (OR:2.46, CI:1.80-3.36, $p < 0.001$), followed by the junior high school graduates (OR:1.84, CI:1.35-2.51, $p = 0.001$), and the high school graduates (OR: 1.29, CI: 1.03-1.62, $p = 0.026$) in their respective order, which were rather more related to the prevalence of the periodontal disease.

As a result of the classification and analysis by sex, among men, the prevalence of the periodontal disease was 2.42 times lower as 1st quantile of the vitamin A intake increased compared to the recommended amount (OR: 2.42, CI: 1.202-4.866, $p = 0.014$), and among women, as the vitamin E intake increased by 1st quantile, the prevalence of periodontal disease decreased 1.02 times (OR: 1.02, CI: 1.004-1.041, $p = 0.014$).

Table 3. Association between vitamin A and E and the periodontal diseases according to sex

Variables	Total (n = 4478)		Male (n = 2054)		Female (n = 2424)	
	OR (95% CI)	*p**	OR (95% CI)	*p**	OR (95% CI)	*p**
Sex						
Male	2.08 (1.59-2.71)	< 0.001				
Female	1.00					
Blood components						
Vitamin A	1.27 (0.73-2.21)	0.390	2.42 (1.20-4.87)	0.014	0.45 (0.18-1.10)	0.078
Vitamin E	1.02 (1.01-1.04)	0.011	1.02 (0.99-1.05)	0.144	1.02 (1.00-1.04)	0.014
Urea nitrogen	0.99 (0.96-1.01)	0.294	0.97 (0.94-1.01)	0.098	1.00 (0.96-1.03)	0.794
Creatinine	0.79 (0.42-1.48)	0.458	0.90 (0.35-2.36)	0.833	0.76 (0.30-1.89)	0.553
White blood cell	1.19 (1.12-1.27)	< 0.001	1.19 (1.08-1.30)	< 0.001	1.23 (1.13-1.33)	< 0.001
Red blood cells	0.94 (0.75-1.19)	0.608	1.05 (0.79-1.41)	0.736	0.72 (0.49-1.06)	0.095
Platelets	1.00 (1.00-1.00)	0.666	1.00 (1.00-1.00)	0.952	1.00 (1.00-1.00)	0.686
High sensitivity C-reaction protein	0.97 (0.93-1.02)	0.199	0.93 (0.87-0.99)	0.018	0.99 (0.93-1.05)	0.716
Uric acid	0.99 (0.91-1.08)	0.804	0.91 (0.82-1.00)	0.044	1.09 (0.95-1.25)	0.199
Folic acid	0.97 (0.95-1.00)	0.032	0.97 (0.93-1.01)	0.096	0.97 (0.94-1.01)	0.121

Variables	Total (n = 4478)		Male (n = 2054)		Female (n = 2424)	
	OR (95% CI)	*p**	OR (95% CI)	*p**	OR (95% CI)	*p**
Age						
≤ 19	0.01 (0.00-0.02)	< 0.001	0.00 (0.00-0.03)	< 0.001	0.02 (0.00-0.11)	< 0.001
20-29	0.08 (0.04-0.16)	< 0.001	0.06 (0.02-0.15)	< 0.001	0.14 (0.05-0.40)	0.001
30-39	0.20 (0.13-0.30)	< 0.001	0.18 (0.10-0.33)	< 0.001	0.19 (0.10-0.36)	< 0.001
40-49	0.43 (0.30-0.62)	< 0.001	0.58 (0.35-0.95)	0.032	0.30 (0.17-0.51)	< 0.001
50-59	0.81 (0.58-1.13)	0.212	0.66 (0.41-1.06)	0.087	0.95 (0.58-1.57)	0.842
60-69	0.76 (0.55-1.05)	0.097	0.59 (0.36-0.97)	0.036	0.97 (0.63-1.48)	0.871
≥ 70	1.00		1.00		1.00	
Region						
Seoul	0.78 (0.60-1.01)	0.063	0.75(0.54-1.03)	0.077	0.83 (0.58-1.18)	0.297
City	0.90 (0.70-1.17)	0.450	0.88(0.66-1.18)	0.392	0.94 (0.66-1.35)	0.742
etc.	1.00		1.00		1.00	
Income						
Low	1.05 (0.75-1.48)	0.769	1.17 (0.72-1.88)	0.529	1.00 (0.64-1.57)	0.994
Mid-low	1.07 (0.84-1.37)	0.570	1.17 (0.85-1.61)	0.351	1.02 (0.71-1.47)	0.916
Mid-high	0.95 (0.74-1.21)	0.656	0.99 (0.71-1.36)	0.927	0.95 (0.67-1.34)	0.759
High	1.00		1.00		1.00	
Education						
≤ elementary school	2.46 (1.80-3.36)	< 0.001	2.11 (1.33-3.33)	0.002	2.57 (1.62-4.09)	< 0.001
Middle school	1.84 (1.35-2.51)	0.001	2.39 (1.53-3.73)	0.001	1.47 (0.94-2.30)	0.090
High school	1.29 (1.03-1.62)	0.026	1.30 (1.97-1.75)	0.077	1.26 (0.88-1.81)	0.209
≥ University	1.00		1.00			
Marriage						
Married	1.23 (0.84-1.79)	0.283	1.08 (0.68-1.71)	0.741	2.57 (1.10-6.00)	0.030
Unmarried	1.00		1.00		1.00	
Subjective health						
Good	1.05 (0.78-1.40)	0.752	0.77 (0.52-1.16)	0.208	1.25 (0.86-1.83)	0.248
Average	1.05 (0.82-1.35)	0.700	0.71 (0.49-1.03)	0.068	1.39 (0.98-1.97)	0.065
Bad	1.00		1.00		1.00	

OR = adjusted odds ratios; CI = Confidence Interval; * By complex sample multiple logistic regression

4. Discussion

Various studies have been conducted on the association between the periodontal disease and nutritional condition, and it has been reported that the vitamins are closely related to the oral health by type (Kim et al., 2016; Kim & Hwang, 2018; Paek & Lee, 2010; Baek et al., 2009; Nishida et al., 2000; Tada & Miura, 2019; Dragonas et. al., 2020; Jagelavičienė et al., 2018). Vitamins A and E, which are known to be beneficial for their antioxidant role (Jeong et al., 2016) and the periodontal health recovery (Najeeb et al., 2016), are considered to be involved in the development of the periodontal disease.

Periodontal disease is caused by the bacterial infection and is an inflammatory disease. Once the loss of alveolar bone begins to progress, it is difficult to restore it to a healthy condition,

and in severe cases, it can even cause a loss of teeth, and hence, it is a severe oral disease (Kim, 2016). Various risk factors related to the periodontal disease have been reported, including diet, hormones, smoking, and genetics (Kim, 2016). Among which, nutrition is an essential factor for the growth and development of hard and soft tissues, as well as for maintaining the oral tissues healthy throughout life, and also affects the periodontal disease (Moon et al., 2020). Vitamin C affects the extracellular matrix and also plays a role in the immune and inflammatory response, thereby reducing the prevalence of the periodontal disease[21, 22], and it has been reported that vitamin D is related to the bone mineral density and chronic periodontitis (Tada & Miura , 2019).

In this study, the periodontal disease was more prevalent among men than women, and the incidence of the periodontal disease was higher among those of the lower educational levels, which was consistent with Paek et al.'s study (Paek et al., 2015). It is determined that this is the case since men are less interested in the oral health than women, and oral care is inadequate due to frequent drinking and smoking due to social life. Furthermore, the lower the level of education, the less knowledge about health and the lesser interest, and hence, the periodontal disease seems to occur more frequently.

As a result of analyzing the association between the vitamins A and E and the periodontal disease, as the intake of vitamin E increased by 1st quantile, the prevalence of the periodontal disease decreased by 1.02 times, and hence, there was a significant difference, yet vitamin A was not significant. In a similar study, Singh et al. (2014) claimed that the treatment results were better when the vitamin E supplements were used during the periodontal treatment for the patients with chronic periodontitis, which is supportive of the results of this study by claiming that vitamin E improves the periodontal treatment effect.

As a result of analyzing the association between the vitamins A and E and the periodontal disease by sex, the prevalence of the periodontal disease decreased 2.42 times among men as the vitamin A intake increased by 1st quantile compared to the recommended amount. While it is difficult to search a previous study targeting only men, Cheon & Jeong (2014) claimed that the lower the vitamin A intake, the higher the risk of periodontitis, whose results were similar. Among women, unlike men, as the vitamin E intake increased by 1st quantile, the prevalence of the periodontal disease decreased by 1.02 times. The studies involving only women are also difficult to find, yet similarly, O'Connor et al. (2020) claimed that the increased vitamin E intake was associated with a decrease in the periodontal disease in a study on the elderly.

As a result of analyzing the nutrient intake of the Koreans by the Ministry of Health and Welfare, it turned out that 74.7% of them consumed less than the average required amount of vitamin A (Ministry of Health and Welfare, 2020). Hence, it would be necessary to help reduce the occurrence of the periodontal disease by increasing the public service advertisements for the nutrients and actively encouraging hospitals and others to promote the vitamin intakes. In particular, since men have many risk factors related to the oral diseases such as smoking, drinking, and poor oral hygiene (Kim & Lee, 2017), the adequate intake of vitamin A while reducing the risk factors will be helpful for the oral health, and as for women, it would be important to take the adequate vitamin E together with the oral care.

In summary, this study confirmed that the association between the vitamins and the periodontal health was related to vitamin A among men, and vitamin E among women. This study is significant in that the reliability of the analysis data was high using the large scaled KNHANES data, and

that there was a significant gender difference in the association between the vitamins A and E and the periodontal disease. However, there is a limitation in that the subjects' oral health condition and oral health behavior, which can act as the variables of confusion, are omitted among the measurement variables. Furthermore, since the data used for this study are the cross-sectional findings and as the temporal changes cannot be measured, it has been presented that a longitudinal study is needed to identify the changes in the related factors affecting periodontal disease. Furthermore, in the future studies, it would be necessary to investigate the oral health condition and oral health behavior of the subjects as the control variables to examine and understand the association between the vitamins A and E and the oral health.

5. Conclusions

The nutrient intake is very important for maintaining the periodontal health. This study analyzed the data of the 7th period (2016-2018) of the Korea National Health and Nutrition Examination Survey to examine and understand the association between the vitamin A and E intake and the prevalence of the periodontal disease among the Koreans, and acquired the following main results.

1. As a result of examining the association between the prevalence of the periodontal disease and the vitamins A and E among all participants, the prevalence of the periodontal disease decreased 1.02 times as 1st quantile of the vitamin E intake increased compared to the recommended amount (CI: 1.005-1.036, p = 0.011).

2. As a result of the analysis following sex classification, the prevalence of the periodontal disease decreased 2.42 times as the vitamin A intake increased by 1st quantile compared to the recommended amount among men (CI: 1.202-4.866, p = 0.014), and as for women, the vitamin E intake decreased 1.02 times for the prevalence of the periodontal disease as 1st quantile increased (CI: 1.004-1.041, p = 0.014).

Based on the results above, the vitamins A and E and the periodontal disease turned out to be closely related. Hence, it is presented that a vitamin intake promotion strategy is needed to help reduce the prevalence of the periodontal disease.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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