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The relationship between depression and periodontal diseases

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Objective: A cross-sectional study was conducted to investigate whether depression is associated with periodontal diseases in a representative sample of South Korean adults ***Methods:*** We used data from the sixth Korea National Health and Nutrition Examination Survey (KNHANES VI), conducted in 2014. We included in this study 4328 participants aged over 20 years (1768 males and 2560 females). Depression was assessed with the Patient Health Questionnaire (PHQ-9) and history of physician-diagnosed depression. Periodontal diseases were assessed a gingival bleeding, calculus and periodontal pockets. The data were analyzed using the chi-square test and multiple logistic regression. ***Results:*** People with any periodontal diseases tended to be old, male, married, low income, poor education, blue-collar occupation, diabetes mellitus, hypertension, overweight, smoking, not using dental floss or interdental brush in univariate analysis. Neither self-reported nor diagnosed depression was associated with the presence of any or severe periodontal disease in the total sample. In participants aged 20-29 years only, the presence of any periodontal disease was associated with self-reported depression (OR, 2.031; 95% CI, 1.011-4.078). In the same age group, the presence of severe periodontal disease was associated with both self-reported depression (OR, 6.532; 95% CI, 2.190-19.483) and diagnosed depression (OR, 7.729; 95% CI, 1.966-30.389). ***Conclusion:*** Self-reported depression was significantly associated with the presence of any or severe periodontal disease, and diagnosed depression was significantly associated with severe periodontal diseases only in participants aged 20-29 years.

Keywords: *Depression, periodontal diseases, age groups*

Introduction

Periodontal disease is a diverse group of inflammatory diseases that can affect the periodontium at any age. Symptoms include the progressive destruction of the periodontal ligament and alveolar bone with pocket formation, gingival recession or both (Ababneh *et al*., 2010). Risks for periodontal diseases range from microbial and environmental to behavioral and systemic disease factors, in addition to the individual's genetic makeup (Nunn, 2000). The literature consistently shows that smoking, non-controlled diabetes, and infection with specific periodontal pathogens increase the risk for periodontal diseases (Pihlstrom *et al*., 2005). Psychological factors such as depression are not confirmed as risk factors.

Evidence for an association between depression and periodontal diseases is contradictory. Some studies showed a positive association (Genco *et al*., 1999; Johannsen *et al*., 2007; Ng and Keung, 2006; Rosania *et al*., 2009), but other studies did not (Ababneh *et al*., 2010; Castro, *et al*., 2006; Khambaty and Stewart, 2013; Solis *et al*., 2014). A systematic review and meta-analysis of 15 selected studies showed only six with a positive association. This study failed to confirm an association between depression and periodontal disease and suggested future studies with different designs in distinct populations should be conducted to investigate this association (Araújo, *et al*., 2016).

Previous cross-sectional studies were at risk of bias in sample selection. Most used convenience samples from hospitals, groups of specific age, advertisement recruitment, and neighborhood samples (Ababneh *et al*., 2010; Mendes *et al*., 2010; Ng and Keung, 2006; Persson *et al*., 2003; Rosania *et al*., 2009). Studies using a representative sample of the general adult population are very rare. The field of psychiatric epidemiology continues to employ self-report instruments, but weak agreement between diagnoses achieved using these instruments compared to those achieved by physicians continues to threaten the credibility of estimates of prevalence of specific disorders such as depression. Thus, when evaluating depression in epidemiologic studies, it may be worth using both assessments (Eaton *et al*., 2000).

Age is strongly related to the prevalence of both depression and periodontal diseases (Abdellatif *et al*., 1987;Kessle *et al*., 2013).Previous studies have lacked age-stratified analyses to investigate any association between depression and periodontal disease

Hence, we investigated the association between depression and periodontal diseases according to age groups in Korean adults using a representative sample of Koreans from the Sixth Korean National Health and Nutrition Examination Survey (KNHANES VI).

Methods

Study population

The Korean National Health and Nutrition Examination Survey (KNHANES) is a series of cross-sectional surveys of nationally representative samples of the civilian Korean population that are conducted annually to assess the health and nutrition status of the South Korean population. We used data from KNHANES VI, which was conducted in 2014.

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KNHANES is a nationwide survey drawn from different census populations and housing units that samples using clustered weights on subgroups to ensure representation of each cluster. The survey is carried out by the Centers of Disease Control (CDC) of Korea to obtain statistically reliable and representative data on the health, food, and lifestyles of the Korean population.

KNHANES VI was approved by the Institutional Review Board for Human Subjects of the Korea CDC (2014-12EXP-03-5C). The KNHANES data are open access. For this study, we selected participants over 20 years of age who had oral health examinations (n=5,897), and from those, only dentate adults over 20 years of age with information on both depression and periodontal disease, leaving a final sample of 4,328 participants (1,768 males and 2,560 females).

Depression

Self-report depression was measured with the Patient Health Questionnaire (PHQ-9), which quantifies the frequency of a positive response to each of the nine diagnostic criteria of major depression over the past two weeks. Responses are summed to create a score between 0 and 27 points. A PHQ-9 sum score of ≥10 defined a case of depression, yielding a sensitivity of 81% and a specificity of 82% for any depressive disorder (Löwe *et al*., 2004).

Diagnosed depression was assessed by a trained interviewer asking participants "Have you ever been diagnosed by a physician as having depression?" Emphasis was placed on the phrase ''by a physician" (Ahn *et al*., 2014). The possible responses to the question about a previous diagnosis were "No" or "Yes".

Periodontal Diseases

Standardized dental examinations were conducted by trained dentists. Three indicators of periodontal status were used for this assessment, gingival bleeding, calculus and periodontal pockets. A specially designed lightweight community periodontal index (CPI) probe with a 0.5-mm ball tip was used, with a black band between 3.5 and 5.5mm and rings at 8.5 and11.5 mm from the ball tip. The mouth was divided into sextants defined by tooth numbers: 18-14, 13-23, 24-28, 38-34, 33-43 and 44-48. A sextant was examined only if there were two or more teeth present that were not indicated for extraction (WHO, 1997).

Periodontal health was recorded as:

0 - Healthy.

1 - Bleeding observed, directly or by using a mouth mirror, after probing.

2 - Calculus detected during probing, but the entire black band on the probe visible.

3 - Pocket 4-5 mm (gingival margin within the black band on the probe).

4 - Pocket 6 mm or more (black band on the probe not visible).

Periodontal disease was defined by a score over 1, and severe periodontal disease by a score over 3 (WHO, 1997).

Other factors

The following variables were included in our analyses: age, sex, marital status, income, education level, occupation, diabetes, hypertension, stroke, myocardial infarction (MI) or angina, weight, smoking, alcohol, use of dental floss or interdental brush.

Trained interviewers asked participants for a history of systemic diseases. For example, "To date, have you ever been diagnosed by a physician as having diabetes?" Emphasis was placed on the phrase ''by a physician". This phrasing was used for diabetes, stroke, MI or angina, hypertension and data were recorded as yes or no. Weight was divided into three groups by body mass index: underweight (<18.5kg/m^2), normal, overweight (≥25kg/m^2).Occupations were classified into 10 types according to the Korean standard occupational classification, but dichotomized (White collar and Blue collar) for analysis. Income was classified into quartiles. Tooth brushing and other oral hygiene activities (dental floss or interdental brush) were affected by multi-collinearity and tooth brushing was excluded from the variables.

Statistical analysis

We performed chi-square tests to compare differences in periodontal diseases associated with general characteristics. Following the initial analysis, we used multiple logistic regression model to assess the association between depression and the presence of any periodontal disease and of severe periodontal disease adjusting for potential confounders in age stratified groups.

Univariate analyses (chi-square tests) were performed for each age group to identify potential confounders in each age group. Significant variables in the univariate analysis of each age group were defined as the potential confounders of age groups, respectively.

We used SPSS for Windows (version 19.0; SPSS Inc., an IBM company, Chicago, IL, USA) for all analyses. We rejected null hypotheses of no difference if p-values were less than .05, or, equivalently, if the 95% CIs of odds ratio estimates excluded 1.

Results

The characteristics of the sample in relation to the outcomes are shown in Table 1. Ages ranged from 20 to 95 years, with a mean age of 50.84.

People with any periodontal disease tended to be old, male, married, of low income, of lower education, in blue-collar occupations, have diabetes mellitus, have hypertension, to be overweight, to smoke and not use dental floss or interdental brushes. The presence of severe periodontal diseases was associated with all the above categories and with having had a stroke, MI or angina, and not abusing alcohol.

Table 2 shows that neither self-reported nor diagnosed depression were associated with the presence of any or severe periodontal disease. Among participants aged 20-29 only, self-reported depression was associated with the presence of any periodontal disease, and diagnosed depression was associated with the presence of any and severe periodontal disease.

Table 3 shows the odds ratios (95% confidence interval, CI) from the multiple logistic regression analyses of the association between depression and periodontal diseases by age group. Before performing multiple logistic regression analyses, univariate analyses (chi-square tests) were performed for each age group to identify potential confounders.

Table 1. General characteristics and the presence of any and severe Periodontal diseases

	Any Periodontal Disease Present		*Severe Periodontal Disease Present*	
	n (%)	*P (Chi sq.)*	*n (%)*	*P (Chi sq.)*
Age				
≤29	252 (54.4)		17 (3.7)	
30 - 39	527 (66.8)		124(15.7)	
40 - 49	554 (71.3)		217(27.9)	
50 - 59	700 (80.5)		373(42.9)	
≥60	1077 (75.4)	0.000	653(45.7)	0.000
Sex				
Male	1375 (77.8)		718(40.6)	
Female	1735 (67.8)	0.000	666(26.0)	0.000
Marital status				
Married	2747 (74.0)		1320(35.6)	
Single	363 (58.8)	0.000	64(10.4)	0.000
Income				
Low	759 (76.1)		344(34.5)	
Lower middle	825 (75.1)		370(33.7)	
Upper middle	769 (68.6)		324(28.9)	
Upper	747 (68.1)	0.000	341(31.1)	0.023
Education				
≤Elementary	761 (77.3)		450(45.7)	
Middle school	385 (82.4)		202(43.3)	
High school	1027 (72.1)		422(29.6)	
≥College	935 (64.5)	0.000	309(21.3)	0.000
Occupation				
White collar	666 (66.8)		233(23.4)	
Blue collar	1199 (77.8)		589(38.2)	
Unemployed	1243 (69.6)	0.000	562(31.5)	0.000
Diabetes				
No	2820 (71.1)		1192(30.1)	
Yes	290 (79.9)	0.000	192(52.9)	0.000
Hypertension				
No	2387 (70.6)		953(28.2)	
Yes	723 (76.4)	0.000	431(45.6)	0.000
Stroke				
No	3033 (71.7)		1343(31.8)	
Yes	77 (77.0)	0.247	41(41.0)	0.050
MI or Angina				
No	3030 (71.7)		1334(31.6)	
Yes	80 (78.4)	0.135	50(49.0)	0.000
Weight				
Underweight	110 (58.2)		32(16.9)	
Normal	1921 (69.8)		811(29.5)	
Obese	1060 (77.9)	0.000	538(39.6)	0.000
Smoking				
No	1796 (67.4)		690(25.9)	
Yes	1280 (79.1)	0.000	672(41.5)	0.000
Alcohol				
No	395 (75.0)		195(37.0)	
Yes	2686 (71.4)	0.088	1169(31.1)	0.006
Dental floss or Interdental brush				
No	2068 (75.1)		1016(36.9)	
Yes	1008 (65.8)	0.000	345(22.5)	0.000

Table 2. Depression and the presence of any and severe periodontal by age

Age Groups		Any periodontal disease		Severe periodontal disease	
		n (%)	*P*	*n (%)*	*P*
All	*Self-report depression*				
	No	2889 (71.7)		1296 (32.2)	
	Yes	221 (74.4)	0.311	88 (29.6)	0.369
	Diagnosed depression				
	No	2951 (72.0)		1311 (32.0)	
	Yes	159 (69.1)	0.345	73 (31.7)	0.936
≤29y	*Self-report depression*				
	No	222 (53.0)		11 (2.6)	
	Yes	30 (68.2)	0.054	6 (13.6)	0.000
	Diagnosed depression				
	No	240 (53.8)		13 (2.9)	
	Yes	12 (70.6)	0.173	4 (23.5)	0.000
30-39y	*Self-report depression*				
	No	496 (66.9)		119 (16.1)	
	Yes	31 (64.6)	0.737	5 (10.4)	0.298
	Diagnosed depression				
	No	509 (66.9)		118 (15.5)	
	Yes	18 (64.3)	0.774	6 (21.4)	0.398
40-49y	*Self-report depression*				
	No	531 (71.3)		213 (28.6)	
	Yes	23 (71.9)	0.941	4 (12.5)	0.047
	Diagnosed depression				
	No	535 (71.7)		213 (28.6)	
	Yes	19 (61.3)	0.209	4 (12.9)	0.057
59-59y	*Self-report depression*				
	No	654 (80.0)		354 (43.3)	
	Yes	46 (86.8)	0.230	19 (35.8)	0.286
	Diagnosed depression				
	No	654 (80.7)		351 (43.3)	
	Yes	46 (76.7)	0.443	22 (36.7)	0.314
≥60y	*Self-report depression*				
	No	986 (75.3)		599 (45.8)	
	Yes	91 (75.8)	0.901	54 (45.0)	0.873
	Diagnosed depression				
	No	1013 (75.9)		616 (46.1)	
	Yes	64 (68.1)	0.090	37 (39.4)	0.202

Univariate analyse for each age group are not presented in the table. For example, in 20 univariate analyzes, sex, marital status, education, weight, and smoking were associated with total periodontal diseases, and education and weight were statistically significantly associated with severe periodontal diseases.

After adjusting for all confounders, neither self-reported nor diagnosed depression was associated with the presence of any or severe periodontal disease in the total sample. In participants aged 20-29 years only, the presence of any periodontal disease was associated with self-reported depression (OR, 2.031; 95% CI, 1.011-4.078). In the same age group, the presence of severe periodontal disease was associated with both self-reported depression (OR, 6.532; 95% CI, 2.190-19.483) and diagnosed depression (OR, 7.729; 95% CI, 1.966-30.389).

Discussion

This large, representative sample-based survey that adjusted for confounding factors showed that depression was strongly associated with the presence of periodontal diseases only in participants aged 20-29.

Depression may only have been associated with the presence of periodontal diseases in participants in their twenties because the age of onset for depression is usually in the early to mid 20s (Kessle *et al*., 2013). Since the physical risk factors (e.g. diabetes) for periodontal disease are uncommon at this age, the effect of psychological factors such as depression in the occurrence of periodontal disease may have been more evident. In the present study, the univariate analyses of risk factors for periodontal disease found many variables including diabetes were found to be associated with the presence periodontal diseases in the total sample,

Table 3. Odds ratios and confidence intervals for the presence of any or presence severe periodontal disease by age group

Age groups		Any Periodontal Disease				Severe Periodontal Disease			
		CrudeOR	95%CI	Adjusted OR[a]	95%CI	Crude OR	95%CI	Adjusted OR[b]	95%CI
All	*Self-report depression*								
	no	1		1		1		1	
	yes	1.149	0.878-1.505	1.213	0.910-1.618	0.889	0.687-1.150	0.893	0.667-1.196
	Diagnosed depression								
	no	1		1			1	1	
	yes	0.870	0.653-1.161	0.815	0.601-1.106	0.988	0.743-1.315	0.960	0.705-1.308
≤29y	*Self-report depression*								
	no	1		1		1		1	
	yes	1.902	0.980-3.689	2.031	1.011-4.078	5.856	2.052-16.716	6.532	2.190-19.483
	Diagnosed depression								
	no	1		1		1		1	
	yes	2.060	0.714-5.944	1.594	0.518-4.901	10.294	2.939-36.738	7.729	1.966-30.389
30-39y	*Self-report depression*								
	no	1		1		1		1	
	yes	0.901	0.489-1.659	0.840	0.440-1.604	0.608	0.236-1.566	0.527	0.199-1.395
	Diagnosed depression								
	no	1		1		1		1	
	yes	0.891	0.405-1.959	0.831	0.365-1.888	1.486	0.590-3.743	1.567	0.602-4.079
40-49y	*Self-report depression*								
	no	1		1		1		1	
	yes	0.971	0.442-2..133	1.071	0.473-2.422	0.357	0.124-1.029	0.392	0.129-1.192
	Diagnosed depression								
	no	1		1		1		1	
	yes	0.624	0.298-1.309	0.725	0.336-1.565	0.371	0.128-1.072	0.606	0.203-1.812
50-59y	*Self-report depression*								
	no	1		1		1		1	
	yes	1.638	0.726-3.694	1.574	0.669-3.704	0.731	0.410-1.303	0.781	0.419-1.456
	Diagnosed depression								
	no	1		1		1		1	
	yes	0.784	0.420-1.462	0.589	0.324-1.072	0.757	0.440-1.303	0.704	0.441-1.125
≥60y	*Self-report depression*								
	no	1		1		1		1	
	yes	1.028	0.664-1.590	1.036	0.657-1.633	0.970	0.666-1.412	0.985	0.664-1.460
	Diagnosed depression								
	no	1		1		1		1	
	yes	0.678	0.432-1.065	0.702	0.443-1.113	0.758	0.494-1.162	0.917	0.649-1.296

a: total; adjusted by age, sex, marital status, income, education, occupation, diabetes, hypertension, MI or angina, weight, smoking, dental floss or interdental brush
≤29; adjusted by sex, marital status, education, weight, smoking
30-39; adjusted by sex education, occupation, smoking, dental floss or interdental brush
40-49; adjusted by sex occupation, weight, smoking, dental floss or interdental brush
50-59; adjusted by sex, income, education, weight, smoking, dental floss or interdental brush
≥60; adjusted by income, occupation, smoking
b: total; adjusted by age, sex, marital status, income, education, occupation, diabetes, hypertension, MI or angina, weight, smoking, dental floss or interdental brush, stroke, alcohol
≤29; adjusted by education, weight
30-39; adjusted by sex education, diabetes, smoking
40-49; adjusted by sex, occupation, diabetes, hypertension, weight, smoking, dental floss or interdental brush
50-59; adjusted by sex, occupation,weight, smoking, alcohol
≥60; adjusted by sex, diabetes, smoking, dental floss or interdental brush

but in the 20-29 year olds, sex, marital status, education, weight, and smoking were related to the presence of any periodontal disease, and education and weight were related to the presence of severe periodontal disease. It may be that risk factors for periodontal disease are age-specific.

However, it is not clear how severe periodontal disease, which is irreversible, should be more common among people with depression at this young age, but no more common amongst older people with depression. An alternative explanation is that the associations for this age group arise from Type 1 error. This might be due to a small number of people with depression in this age group having severe periodontal disease, but who would have been present in the 'any periodontal disease' category.

Depression-associated periodontal disease may be related to psychoneuroimmunologic changes, at-risk health behavior, or a combination of both (Rosania *et al*., 2015). Depression has been hypothesized to reduce immune responsiveness, resulting in higher rates of infection with pathogenic organisms and a greater degree of periodontal destruction (Araújo *et al*., 2016). Depression can mediate risk for periodontal diseases through changes in health-related behaviors, such as oral hygiene, smoking, and diet (Aleksejunñiené *et al.,* 2002; Araújo *et al*., 2016).

Although lacking age-stratified analysis, other studies have also used large population-based samples. Khambaty and Stewart (2013) and Delgado-Angulo *et al.,* (2013) did not find depression to be associated with periodontal diseases.

Khambaty and Stewart studied 1979 American adults aged between 20 and 39 years old. Parameters for the diagnosis of periodontal disease were probing depth and clinical attachment level (CAL). They found no association between having a major depressive disorder and periodontal diseases. Delgado-Angulo *et al*., studied 4673 adults over the age of 30 and found depression and periodontal pocketing to be unrelated.

In contrast, Ng and Keung (2006) and Gengo *et al*., (1999) reported significant relationships between depression and periodontal disease. Ng and Keung studied 1000 Chinese adults aged 25 to 64 years and found CAL was to be associated with both a Symptom Checklist 90 and depression traits. Genco *et al.,* investigated 1426 American adults aged between 25 and 74 years old using the depression subscales (6 items) of the Symptom Checklist 90-revised (SCL-90-R). Parameters for the diagnosis of periodontal disease were supragingival plaque, bleeding on probing, probing depth, subgingival calculus and clinical attachment loss (CAL). More severe CAL was associated with depression (Genco *et al*., 1999).

There are several differences between other studies and ours. Different age groups were included in the sample with consequent differences in the prevalence of depression and periodontal diseases. The instruments used to assess depression and periodontal diseases differed. We also included potential confounders to account for them in the analysis.

The strengths of the present study include the age stratified analysis, which is important because age is associated with both periodontal disease and depression. We also used a representative large sample and assessed depression with both a questionnaire and a physician diagnosis.

This study is the first to evaluate the correlation between depression and periodontal diseases using a large representative sample according to age groups. It showed no significant association between depression and periodontal diseases in the total sample, including all age groups. However, age stratified analysis revealed self-reported depression was associated with any periodontal disease and with severe periodontal disease, and diagnosed depression was significantly associated with severe periodontal diseases among participants in their twenties.

This study has some limitations that need to be addressed. The methods used to diagnose periodontal disease were limited as they rely mainly on periodontal pocket depth and excluded clinical attachment loss, which could underestimate the severity of the disease. Diagnosed depression was assessed by asking questions to participants, which could underestimate the prevalence of the disease. Because this is a cross-sectional study, causal relationships cannot be identified. Some studies have suggested that periodontitis increases the risk of subsequent depression (Hsu *et al,* 2015). Further studies should be performed to confirm and generalize these results.

Conclusions

Neither self-reported nor diagnosed depression was associated with the presence of any periodontal disease or severe periodontal disease in the total sample. In participants aged 20-29 years only, self-reported depression was significantly associated with the presence of periodontal disease, and diagnosed depression was significantly associated with the presence of any and severe periodontal disease.

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