Obesity in relation to oral health behaviors: An analysis of the Korea National Health and Nutrition Examination Survey 2008-2010

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Abstract. Obesity is reported to be associated with an increased incidence and prevalence of periodontal disease. The present study aimed to evaluate the relationship between oral health behaviors and obesity in South Korean adults. Data from the Korea National Health and Nutrition Examination Survey between 2008 and 2010 was used to assess this and a total of 15,666 participants were included in the analysis performed. Oral behaviors, including the time of day and rate of tooth brushing, and usage of secondary oral products, were considered in this analysis. Obesity was defined using the following three methods: Body mass index, waist circumference and percentage body fat (PBF). Hierarchical multivariable logistic regression analyses were performed to determine the association of oral health behavior with obesity after adjusting for possible confounding variables. The frequency of daily tooth brushing and usage of secondary oral products was lower in individuals with obesity, irrespective of the method used to define obesity. Conversely, the risk of general obesity, abdominal obesity and high PBF was higher in individuals with a lower daily frequency of tooth brushing and usage of secondary oral products.

Introduction

With its growing prevalence, obesity is emerging as a serious health issue worldwide (1). Obesity has been documented as a risk factor for a number of systemic disorders with an inflammatory background (2). In addition, obesity has been reported to be associated with an increased incidence and prevalence of periodontal disease in adults (3). A longitudinal study in Japan identified a positive correlation between body mass index (BMI) and 5-year incidence of periodontal disease (4).

Obesity is typically associated with unhealthy lifestyle behaviors, such as a high-calorie diet and low physical activity, and the modification of these behaviors is essential to prevent obesity (5). In addition, it has been reported that oral health behaviors are associated with general health-related behaviors, in particular, the frequency of tooth brushing is an indicator of general health-related behaviors (6). Furthermore, previous studies have shown that a lower frequency of tooth brushing is associated with cardiovascular disease risk factors, including metabolic syndrome (7,8).

However, there is limited information available regarding the association of oral health behaviors and obesity in the South Korean population. In addition, the aforementioned studies used BMI or waist circumference (WC) as indicators of cardiovascular risk (including obesity). Although these are popular measurements for evaluation of obesity, they may not accurately correspond to the degree of adiposity. A direct measurement of adiposity, such as percentage of body fat (PBF) may be a better indicator of obesity in relation to cardiometabolic changes (9). Thus, the present study aimed to assess the relationship between oral health behaviors and obesity, as defined by BMI, WC or PBF, in South Korean adults using nationally representative data.

Materials and methods

Source of data analyzed. This study retrospectively analyzed on data obtained from the Korea National Health and Nutrition Examination Surveys [KNHANES; Korea Centers for Disease Control and Prevention (KCDC), Cheongju, Korea; and the Korean Ministry of Health and Welfare, Sejong, Korea] between 2008 and 2010 (10). The KNHANES is a nation-wide survey of non-institutionalized civilians that uses a stratified and multi-stage probability sampling design,

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and a rolling survey-sampling model (11). Sampling units are based on population and housing from the 2005 National Census Registry in Korea, which records the age, gender and geographic of the population. Initially, 20,730 participants ≥19 years old were targeted for the survey, and finally, a total of 15,666 individuals (6,744 males and 8,922 females aged 19-92) with complete data, including socio-demographic and lifestyle characteristics, oral health behaviors, periodontitis and anthropometric measurements, were included in the present analyses. All participants in the survey signed an informed consent form prior to participation. This survey was reviewed and approved by the Institutional Review Board of the KCDC.

Socio-demographic and lifestyle characteristics of participants. All participants were asked about their socio-demographic status and lifestyle by trained interviewers. Educational level was classified as a high school diploma or higher, or under a high school diploma. Monthly household income was divided into quartiles following adjustment for the number of family members. Participants were categorized based on the quantity of alcohol consumed (per day for a month prior to the interview) into the following three groups: Non-drinker, light to moderate drinker (1-30 g/day) and heavy drinker (≥30 g/day) (12). Smoking status of participants was categorized into the following three groups in accordance with respondents' answers on a self-report questionnaire: Non-smokers (those who had never smoked or had smoked <100 cigarettes in their lifetime), ex-smokers (those who had smoked ≥100 cigarettes in the past) and current smokers (those smoking currently and who had smoked ≥100 cigarettes). Based upon responses to a modified form of the International Physical Activity Questionnaire for Koreans (13), individuals were regarded as regular physical exercisers if they performed moderate exercise ≥5 times per week for ≥30 min per session or vigorous exercise ≥3 times per week for ≥20 min per session (14). Daily food intake over 24 h was assessed using the 24-h recall method and a food frequency questionnaire (15). This was used to calculate the caloric and fat intake of participants using a food database developed for the KNHANES (13) and the food composition table published by the National Rural Living Science Institute under the Rural Development Administration (Suwon, Korea) (10).

Measuring and defining obesity. General obesity, abdominal obesity and high PBF. A trained staff member performed anthropometric measurements. Body weight and height were measured to the nearest 0.1 kg and 0.1 cm, respectively, with participants in light indoor clothing without shoes. BMI was calculated as body weight (kg) divided by height squared (m^2). WC was measured at the narrowest point between the lower border of the rib cage and the iliac crest in a standing position. A BMI ≥25 kg/m^2 was defined as general obesity (16), and abdominal obesity was defined as a WC ≥90 cm in men or ≥85 cm in women (17). Total body fat mass (g) and lean mass (g) were measured using whole-body dual-energy X-ray absorptiometry (DEXA; QDR-4500A fan-beam densitometer; Hologic, Inc., Bedford, MA, USA) performed by qualified technicians according to the manufacturer's instructions. Results were analyzed with industry standard techniques outlined by the Korean Society of Osteoporosis using Hologic Discovery Software (version 13.1; Hologic, Inc.). Total PBF was calculated as total body fat mass / total body mass x 100 (%), and total body mass (g) was calculated as the sum of fat mass, lean mass and total body mineral content (g). Participants defined as having a high PBF were those whose PBF was in the highest quartile of individuals in the current study.

Oral health behaviors and periodontitis. The number of times (frequency) and the time of day when tooth brushing was performed, and the use of secondary oral products were recorded based upon responses to the questionnaire (13). Time of day was categorized as prior to or following breakfast, after lunch and dinner, or prior to bedtime. Secondary oral products included the following: dental floss, mouthwash, interdental brushes and electric toothbrushes.

The World Health Organization (WHO) community periodontal index (CPI) was used to assess periodontitis, defined as CPI ≥code 3 (18-21). A code 3 CPI score indicates that there is ≥1 periodontal pocket of >3.5 mm in 11, 16, 17, 26, 27, 31, 36, 37, 46 and 47 teeth, according to the Federation Dentaire Internationale system (22,23). Participant's mouths were divided into sextants and a trained dentist used a CPI probe (Osung MND Co., Ltd., Seoul, Korea) with a 0.5 mm ball tip that met WHO guidelines (21) was used to measure CPI scores at a probing force of ~20 g. Training was provided to minimize errors in the measurement of periodontal pocket depth by each examiner during the examination. Participant's mouths were divided into sextants, where a sextant was examined if there were ≥2 teeth present that were not scheduled for extraction. If no index teeth were present in the sextant qualifying for examination, all remaining teeth were examined and the highest score was recorded as the score for that sextant. In the 2008, 2009 and 2010 KNHANES, 24, 29 and 36 trained dentists examined the periodontal status of participants, respectively, and this data was used for the present secondary analysis.

Statistical analysis. Results are presented as the mean ± standard error or as a percentage. A chi-squared test was applied to the data acquired to examine the relationship between the time of day of tooth brushing, frequency of tooth brushing, or usage of secondary oral products and obesity. Independent t-test was used for continuous variables. A multivariate logistic regression analysis was performed to estimate the odds ratios (ORs) and 95% confidence intervals (CIs) of obesity according to the frequency of tooth brushing per day and what secondary oral products were used. Variables were adjusted for multivariate logistic regression analysis as follows: Model 1 was adjusted for age and sex; model 2 was adjusted for the same as model 1, plus alcohol drinking, smoking status, physical activity, education level and monthly household income level; and model 3 was adjusted for the same variables as model 2, plus daily total energy intake, fat intake per day and periodontitis (CPI ≥3). Statistical analysis was performed using statistical analysis software (version 9.2; SAS Institute, Inc., Cary, NC, USA), using survey sampling and analysis procedures to account for the complex sampling design. $P<0.05$ was considered to indicate a statistically significant difference.

Table I. Characteristics of study participants according to their obesity status.

Characteristic	General obesity status			Abdominal obesity status			High body fat percentage status		
	No	Yes	P-value	No	Yes	P-value	No	Yes	P-value
No. of people (unweighted)	10,720	4946	<0.001	10,143	5523	<0.001	11,750	3916	<0.001
Age (years)	43.1±0.3	46.5±0.3	<0.001	41.4±0.3	50.2±0.3	<0.001	43.4±0.3	46.3±0.4	<0.001
No. of males	46.3 (0.5)	57.7 (0.8)	<0.001	55.2 (0.5)	38.5 (0.8)	<0.001	49.8 (0.5)	50.3 (0.9)	0.641
No. of females	53.7 (0.5)	42.3 (0.8)	<0.001	44.8 (0.5)	61.5 (0.8)	<0.001	50.2 (0.5)	49.7 (0.9)	0.641
BMI (kg/m^2)	21.8±0.0	27.5±0.0	<0.001	22.1±0.0	26.8±0.1	<0.001	22.7±0.0	26.4±0.1	<0.001
WC (cm)	76.2±0.1	90.5±0.2	<0.001	76.1±0.1	90.7±0.1	<0.001	78.2±0.1	88.3±0.3	<0.001
PBF (%)	26.0±0.1	30.6±0.2	<0.001	25.1±0.1	32.6±0.1	<0.001	25.2±0.1	34.3±0.1	<0.001
Education (beyond high school)	73.6 (0.8)	66.3 (0.9)	<0.001	78.4 (0.7)	56.1 (1.0)	<0.001	72.7 (0.8)	67.3 (1.1)	<0.001
Household income (lowest quartile)	15.0 (0.6)	16.8 (0.8)	0.017	13.7 (0.6)	19.7 (0.8)	<0.001	14.8 (0.6)	18.0 (0.9)	<0.001
Alcohol consumption			<0.001[a]			<0.001[a]			<0.001[a]
Non drinker	22.5 (0.5)	23.0 (0.7)		19.8 (0.5)	28.9 (0.8)		21.7 (0.5)	25.6 (0.9)	
Light-moderate	60.3 (0.6)	54.4 (0.8)		60.6 (0.6)	53.8 (0.9)		59.0 (0.6)	56.7 (1.0)	
Heavy	17.3 (0.5)	22.6 (0.8)		19.7 (0.5)	17.3 (0.7)		19.3 (0.5)	17.7 (0.8)	
Smoking status			<0.001			<0.001			0.004
Non-smoker	58.4 (0.6)	51.2 (0.8)		53.1 (0.6)	62.8 (0.8)		55.9 (0.5)	57.0 (0.9)	
Ex-smoker	15.6 (0.4)	19.5 (0.7)		17.3 (0.4)	15.8 (0.6)		16.3 (0.4)	18.2 (0.8)	
Current smoker	26.0 (0.5)	29.3 (0.8)		29.6 (0.6)	21.4 (0.7)		27.8 (0.5)	24.8 (0.9)	
Physical active regularly	24.6 (0.6)	27.8 (0.9)	<0.001	26.1 (0.6)	24.6 (0.8)	0.073	26.5 (0.6)	22.7 (0.9)	<0.001
Energy intake (kcal/day)	1989.7±12.7	2098.3±21.5	<0.001	2072.0±13.6	1920.0±17.8	<0.001	2054.5±13.2	1933.2±20.0	<0.001
Fat intake/day (%)	18.2±0.1	17.7±0.2	0.023	18.8±0.1	16.3±0.2	<0.001	18.1±0.1	17.8±0.2	0.118
Periodontitis	26.8 (0.8)	34.0 (1.1)	<0.001	25.9 (0.8)	35.8 (1.1)	<0.001	28.5 (0.8)	30.8 (1.1)	0.032
Dental checkup in <year	25.3 (0.7)	23.4 (1.0)	0.054	26.2 (0.7)	21.4 (0.9)	<0.001	25.4 (0.8)	23.6 (1.2)	0.113
Experience of caries in permanent teeth	90.9 (0.4)	89.0 (0.6)	0.003	90.0 (0.4)	91.0 (0.5)	0.110	90.7 (0.4)	89.2 (0.7)	0.037
Chewing discomfort			0.006[a]			<0.001[a]			0.419[a]
Great discomfort	5.0 (0.2)	5.9 (0.4)		4.3 (0.2)	7.4 (0.4)		5.3 (0.3)	5.3 (0.4)	
Discomfort	20.2 (0.5)	22.6 (0.7)		19.2 (0.5)	24.8 (0.7)		21.0 (0.5)	20.8 (0.8)	

Table I. Continued.

Characteristic	General obesity status			Abdominal obesity status			High body fat percentage status		
	No	Yes	P-value	No	Yes	P-value	No	Yes	P-value
Minor problem	16.3 (0.5)	15.1 (0.7)		16.3 (0.5)	15.1 (0.6)		16.1 (0.5)	15.3 (0.8)	
Minimal problem	26.4 (0.8)	25.6 (1.0)		27.1 (0.8)	24.3 (0.9)		26.4 (0.8)	25.4 (1.3)	
No discomfort	32.0 (0.9)	30.8 (1.0)		33.0 (1.0)	28.5 (1.0)		31.1 (0.9)	33.2 (1.4)	
Speech discomfort			0.038[a]			<0.001[a]			0.007[a]
Great discomfort	1.2 (0.1)	1.2 (0.2)		1.1 (0.1)	1.4 (0.2)		1.3 (0.1)	0.9 (0.1)	
Discomfort	5.7 (0.3)	7.1 (0.4)		5.1 (0.3)	8.4 (0.4)		5.7 (0.3)	7.3 (0.5)	
Minor problem	7.7 (0.3)	7.9 (0.5)		7.5 (0.4)	8.3 (0.5)		8.0 (0.3)	7.1 (0.5)	
Minimal problem	26.5 (1.0)	25.9 (1.1)		26.1 (1.0)	26.7 (1.2)		26.7 (1.0)	25.2 (1.4)	
No discomfort	58.9 (1.1)	58.0 (1.2)		60.2 (1.1)	55.2 (1.3)		58.3 (1.0)	59.5 (1.6)	

Results are presented as the mean ± standard error or percentages (standard error). General obesity was defined as body mass index of ≥25 kg/m^2. Abdominal obesity was defined as a WC ≥90 cm in males or ≥85 cm in females. Total body fat percentage was calculated as the total body fat mass/total body mass x 100. P-values were obtained by independent t-test for continuous variables or chi-square test for categorical variables. [a]Comparison of all non-obese results with all obese results. BMI, body mass index; WC, waist circumference; PBF, percentage of body fat.

Results

Relationship between socio-economic and lifestyle characteristics of study participants and general obesity, abdominal obesity or high PBF. Table I describes characteristics of study participants according to their obesity status. The mean age, BMI, WC and PBF were found to be significantly higher in obese participants (general obesity, abdominal obesity or high PBF) compared with non-obese participants (all P<0.001). In addition, there was a significant difference in the status of alcohol consumption, smoking, education level (decrease; all P<0.001), household income (increase in the lowest quartile; P<0.05) and daily energy intake (increase; P<0.001) between obese (all definitions) and non-obese participants. The percentage of periodontitis was significantly higher in individuals with general obesity (P<0.001), abdominal obesity (P<0.001) or high PBF (P=0.032) compared with non-obese participants. The percentage of individuals who had had a dental checkup within a year was decreased in generally obese (P=0.054), abdominally obese (P<0.001) and high PBF (P=0.113) individuals. The percentage of feeling discomfort whilst chewing or speaking was significantly different between non-obese and obese participants (all definitions of obesity; all P<0.05).

Time of day of tooth brushing and type of secondary oral products used in relation to obesity status. Table II shows the relationship between obesity status and the time of day tooth brushing occurred or the secondary oral products that were used. Participants with general obesity or high PBF brushed their teeth significantly less after meals or snacks compared with non-obese individuals (P<0.05). In addition, abdominally obese individuals had a lower tooth brushing rate following lunch or snacks (P<0.05). Participants with general obesity, abdominal obesity or high PBF exhibited a significantly lower rate of using floss (P<0.001) compared with non-obese individuals. A significantly lower amount of those with general obesity (P=0.002) or a high PBF (P=0.002) used mouthwash compared to individuals without general obesity or high PBF.

Daily frequency of tooth brushing and secondary oral products used in relation to obesity status. Figure 1 shows the percentage of participants with general obesity, abdominal obesity or a high PBF related to daily frequency of tooth brushing and secondary oral products used. The prevalence of general obesity and abdominal obesity significantly decreased (P<0.001 for overall trend) with increasing number of tooth brushing episodes (P<0.001 for trend) and secondary oral products used (P<0.001 for trend). The prevalence of high PBF significantly decreased as the frequency of tooth brushing episodes increased (P<0.001 for trend). Table III shows the adjusted ORs and their 95% CIs for all definitions of obesity according to the frequency of tooth brushing and the number of secondary oral products used. According to trend analysis using a generalized linear model, the OR of all definitions of obesity significantly increased as the frequency of tooth brushing decreased (all P<0.001) and the number of secondary oral products used (all P<0.05) decreased in all variable-adjusted models.

Table II. Time of day of tooth brushing and type of secondary oral products used in relation to obesity status.

	General obesity			Abdominal obesity			High body fat percentage		
Parameter	No	Yes	P-value	No	Yes	P-value	No	Yes	P-value
Time of tooth brushing									
Before breakfast	30.7 (0.5)	33.5 (0.9)	0.004	31.9 (0.6)	30.6 (1.0)	0.197	24.7 (0.8)	25.6 (1.1)	0.366
After breakfast	33.9 (0.8)	30.4 (0.5)	<0.001	30.4 (1.0)	32.1 (0.6)	0.111	26.7 (1.0)	24.2 (0.8)	0.008
Before lunch	31.5 (0.5)	31.9 (4.3)	0.919	31.6 (0.6)	28.4 (3.4)	0.351	25.0 (0.8)	23.1 (3.4)	0.583
After lunch	34.5 (0.6)	27.2 (0.7)	<0.001	35.6 (0.7)	25.9 (0.7)	<0.001	26.6 (0.9)	22.7 (0.9)	<0.001
Before dinner	31.5 (0.5)	29.0 (2.6)	0.347	31.6 (0.6)	30.8 (2.8)	0.788	25.0 (0.8)	22.3 (2.6)	0.290
After dinner	33.2 (0.8)	30.4 (0.6)	0.003	32.7 (0.9)	30.9 (0.7)	0.069	27.2 (1.1)	23.7 (0.8)	<0.001
After snacks	31.6 (0.5)	25.5 (2.6)	0.027	31.8 (0.6)	23.8 (2.3)	0.001	25.1 (0.8)	20.1 (2.2)	0.039
Before bedtime	32.1 (0.6)	30.3 (0.7)	0.058	33.6 (0.7)	28.1 (0.8)	<0.001	25.4 (0.9)	24.2 (1.0)	0.233
Secondary oral products used									
Floss	32.3 (0.5)	25.3 (1.2)	<0.001	32.7 (0.6)	24.0 (1.2)	<0.001	25.7 (0.8)	19.5 (1.2)	<0.001
Interdental brush	31.6 (0.5)	29.6 (1.7)	0.248	32.0 (0.6)	27.0 (1.5)	0.001	25.0 (0.8)	24.7 (1.6)	0.868
Mouthwash	32.0 (0.5)	27.3 (1.3)	0.002	31.9 (0.6)	29.4 (1.2)	0.054	25.4 (0.8)	21.3 (1.3)	0.002
Electric toothbrush	31.4 (0.5)	32.3 (1.9)	0.650	31.7 (0.6)	29.1 (1.9)	0.189	25.1 (0.8)	22.7 (1.8)	0.200
Other(s)	31.5 (0.5)	26.8 (3.6)	0.224	31.6 (0.6)	28.4 (3.6)	0.397	25.0 (0.8)	25.1 (3.8)	0.979

Results are presented as percentages (standard error). General obesity was defined as body mass index of ≥25 kg/m^2. Abdominal obesity was defined as a WC ≥90 cm in males or ≥85 cm in females. Total body fat percentage was calculated as the total body fat mass / total body mass x 100. P-values were obtained by chi-square test for categorical variables. Other(s) included irrigation device, tongue cleaner, end-tufted brush and/or a special device for dentures.

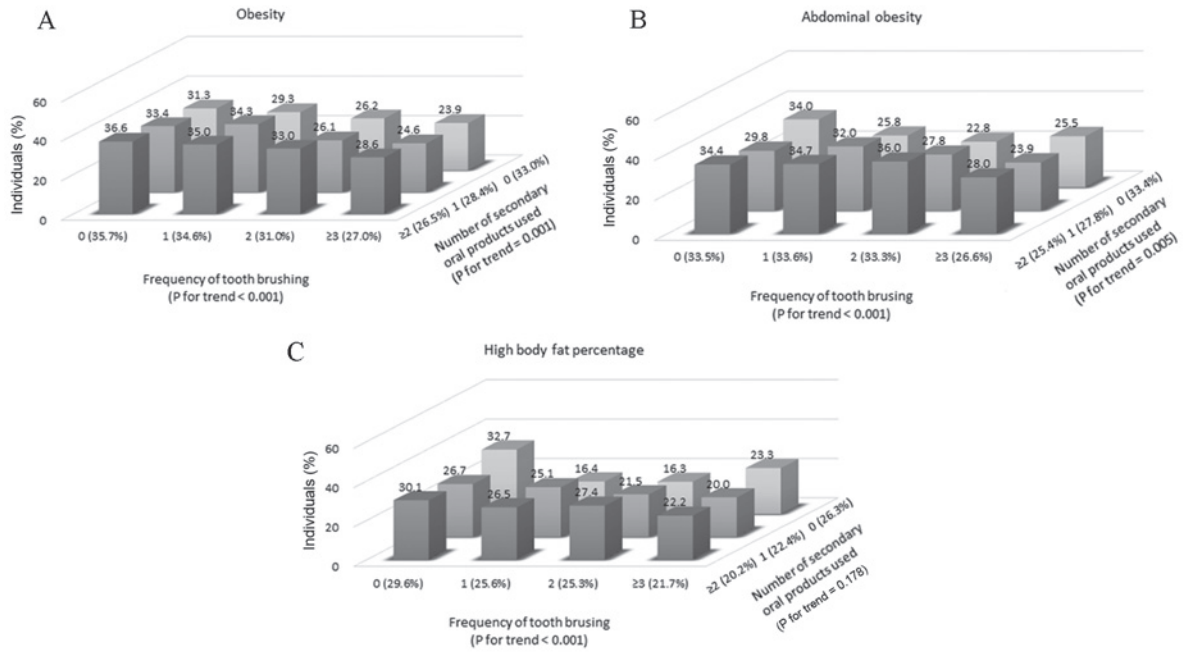

Figure 1. The prevalence of (A) general obesity, (B) abdominal obesity and (C) high body fat percentage, related to the frequency of daily tooth brushing and number of secondary oral products used.

Discussion

The aim of the present study was to assess the relationship between oral health behaviors and a number of measures of obesity. A strong association was identified between poor oral health behavior and obesity (all definitions). Typically, individuals with obesity defined by BMI, WC or PBF brushed their teeth less frequently and used fewer secondary oral products

Table III. Adjusted odds ratios for general obesity, abdominal obesity and high body fat percentage according to the daily frequency of tooth brushing and number of secondary oral products used.

	Frequency of tooth brushing per day					Number of secondary oral products used per day			
Type of obesity and model	≥3	2	1	0	P-value for trend	≥2	1	0	P-value for trend
General obesity									
Model 1	1	1.19 (1.06-1.33)	1.34 (1.20-1.49)	1.36 (1.19-1.56)	<0.001	1	1.04 (0.87-1.25)	1.18 (0.98-1.41)	0.008
Model 2	1	1.34 (1.20-1.49)	1.45 (1.30-1.60)	1.50 (1.30-1.73)	<0.001	1	1.14 (0.94-1.38)	1.33 (1.12-1.59)	0.029
Model 3	1	1.21 (1.08-1.35)	1.22 (1.08-1.38)	1.48 (1.28-1.72)	<0.001	1	1.12 (0.91-1.39)	1.32 (1.07-1.61)	0.021
Abdominal obesity									
Model 1	1	1.17 (1.05-1.31)	1.33 (1.19-1.48)	1.38 (1.20-1.58)	<0.001	1	1.02 (0.85-1.22)	1.14 (0.95-1.36)	<0.001
Model 2	1	1.30 (1.16-1.45)	1.39 (1.25-1.54)	1.48 (1.27-1.71)	<0.001	1	1.10 (0.91-1.34)	1.23 (1.03-1.48)	0.004
Model 3	1	1.21 (1.08-1.35)	1.23 (1.09-1.39)	1.55 (1.34-1.80)	<0.001	1	1.10 (0.88-1.36)	1.28 (1.04-1.57)	0.013
High body fat percentage									
Model 1	1	1.13 (0.99-1.27)	1.28 (1.13-1.45)	1.37 (1.17-1.61)	<0.001	1	1.03 (0.85-1.25)	1.16 (0.96-1.40)	<0.001
Model 2	1	1.28 (1.14-1.43)	1.41 (1.25-1.58)	1.54 (1.32-1.81)	<0.001	1	1.16 (0.94-1.44)	1.25 (1.03-1.51)	0.002
Model 3	1	1.18 (1.04-1.34)	1.21 (1.07-1.38)	1.60 (1.36-1.87)	<0.001	1	1.17 (0.93-1.48)	1.38 (1.10-1.73)	<0.001

Results are presented as adjusted odds ratio (95% confidence interval). General obesity was defined as body mass index of ≥25 kg/m^2. Abdominal obesity was defined as a WC ≥90 cm in males or ≥85 cm in females. Total body fat percentage was calculated as the total body fat mass/total body mass x 100. Model 1 is adjusted for age and sex. Model 2 is adjusted for the same variables as model 1, plus alcohol consumption, smoking status, physical activity level, educational level and household income level. Model 3 is adjusted for the same variables as model 2, plus total daily energy intake, fat intake per day and periodontitis. P-values were obtained by independent t-test for continuous variables or chi-square test for categorical variables.

compared with participants without obesity. A previous study found that the hazard ratios after adjusting for age, smoking status and clinical history of diabetes mellitus were 1.30 (P<0.001) and 1.44 (P=0.072) in males and 1.70 (P<0.01) and 3.24 (P<0.05) in females for those with a BMI between 25 and 30 kg/m^2 and ≥30 kg/m^2, respectively, compared with those with BMI <22 kg/m^2 (4). In addition, a systematic review and meta-analysis reported significant associations between periodontitis and BMI category, with an OR of 1.81 for obesity, 1.27 for overweight, and 2.13 for obese and overweight participants combined (24).

Inflammation may be the causative factor for the association identified between oral health behavior and obesity. Poor oral health behavior and a low frequency of tooth brushing may increase inflammation (25,26). Previous studies have found that poor oral hygiene is associated with higher levels of inflammatory markers in the blood, such as C-reactive protein and fibrinogen (27,28). In addition, a recent systematic review determined that an elevated level of C-reactive protein was associated with obesity (29). Studies on fibrinogen levels from the blood of obese patients prior to and following weight reduction observed negative correlations between BM and fibrinogen levels (30).

Oral health behavior is typically associated with other health-related behaviors, which may explain the association between oral health behavior and obesity (31). A previous study noted that oral disease, such as dental caries, has substantial negative medical consequences, which may not be fully appreciated due to the separation of the fields of medicine and dentistry (32). Authors of previous studies emphasize that health-promotion activities should include promotion of oral health (31,33). Furthermore, the results of a previous study examining the relationships among health-enhancing behaviors, indicated that regular tooth brushing reinforces other healthy lifestyle habits (34). Moreover, the results of a study on Korean university students highlighted the importance of oral health behavior, and suggested that obesity, oral health and nutrition need to be addressed jointly in health-promotion strategies (35). In addition, due to the links between nutrition and obesity with caries, pediatric dentists have a growing role in the battle against childhood obesity (36).

General obesity and abdominal obesity have classically been defined by BMI and WC, respectively. However, adiposity has recently been determined to be closely correlated with metabolic risk, and measurements, such as PBF and waist to hip ratios, have been noted as valuable tools for the assessment of obesity (37). In the present study, BMI, WC and PBF were used to define obesity, which revealed that poor oral health behaviors were significantly associated with obesity, irrespective of the measurement used. However, a previous study found that independent variables representing dental health were more often associated with BMI and WC obesity indicators compared with waist to hip ratio (38). Thus, the choice of obesity measurements may affect the results of studies related to oral health.

The present study identified that obese individuals had higher rates of periodontitis, which was in agreement with the findings of a recent systemic review (39). In addition, the current study observed that the percentage of participants who had a dental check-up within the past year was lower in those with obesity (all measurements) compared with non-obese individuals. This is in agreement with previous studies, which have shown that obesity is associated with behaviors such as irregular dental visits (36,38). Furthermore, in the present study, a higher percentage of non-obese participants had no discomfort when chewing compared with generally obese and abdominally obese participants, similarly to previous studies that showed a cause-and-effect association between masticatory function and obesity (40,41).

The present study has several limitations. Firstly, the cross-sectional design of the KNHANES prevents the deduction of causal relationships between poor oral health behaviors and obesity, thus the directions of the demonstrated associations could not be established. Secondly, DEXA scanning during the KNHANES study may lead to hydration-induced errors, and therefore may vary in accuracy according to each individuals' fluid balance (42). Thirdly, visceral fat and inflammatory markers could not be investigated due to the limited data of the KNHANES. However, the current study analyzed a nationally representative sample of South Koreans, considered different measurements of obesity and adjusted for a number of relevant confounding factors.

In conclusion, the present study identified that individuals with obesity, irrespective of the method used to define obesity, had a lower daily frequency of tooth brushing and used fewer secondary oral products. Conversely, poor oral health behaviors were positively associated with general obesity, abdominal obesity and a high PBF. This indicates that good oral health behaviors should be emphasized in the health-promotion strategies for obese patients.

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