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Original Contribution

Regular Tooth Brushing is Associated with a Decreased Risk of Metabolic Syndrome According to a Medical Check-Up Database

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Summary: Associations have been reported between periodontal disease and increased cardiovascular disease risk, as well as between healthy self-reported tooth brushing behavior and reduced cardiovascular disease risk. We examined the association between self-reported tooth brushing behavior and the risk of metabolic syndrome (MetS) using a large medical check-up database. A total of 12,548 medical checkup records from a medical screening center in a city in southwest Japan were assessed. Subjects were aged 30 to 59 years. As lifestyle is associated with both tooth brushing and MetS, many lifestyle variables were considered as potential confounders. Logistic regression model were employed with a list of 127 lifestyle variables. Twenty variables associated with both tooth brushing and MetS were selected for both males and females. Furthermore, final confounding variables were selected by principal component analysis to avoid collinearity problems. The association of tooth brushing and MetS was evaluated for males and females separately by calculating adjusted odds ratios (ORs) with selected confounders plus age. The association between daily tooth brushing frequency and MetS risk for both genders was significant after adjusting for confounders, with the risk of MetS decreasing with increased frequency of daily tooth brushing (adjusted OR = 0.57 (95%Cl:0.48–0.81), 0.50 (95%Cl:0.35–0.71), 0.42 (95%Cl: 0.29–0.61) for males and adjusted OR = 0.65 (95%Cl:0.48–0.87), 0.44 (95%Cl:0.32–0.62) for females). Therefore, oral hygiene, including the frequency of tooth brushing as a significant component, may be an important factor in preventing MetS.

Key words tooth brushing, metabolic syndrome, medical checkup database, health behavior, cross-sectional studies, confounding factor

INTRODUCTION

Physical examinations performed under the auspices of the Japanese national public health insurance system play an important role in secondary preventive care for the purposes of earlier detection and treatment of disease, and it is also one of the national strategies to improve the level of public health in Japan. Self-reporting questionnaires concerning lifestyle, and data from blood tests and body measurements obtained through physical examinations, can be used for the screening of disease and health guidance, and these are accumulated in medical checkup institutes as individual longitudinal data. Analysis of the accumulated data is useful for effective health guidance [1]. As metabolic syndrome (MetS) is a risk factor for cardiovascular disease (CVD) and carries increased risk for CVD [2,3], preventing MetS is of high public health importance. The International Obesity Taskforce has stated that interventions on a sociopolitical level are required to reduce development of MetS in populations [4]. In a previous study the authors conducted an exploratory analysis of health checkup data to research the lifestyle habits that affected the risk of

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Abbreviations: CVD, cardiovascular disease; JHPI, Japan Health Practice Index; MetS, metabolic syndrome; ORs, odds ratio.

MetS. The results suggested that the frequency of tooth brushing, as well as dietary, exercise and drinking habits affected the risk of metabolic syndrome [5]. Although diet, exercise, stress management, smoking and alcohol consumption are identified as items for health guidance in the "Standard Physical Checkup and Health Guidance Program" by the Health, Labor and Welfare Ministry [6], oral care is not included. Yatabe et al. [7] raised a concern about whether it is appropriate to add tooth brushing to the list in the Japan Health Practice Index (JHPI), because although tooth brushing is one of the 10 lifestyle habit behavior items in the JHPI, it correlates weakly with the total score of the JHPI. Although a study by Yoshida evaluated tooth brushing as an active healthy activity, he did not describe its relationship with the results of physical examinations [8]. As described above, although oral care is encouraged as a healthy activity, its effect on MetS has not been clarified.

Over the past two decades, numerous studies have investigated the association of periodontal diseases with an increased risk for CVD [9]. From a public health perspective, improving periodontal health is important because it may reduce the risk of cardiovascular disease [10]. While a meta-analysis [11] of prospective and retrospective studies showed that periodontal disease might only slightly increase the risk of CVD, another meta-analysis study [12] showed an association between systemic bacterial exposure from periodontal disease and coronary heart disease events. However, it has been concluded that properly powered longitudinal case-control and intervention trials are needed to identify how periodontitis and periodontal intervention may impact CVD [13].

In recent years there has been an increasing interest in the relationship between MetS and periodontal disease [14-17]. Although a recent national population-based study [18] showed that self-reported tooth brushing behavior is inversely associated with CVD, we know of no population-based studies that have examined the association between self-reported tooth brushing behavior and the risk of MetS.

Lifestyle behaviors are considered to be mutually related [5]. Accordingly, the relationship between MetS and oral care activity may possibly be affected by other lifestyle behaviors. Therefore, the purpose of this research was to clarify the relationship between MetS and oral care activity, while controlling for other possible lifestyle behavior effects related to MetS.

MATERIALS AND METHODS

Data were collected from the periodical medical checkups of 12,548 participants (male: female 7703:4845) from 2004 to 2006 at the medical screening center located in Kurume, Fukuoka Prefecture. Recipients were 30 to 59 years of age (mean±SD: 46.3±7.5), either covered by Social Insurance or National Health Insurance. For those who had multiple checkup data, we utilized data only from their first visit.

High MetS risk group

The diagnostic criteria of MetS, such as abdominal obesity, lipid metabolic disorder, glucose intolerance and hypertension, were applied to identify the high MetS risk group. Because waist size was not included in the data from the physical examination, visceral fat value was used to show abdominal obesity in place of waist value. In maintaining the diagnostic standard of the National Health and Nutrient Survey 2004 [19], and to obtain more subjects with high MetS risk than by using only one of the diagnostic standards, the high MetS risk conditions were defined by one applicable item being added to abdominal obesity and expressed by binary variables, as shown in Table 1.

Factors relating to attributes and lifestyle

The items on the questionnaire form can be broadly classified into three categories: 1) attributes, 2) lifestyle behaviors and 3) mental and emotional factors. The category of attributes had four items, consisting of: absence or presence of persons living together; occupation, working pettern, average of weekly working hours ; the 60 items related to lifestyle behaviors covered the frequency of intake of food and nonessential luxury items, dietary habits, fitness habits, oral health care and the way holidays are spent, and the 64 items related to mental and emotional factors covered amusements, health awareness, and psychological state. All of these were categorical variables other than age.

Analysis of data

Although five choices ('none', 'once a day', 'twice a day', 'three times a day' and 'more than three times a day') were presented in the tooth-brushing question, some choices were selected very seldom by the subjects. Thus, five items were combined into fewer categories as follows: four categories ('none', 'once a day', 'twice a day' and 'more than twice a day') for males. Since only 4 females answered 'none', the first two categories were combined into 'at most once a day',

TABLE 1.
Criteria used to define high risk MetS

Obese				
	Body mass percentage	Male	≥	20%
		Female	≥	30%
	and/or			
	Body mass index		≥	25 kg /m^2
One or more of the following items are added to the above:				
	Hypertriglyceridemia		≥	150 mg/dl
	and/or			
	Low HDL cholesterol		<	40 mg/dl
	Systolic blood pressure		≥	130 mmHg
	and/or			
	Diastolic blood pressure		≥	85 mmHg
	Fasting plasma glucose		≥	110 mg/dl

Note* Receiving drug therapy for hypertriglyceridemia, hypertension, or diabetes should be included in the respective items.

resulting in three categories for females.

The purpose of this research was to clarify the relationship between tooth brushing frequency and MetS risk. Generally speaking, when the effect of an exposure on an outcome is examined by an epidemiological study, there may exist a set of covariates affecting both exposure and outcome. These covariates are known to distort the association between exposure and outcome, and are referred to as confounders or confounding variables. Therefore, to properly assess the association, the effect of the confounders must be removed in the analysis. The number of covariates available in this research was 127, and many of the variables were highly associated with each other. Because of this collinearity problem, it was not feasible to adjust for the effects of all 127 covariates in the analysis.

Therefore, a logistic regression model was employed to select variables that were associated with both MetS and tooth brushing frequency. Because lifestyle behaviors were quite different between males and females [5], variable selection was carried out separately by gender. In addition, age was considered as a confounder *a priori* [5].

The specific method for selecting confounding variables was as follows. First, the strength of association between each covariate and MetS was evaluated using the Wald Chi-Square statistic obtained from a univariate logistic regression model. Because of the large sample size, almost all p-values were highly significant. Since the p-values alone were not useful in the variable selection process, we arbitrarily decided to use the first 50 covariates with the smallest p-values as potential confounding variables. The same procedures were used for the tooth brushing categories, except that the univariate logistic regression was replaced with a nominal logistic regression model. Twenty variables that were selected in both procedures were considered confounding variables. Table 2 shows the list of 50 covariates for each gender and the confounding factors were marked with the symbol *.

Although the number of potential confounders was reduced from 127 to 20 for both genders, these 20 variables exhibited strong associations among themselves. To avoid a collinearity problem, further variable selection was necessary. To select a few confounding variables, principal component analysis was carried out. Principal components with an eigenvalue greater than one were retained. The variable with the largest loading score within each principal component was selected as a final confounding variable. Finally, selected confounders plus age were then used in a logistic regression model, and the effect of tooth brushing on MetS risk was evaluated using the ORs.

To evaluate the reliability of our findings, two additional data analyses were performed. The first analysis was to examine the reliability of controlling for the effects of confounding variables. Propensity score stratification is an effective method to adjust for selection bias and confounding in a cross-sectional study [20]. To this end, propensity scores were estimated based

TABLE 2.
List of 50 covariates for each gender

Male						Female					
MetS risk			Tooth brushing			MetS risk			Tooth brushing		
Potential confounder		Wald-ChiSq	Potential confounder		Wald-ChiSq	Potential confounder		Wald-ChiSq	Potential confounder		Wald-ChiSq
Wakes up early		340.1	Cannot sleep because of worry		221.5	Has interest in losing weight		70.9	Yogurt		47.1
Inadequate sleep		273.9	Feels no meaning to life		160.0	Eats too much	*	50.8	Sugar in coffee		40.7
Cannot cope with job		113.2	Lacks concentration		157.0	Eats quickly	*	48.7	Vegetables with lunch		39.1
Burdened by raising children and housework		44.2	Feels unmotivated		137.3	Has interest in walking		30.6	Conscious of salt intake	*	38.8
Has chance to talk with someone freely		31.2	Cannot work as expected		131.3	Drinking frequency		14.7	Favorite seasoning	*	38.6
Conscious of regular life	*	25.7	Has no one who understands their job		122.1	Salty food		13.9	Too many overtime hours	*	34.6
Mood swings		25.6	Enjoys daily life		102.7	Worries about being sick		13.5	Juice	*	34.4
Working pattern		25.3	No way to cope with stress		101.6	Irregular diet		12.7	Green and yellow vegetables		34.4
Too many overtime hours		23.7	Conscious of regular life	*	94.2	Coffee and red tea		12.2	Hobbies		34.2
Extensive contacts		19.9	Maintains balance between activities and rest		91.8	Burdened by relationship with neighbors	*	12.2	Fruits		26.1
Assumes heavy responsibility		17.0	Occupation		91.4	Fried vegetables		11.6	Fatty meat		25.0
Walking		17.0	Has interest in walking	*	87.1	Seasonings on the table	*	10.3	Problems with boss and colleagues		24.5
Has interest in walking	*	16.9	Exercise other than walking	*	85.6	Favorite seasoning		9.9	Soy beans		24.4
Exercise other than walking	*	16.9	Has interest in exercise		85.0	Suffers from gastrointestinal upset		9.8	Has interest in exercise		23.4
Exercises during holidays	*	16.8	Exercises during holidays	*	81.9	Too many overtime hours	*	9.3	Vegetables for breakfast	*	20.9
Does housekeeping during holidays	*	14.6	Does housekeeping during holidays	*	78.3	Sometimes skips meals	*	9.2	Eats more for dinner		20.2
Rests at home during holidays	*	14.2	Rests at home during holidays	*	73.6	Vegetables for dinner	*	8.3	Sometimes skips meals	*	18.9
Enjoys drinking		14.1	Enjoys playing sports	*	71.9	Extensive contacts		8.3	Smokes		17.3
Enjoys eating		14.1	Hobbies		69.3	Thinks current job is not suitable		8.3	Hobbies or learning during holidays		17.0
Enjoys playing sports	*	13.4	Has interest in losing weight	*	65.3	Cake		7.9	Seasonings on the table	*	16.9
Has interest in losing weight	*	13.4	Smoking		60.8	Wakes up early		7.7	Seaweed		16.3

Fatty meat	*	13.1	Potatoes		55.6	Conscious of salt intake	*	7.0	Maintains balance between activities and rest		15.7
Egg		12.8	Fatty meat	*	50.0	Drinking period		6.9	Noodle soup		15.3
Yogurt	*	12.2	Soy beans		45.8	Eats dinner		6.8	No particular method to cope with stress	*	14.6
Fried vegetables		11.9	Milk		38.4	Difficulty falling asleep		6.4	Burdened by relationship with neighbors		14.4
Deep fried food		11.3	Yogurt	*	35.7	Enjoys drinking		5.8	Heavy responsibility at work		14.3
Fatty staple food		11.3	Seaweed		35.5	Worries about job	*	5.4	Processed food	*	12.8
Vegetables for breakfast	*	11.1	Vegetables for breakfast	*	30.7	Japanese cake		5.3	Vegetables for dinner	*	12.5
Green and yellow vegetables	*	10.4	Vegetables for lunch		30.1	Has own countermeasures		5.2	Eats too much	*	11.8
Dishes cooked with sugar and sweet cooking rice wine		10.0	Vegetables for dinner		30.1	Preparation of dinner	*	5.2	Often eats a la carte when eating out		11.2
Sugar in coffee	*	9.7	Green and yellow vegetables	*	29.1	Working pattern		5.0	Soup dish		10.9
Juice	*	9.1	Fruits		27.3	Vegetables for breakfast	*	4.9	Eats quickly	*	10.6
Cake		8.9	Sugar in coffee	*	26.2	Pickles and food boiled in soy sauce	*	4.9	Seasoned rice		10.5
Drinking period		7.9	Juice	*	26.0	Cannot cope with job		4.9	Too many overtime hours		10.4
Eats quickly		7.5	Irregular diet		21.7	Burdened by raising children and housework		4.8	Solves problems immediately	*	10.2
Eats too much		7.4	Late dinner		21.5	Exercises during holidays	*	4.8	Pickles and food boiled in soy sauce	*	10.2
Eats out more than 2 times a day		7.3	Sometimes skips meals		21.1	No particular method to cope with stress	*	4.6	Mood swings		10.1
Often eats a la carte when eating out	*	7.2	Eats dinner		21.0	Late dinner		4.3	Exercises during holidays	*	10.0
Has likes and dislikes	*	7.0	Often eats a la carte when eating out	*	21.0	Box lunch from the market		4.2	Deep fried food		9.8
Favorite seasoning	*	6.9	Has likes and dislikes	*	20.9	Does volunteer work during holidays		4.2	Assumes heavy responsibility		9.5
Conscious of salt intake	*	6.9	Favorite seasoning	*	20.6	Solves problems immediately	*	4.0	Feels unmotivated		9.3
Soup	*	6.8	Conscious of salt intake	*	20.0	Consults with expert or hospital		4.0	Milk		9.3
Seasoned rice		6.5	Seasonings on the table		19.8	Worries about family		4.0	Preparation of dinner	*	8.7
Salty food	*	6.5	Soup	*	19.6	Worries about small matters		3.9	Enjoys holidays		8.6
Processed food		6.1	Noodle soup		19.1	Juice	*	3.8	Worries about job	*	8.4

Pickles and food boiled in soy sauce		6.0	Salty food	*	19.0	Enjoys playing sports	*	3.7	Busy	8.4
Suffers from headaches		5.8	Boxed lunch from the market		15.0	Processed food	*	3.7	Eats out more than 2 times a day	8.2
Suffers from gastrointestinal upset		5.7	Prepares breakfast		14.3	Potatoes		3.6	Exercise other than walking	8.1
Feels lethargic		5.7	Fatigue cannot be overcome by sleep		14.0	Skim milk		3.2	Does housekeeping during holidays	* 7.9
Worries about being sick		5.5	Feels lazy		13.2	Does housekeeping during holidays	*	3.0	Enjoys playing sports	* 7.6

*: Treated as confounder.

on logistic regression models where a binary tooth brushing frequency variable was defined as "once a day or less" or "more than once a day" and was used as the response variable with a set of potential confounders as explanatory variables in the model. The Mantel-Haenszel common ORs were obtained based on five strata constructed from the ranks of the propensity scores. Because statistical tests were based on a relatively large sample size in our study, a second analysis examined the effect of sample size. Five thousand bootstrap samples were generated, together with the empirical bootstrap distribution of the Mantel-Haenszel common ORs based on the propensity score method. Empirical 95% confidence intervals of ORs for males and females were constructed. Statistical Analysis System 9.1 software was used in all statistical analyses.

Ethics approval

This epidemiologic study used medical examination data for which informed consent was obtained based on the "Ethics Guidelines for Epidemiological Research" [21]. We obtained approval for the study from the Ethics Committee of the college and the hospital affiliated with the medical screening center [2006 Jun 14]. We obtained data that excluded full names and dates of birth, and set up anonymity safeguards that made it impossible for individuals to be identified.

RESULTS

Characteristics of the subjects

The prevalence of MetS risk was 41% in males and 10% in females. These percentages were slightly higher than the 36.2% in nationally surveyed males and 10% in nationally surveyed females [19]. The tooth brushing frequencies were: 2.1% less than once a day, 35.9% once a day, 46.8% twice a day and 15.3% more than twice a day in males; and 10.0% less than once a day, 53.4% twice a day and 36.5% more than twice a day in females. Table 3 shows the distribution of the tooth brushing frequencies divided into two groups, with once a day or less and more than once per day, and MetS risk according to gender, age group and occupation. Regarding occupational status, White Collar was defined as including professional technical work, managerial and clerical work, and Worker was defined as including all other occupations.

Odds ratios for tooth brushing and MetS risk

The association between MetS risk (high vs. low) and categorized tooth brushing behavior was evaluated using the logistic regression models. The adjusted ORs are shown in Table 4 for males and females. For males, the odds for high MetS risk among people who do not brush their teeth were used as a reference. The ORs were 0.57 (0.4–0.81), 0.50 (0.35–0.71) and 0.42 (0.29–0.61) among the once a day, twice a day and more than twice a day groups, respectively. For females, the odds for high MetS risk among people who brush their teeth at most once a day were used as a reference. The ORs were 0.65 (0.48–0.87) and 0.44 (0.32–0.62) for the twice a day and more than twice a day groups, respectively. Frequency of tooth brushing may have a dose-response effect on risk of MetS as suggested by the magnitude of the ORs.

The Mantel-Haenszel common ORs based on the propensity score methods were (0.86, 0.97) and (0.50, 0.81) for males and females, respectively. Empirical

TABLE 3.
Distribution of tooth brushing frequency and MetS risk based upon selected confounding variables

		MetS Risk			Tooth brushing		
		Low	High	Total	More than once	Once or less	Total
Attribute							
Gender	Male	4553 (59.1%)	3150 (40.9%)	7703	4777 (62.1%)	2921 (37.9%)	7698
	Female	4371 (90.2%)	474 (9.8%)	4845	4342 (90.0%)	485 (10.0%)	4827
Age (years)	30–39	2024 (76.7%)	615 (23.3%)	2639	2015 (76.4%)	624 (23.6%)	2639
	40–49	3677 (72.0%)	1431 (28.0%)	5108	3757 (73.6%)	1350 (26.4%)	5107
	50–59	3223 (67.1%)	1578 (32.9%)	4801	3347 (70.0%)	1432 (30.0%)	4779
Selected Confounders							
Male							
Spends holidays exercising	No	3365 (57.9%)	2445 (42.1%)	5810	3482 (59.9%)	2328 (40.1%)	5810
	Yes	1186 (62.8%)	702 (37.2%)	1888	1295 (68.6%)	593 (31.4%)	1888
Favorite seasoning	Prefers plain taste	1250 (61.5%)	782 (38.5%)	2032	1374 (67.6%)	658 (32.4%)	2032
	Normal	2740 (58.9%)	1914 (41.1%)	4654	2835 (60.9%)	1819 (39.1%)	4654
	Prefers strong taste	532 (55.4%)	429 (44.6%)	961	537 (55.9%)	424 (44.1%)	961
Eats soup	None	470 (62.8%)	279 (37.2%)	749	401 (53.5%)	348 (46.5%)	749
	1 bowl a day	3192 (59.5%)	2175 (40.5%)	5367	3341 (62.3%)	2026 (37.7%)	5367
	2 bowls a day	800 (56.0%)	628 (44.0%)	1428	942 (66.0%)	486 (34.0%)	1428
	3 bowls or more a day	60 (58.3%)	43 (41.7%)	103	62 (60.2%)	41 (39.8%)	103
Sugar in coffee	Does not drink	634 (57.5%)	469 (42.5%)	1103	700 (63.5%)	403 (36.5%)	1103
	No sugar	2681 (57.3%)	2000 (42.7%)	4681	3050 (65.2%)	1631 (34.8%)	4681
	1 teaspoon	842 (63.6%)	482 (36.4%)	1324	740 (55.9%)	584 (44.1%)	1324
	2 teaspoons	358 (67.3%)	174 (32.7%)	532	252 (47.4%)	280 (52.6%)	532
Has interest in losing weight	No interest	1587 (83.2%)	321 (16.8%)	1908	1138 (59.6%)	770 (40.4%)	1908
	Interested, but does not intend to lose weight soon	940 (55.9%)	742 (44.1%)	1682	982 (58.4%)	700 (41.6%)	1682
	Interested and wants to start immediately	1257 (44.0%)	1602 (56.0%)	2859	1783 (62.4%)	1076 (37.6%)	2859
	Interested and has started	767 (61.4%)	482 (38.6%)	1249	874 (70.0%)	375 (30.0%)	1249
Spends holidays housekeeping	No	3756 (58.5%)	2669 (41.5%)	6425	3937 (61.3%)	2488 (38.7%)	6425
	Yes	795 (62.5%)	478 (37.5%)	1273	840 (66.0%)	433 (34.0%)	1273
Female							

Favorite seasoning	Prefers plain taste	1767 (91.7%)	160 (8.3%)	1927	1769 (91.8%)	158 (8.2%)	1927
	Normal	2357 (89.4%)	279 (10.6%)	2636	2344 (88.9%)	292 (11.1%)	2636
	Prefers strong taste	210 (86.8%)	32 (13.2%)	242	208 (86.0%)	34 (14.0%)	242
Worries about job	No	1191 (88.7%)	151 (11.3%)	1342	1196 (89.1%)	146 (10.9%)	1342
	Yes	2860 (91.0%)	283 (9.0%)	3143	2838 (90.3%)	305 (9.7%)	3143
Pickles and food boiled in soy sauce	Does not eat	1360 (91.5%)	127 (8.5%)	1487	1353 (91.0%)	134 (9.0%)	1487
	Once a day	2488 (90.0%)	275 (10.0%)	2763	2465 (89.2%)	298 (10.8%)	2763
	Twice a day	400 (88.1%)	54 (11.9%)	454	417 (91.9%)	37 (8.1%)	454
Spends holidays exercising	No	3977 (90.0%)	444 (10.0%)	4421	3968 (89.8%)	453 (10.2%)	4421
	Yes	379 (93.3%)	27 (6.7%)	406	374 (92.1%)	32 (7.9%)	406
Eats quickly	No	1974 (93.6%)	134 (6.4%)	2108	1926 (91.4%)	182 (8.6%)	2108
	Yes	2360 (87.5%)	337 (12.5%)	2697	2395 (88.8%)	302 (11.2%)	2697
Preparation of dinner	Prepares alone	3395 (89.5%)	397 (10.5%)	3792	3405 (89.8%)	387 (10.2%)	3792
	Prepared by family	852 (93.3%)	61 (6.7%)	913	832 (91.1%)	81 (8.9%)	913
	Eats out or other	87 (87.0%)	13 (13.0%)	100	84 (84.0%)	16 (16.0%)	100
Solves problems immediately	No	3257 (90.7%)	333 (9.3%)	3590	3206 (89.6%)	373 (10.4%)	3579
	Yes	1114 (88.8%)	141 (11.2%)	1255	1136 (91.0%)	112 (9.0%)	1248

95% confidence intervals of ORs based on the bootstrap methods were (0.86, 0.97) and (0.51, 0.99) for males and females, respectively. Results from two additional data analyses suggest that our findings did not depend on the methods of adjusting confounding bias nor the large sample size.

DISCUSSION

The prevalence of MetS, including among the high-risk group subjected to this research, was similar to that of the national survey. It has been shown that the distribution of tooth brushing frequency and MetS risk are very similar by gender, age group and occupation, which suggests that the correlation between them is strong. López *et al*. has found that there may be a correlation between coronary heart disease and periodontal disease using a case-control study, and considers that they may be in the same cluster [22]. This suggests a correlation within a group having the same covariate or lifestyle. However, the results of the present study clarified that the significant correlation that is found after the adjustment for common lifestyle factors cannot be fully explained only because they are in the same cluster. A prospective cohort study in Japan reported that the MetS components (positive conversions of blood pressure and the blood-lipid index) became positive four years after the formation of a periodontal pocket, which supports our findings [16]. One explanation is that a protein component called inflammatory cytokine, produced by the body's own cells, and its stimulation caused by endotoxin derived from periodontal disease, is carried throughout the body, causing the onset and progression of a systemic illness. In the experimental intervention trial whereby subjects refrained from all oral hygiene measures, including the use of dentifrices, mouth rinses, dental floss, and chewing gum, 56% of participants showed an increase

TABLE 4.
Odd ratios for MetS risk and tooth brushing adjusted for age and confounding variables

Male				Female			
Tooth brushing frequency	Odds ratio*	95%CI	P value	Tooth brushing frequency	Odds ratio**	95%CI	P value
Non	–		–	At most once a day			
Once a day	0.57	0.40-0.81	<0.001	Twice a day	0.65	0.48-0.87	0.004
Twice a day	0.50	0.35-0.71	<0.001	More than twice a day	0.44	0.32-0.62	<0.001
More than twice a day	0.42	0.29-0.61	<0.001				

Adjusted Factors were “Age”, “Exercises during holidays”, “Favorite seasoning”, “Eats soup”, “Sugar in coffee”, “Has interest in losing weight “ and “Does housekeeping during holidays” for males
Adjusted Factors were “Age”, “Favorite seasoning”, “Worries about job”, “Sugar in coffee”, “Pickles and food boiled in soy sauce”, “Exercises during holidays”, “Eats quickly”, “Preparation of dinner” and “Solves problems immediately” for females

in blood endotoxin levels [23]. This suggests that oral care may be a significant factor in preventing MetS. Meanwhile, tooth brushing is an important component of oral care, and our findings of a dose-response relationship between tooth brushing and MetS risk calls for further research in this field.

LIMITATIONS

Several limitations in this study ought to be mentioned. The first limitation is the lack of generalizability of our findings because of possible selection bias as a result of our limited study population. Our findings were largely based on self-reported tooth brushing behavior. These responses were obtained from a health questionnaire, which may lack reliability and reproducibility. The third limitation is a lack of dental examination data, such as probing pocket depth and tooth loss. Although a statistically significant association between tooth brushing behavior and risk of MetS is tenable, a carefully designed randomized controlled intervention study is required to establish a causal relationship between oral care activities and MetS risk. Although there are many studies that support the value of a healthy lifestyle, some debate exists on the effectiveness of interventions to reduce MetS. To this end, the authors are engaged in an intervention study to evaluate the effect of oral care activities on other lifestyle factors and MetS risk.

CONCLUSION

Our analyses suggest that self-reported oral care activities are associated with increased risk of MetS after controlling for the effects of many confounding lifestyle factors. This finding may be used to enhance guidance that is provided by health care professionals to participants of medical check-ups. Additionally, we demonstrate the practicality of using statistical methods to analyze large medical databases to develop evidence-based health care strategies.

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