The relationship between metabolic syndrome and number of teeth in Japan

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Knowledge Transfer Statement:

The results of this study can be used by clinicians when they examine patients with periodontal disease or extensive tooth loss to refer for a general medical examination.

Abstract:

The 2004 Japanese National Health and Nutrition Survey collected data on several measures including self-reported dental health. In addition, this was the first nationwide survey to focus on metabolic syndrome in Japan. Therefore, we used this nationwide dataset to assess the relationship between number of teeth present and metabolic syndrome. Anonymized data were available with permission from the Ministry of Health, Labour and Welfare of Japan. Data from 3,195 men and women aged 35 to 99 years old were examined, and logistic regression analyses

were used to evaluate the association between number of teeth and metabolic syndrome.

Moreover, we performed an analysis of covariance to compare the mean number of teeth between those with and those without metabolic syndrome after adjusting for confounders. In comparison with those having 28 or more teeth, those with fewer remaining teeth demonstrated significantly higher odds of having metabolic syndrome. In other words, those having 1 to 9 teeth had higher odds of having metabolic syndrome than those with more teeth and were more than twice as likely to be affected than those with 28 or more teeth. Furthermore, individuals with metabolic syndrome in the 45–54, 55–64, and 65–74 year old age groups had significantly fewer teeth than those without metabolic syndrome in the same age groups. These results suggest that the number of teeth present is associated with the prevalence of metabolic syndrome in the Japanese population.

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Introduction

Metabolic syndrome (MetS) is a combination of several metabolic risk factors, including abdominal obesity, high blood pressure, lipid abnormalities, and hyperglycemia. MetS also increases the risk of various lifestyle-related diseases, such as cardiovascular events and diabetes (Mottillo et al., 2010). Furthermore, the prevalence of MetS is estimated at 17–32% in the general population, representing a considerable concern for public health (Day, 2007).

In Japan, the major reasons for tooth extraction are periodontal disease (41.8%), dental caries (32.7%), and resulting dental fractures (10.6%) (Aida et al., 2006). In addition, periodontal disease has been shown to be associated with obesity, abdominal obesity, and MetS (Saito et al., 1998) (Saito et al., 2001) (Shimazaki et al., 2007), and epidemiological evidence accumulated over the last 2 decades suggests that periodontal disease is associated with dyslipidemia, glucose intolerance, hypertension, and a low-grade systemic inflammatory state including obesity (Cutler et al., 1999; Katz et al., 2002; Nibali et al., 2007; Paraskevas et al., 2008; Tsakos et al., 2010). A systematic review and meta-analysis further demonstrated an association between MetS and periodontitis (Nibali et al., 2013), and Holmlund et al. demonstrated that tooth loss was related to the presence of MetS in 947 subjects aged 70 years or older (Holmlund et al., 2007). Therefore, MetS represents a concern for public health as well as oral health. However, the association between the number of teeth present and MetS

accounting for demographic characteristics has not been clarified. Therefore, the purpose of this study was to clarify the association between number of teeth present and MetS in Japan using data from nationwide study.

Methods

Data source

All data were obtained from the 2004 Japanese National Health and Nutrition Survey. These data were available with permission from the Ministry of Health, Labour and Welfare of Japan. The 2004 National Health and Nutrition Survey consisted of 3 sections concerning physical status, nutrition intake, and lifestyle. In this study, we examined data for 3,195 participants aged 35 years or older. Participants less than 35 years-old were excluded from analyses because they did not have any tooth loss and the prevalence of Mets was estimated to be less than 5% (data not shown). Pregnant women were also excluded from the analysis because their waist circumferences were not measured.

Independent and dependent variables

The independent variable, number of teeth, was measured by self-report. The dependent variable, MetS, was measured according to the 2004 National Health and Nutrition Survey

criteria. The components of MetS included dyslipidemia (high-density lipoprotein cholesterol <40 mg/dl), hypertension (systolic blood pressure $\geq$ 130 mm Hg and/or diastolic blood pressure $\geq$ 85 mm Hg), and hyperglycemia (glycosylated hemoglobin A1C $\geq$ 5.5%) or the use of medications to treat these disorders. MetS is strongly suspected in patients who exhibit at least 2 of these components in addition to abdominal obesity (waist circumference $\geq$ 85 cm for men; $\geq$ 90 cm for women) (Japan Society for the Study of Obesity, 2002).

Potential confounders

Potential confounders included age, gender, alcohol consumption, smoking, intensity of daily activity, and energy intake.

Alcohol consumption was categorized based on dose, 1 dose being 20 g of ethanol per day. Participants were categorized into the habitual group (those who consumed 1 or more doses of alcohol on more than 2 days per week) or the none or less group. Participants were also classified based on smoking habits. Never smokers included those who had never smoked or who had smoked less than 100 cigarettes in the 6-month period after starting smoking. Former smokers included individuals who had smoked more than 100 cigarettes or who continued smoking more than 6 months after starting smoking but who had not smoked within the last month. The current smoker category included individuals who had smoked more than 100

cigarettes or smoked more than 6 months after starting smoking and had smoked within the last month.

Intensity of daily activity was classified into 4 categories. Category I (low) included individuals who had taken a slow walk or gone shopping on foot for about an hour per day but who had spent most of the day in a seated or reclined position (reading, studying, talking, watching TV, or listening to music). Category II (slightly higher) included those who had worked in a standing position for about 2 hours per day but spent most of the day doing office work or talking in a seated position. Category III (moderate) included those who had exercised relatively hard for about an hour per day, spent most of the day working in a standing position, or engaged in relatively hard work (such as agricultural work and fishing) for about an hour per day. Category IV (high) included those who had exercised very hard (such as hard training, carrying wood, or agricultural work during the busy farming season) for about an hour per day.

Statistical analyses

We used bivariate and multivariate logistic regression analyses to evaluate the relationship between the number of teeth present and MetS. Odds ratios (ORs) with 95% confident intervals (CIs) were calculated for these comparisons. Moreover, we performed an analysis of covariance (ANCOVA) to compare the mean number of teeth between those with and those without MetS

after adjusting for potential confounders. A probability value of less than 0.05 was considered significant. Logistic regression analyses and ANCOVA were adjusted for the above-mentioned potential confounders. Statistical analyses were performed using PASW version 18.0 software.

Results

The basic characteristics of the study participants are shown in Table 1. The prevalence of MetS among the 3,195 participants was 16.5% and the prevalence increased with age except among those aged 85 years and older. In the bivariate analysis, MetS was significantly associated with having fewer remaining teeth, increasing age, being male, smoking, and moderate daily physical activity (Table 2). When adjusted by age, gender, alcohol consumption, smoking habit, intensity of daily activity, and energy intake, MetS was significantly associated with having less teeth, increasing age, and being male in the multivariate logistic regression model. In addition, those having 1 to 9 teeth had a higher OR [2.41 (95% CI 1.61–3.59)] than those with more teeth (i.e., those with 10–19 teeth, 20–27 teeth, and those with 28 or more teeth). In table 2, energy intake was not associated with Mets in bivariate and multivariate logistic models. Moreover, energy intake was not associated with number of teeth in each age-group of our subjects, and no-interaction was observed between them (data not shown).

Additionally, the age stratified ANCOVA demonstrated that the number of teeth decreased

with age. In addition, the number of teeth among those with MetS was significantly lower than the number of teeth among those without MetS in the 45–54 year old, 55–64 year old, and 65–74 year old age groups.

Discussion

The results of our analysis of the 2004 Japanese National Health and Nutrition Survey suggest that having fewer remaining teeth is related to MetS. This finding remained after adjusting for known confounders including age, gender, alcohol consumption, smoking, intensity of daily activity, and energy intake.

Although several diagnostic criteria for MetS have been proposed by different organizations over the past decade, we analyzed according the Japanese criteria. It did not use not body mass index but waist circumference to assess MetS. A waist circumference of 85 cm in men and 90 cm in woman indicates a visceral fat area of approximately 100 cm², which is associated with the risk of obesity-related disorders (Japan Society for the Study of Obesity, 2002). In fact, MetS as defined by the Japanese, i.e., modified waist circumference measures (≥ 90 cm in men and ≥ 80 cm in women), might be a better predictor of ischemic stroke subtype (Hata et al., 2010) and cardiovascular disease (Doi et al., 2009) in the Japanese population. Thus, waist circumference is a suitable indicator of the risk of obesity-related disorders in a

population-based study.

As mentioned above, a systematic review and meta-analysis presented clear evidence for an association between MetS and periodontitis (Nibali et al., 2013). Similar studies have also found an association between periodontal disease and obesity, hypercholesterolemia, insulin resistance, and hypertension. Moreover, most studies included in the systematic review showed a gradient effect for the association between periodontitis and number of MetS components (Andriankaja et al., 2010; Bensley et al., 2011; Han et al., 2010; Kushiya et al., 2009; Morita et al., 2009; Nesbitt et al., 2010; Shimazaki et al., 2007; Timonen et al., 2010), and another systematic review estimated that those who were overweight or obese were more likely to have periodontitis (OR=1.3 and 1.8, respectively) (Suvan et al., 2011). Furthermore, in Japan, the major reason for tooth extraction is periodontal disease (41.8%), which is common in Japanese subjects over 45 years old (Aida et al., 2006). Considering these studies, the decreased number of teeth could be a proxy for history of periodontal disease.

Previous research has also shown that elderly people who are edentulous, have fewer natural teeth, or have fewer pairs of opposing teeth have a lower nutrient intake (Nowjack-Raymer and Sheiham, 2007; Sahyoun et al., 2003; Sheiham and Steele, 2001). This may be because this population prefers soft, easily chewable food, and many of those foods generally have a lower nutritional quality (Sahyoun et al., 2003). Another study found that tooth loss among

community-dwelling, middle-aged and elderly Japanese men was associated with poor nutritional status, especially poor intake of vitamins and minerals (Ando et al., 2013). Additionally, a recent national study has shown that a low-fat high-carbohydrate diet is related to periodontal disease suggesting that malnutrition may lead to tooth loss (Hamasaki et al., 2016). Moreover, previous research has also shown that the number of natural teeth was inversely associated with the prevalence of MetS in adults in the United States (Zhu and Hollis, 2015), in rural adults in Taiwan (Tsai et al., 2015), and in women in South Korea (Kim et al., 2016).

This study has several limitations. First, the cross-sectional study design prevented us from confirming causality or identifying the mechanisms underlying the relationship between the number of teeth present and MetS. Second, many confounding factors exist, and the association between MetS and periodontal disease may be weak when compared to other confounding factors (Timonen et al., 2010). However, because we were unable to adjust for all possible confounding factors, other unexamined factors, such as socioeconomic status, might have affected the study results. Third, the analysis was based on self-reported number of teeth, which could lead to response bias; however, participants are generally good at estimating their remaining number of teeth (Buhlin et al., 2002). Therefore, longitudinal studies examining all potential confounders are needed in the future. However, despite these limitations, this study

also has some strengths. For example, this study used data derived from a nationwide population; therefore, these results had enough power and are generalizable to the larger population in Japan.

In conclusion, the results of this nationwide, population-based, cross-sectional study showed that the number of teeth present was significantly associated with MetS. Therefore, oral health may be an important indicator of general health, and individuals suffering from periodontal disease or extensive tooth loss should be referred for a general medical examination.

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Figure legends

Figure. Comparison of number of teeth present between Japanese individuals with and without metabolic syndrome (MetS) according to ANCOVA by age group. Adjusted for age (continuous variable), gender, alcohol consumption, smoking habit, intensity of daily activity, and energy intake.

Figure

Table 1. Characteristics of study participants (N=3,195) among Japanese population aged 35 years or older.

Age (years)		35-44		45-54		55-64		65-74		75-84		85-		Total	
		N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
Metabolic syndrome	Present	25	(5.0)	61	(10.2)	136	(15.8)	194	(24.2)	105	(26.9)	6	(11.8)	527	(16.5)
	Absent	471	(95.0)	537	(89.8)	723	(84.2)	607	(75.8)	285	(73.1)	45	(88.2)	2668	(83.5)
Number of teeth	28-	244	(49.2)	197	(32.9)	173	(20.1)	85	(10.6)	19	(4.9)	1	(2.0)	719	(22.5)
	20-27	233	(47.0)	302	(50.5)	445	(51.8)	301	(37.6)	76	(19.5)	5	(9.8)	1362	(42.6)
	10-19	17	(3.4)	73	(12.2)	155	(18.0)	190	(23.7)	88	(22.6)	9	(17.6)	532	(16.7)
	1-9	2	(0.4)	21	(3.5)	68	(7.9)	128	(16.0)	106	(27.2)	20	(39.2)	345	(10.8)
	0	0	(0.0)	5	(0.8)	18	(2.1)	97	(12.1)	101	(25.9)	16	(31.4)	237	(7.4)
Gender	Female	335	(67.5)	387	(64.7)	512	(59.6)	442	(55.2)	210	(53.8)	31	(60.8)	1917	(60.0)
	Male	161	(32.5)	211	(35.3)	347	(40.4)	359	(44.8)	180	(46.2)	20	(39.2)	1278	(40.0)
Alcohol consumption	Less or none	381	(76.8)	479	(80.1)	659	(76.7)	657	(82.0)	348	(89.2)	50	(98.0)	2574	(80.6)
	Habitual	115	(23.2)	119	(19.9)	200	(23.3)	144	(18.0)	42	(10.8)	1	(2.0)	621	(19.4)
Smoking habit	Never	320	(64.5)	374	(62.5)	553	(64.4)	529	(66.0)	252	(64.6)	39	(76.5)	2067	(64.7)
	Former	56	(11.3)	71	(11.9)	137	(15.9)	147	(18.4)	94	(24.1)	8	(15.7)	513	(16.1)
	Current	120	(24.2)	153	(25.6)	169	(19.7)	125	(15.6)	44	(11.3)	4	(7.8)	615	(19.2)
Intensity of daily activity	I	226	(45.6)	292	(48.8)	461	(53.7)	476	(59.4)	298	(76.4)	42	(82.4)	1795	(56.2)
	II	157	(31.7)	180	(30.1)	240	(27.9)	230	(28.7)	72	(18.5)	9	(17.6)	888	(27.8)
	III	95	(19.2)	106	(17.7)	135	(15.7)	87	(10.9)	20	(5.1)	0	(0.0)	443	(13.9)
	IV	18	(3.6)	20	(3.3)	23	(2.7)	8	(1.0)	0	(0.0)	0	(0.0)	69	(2.2)
Energy intake (kcal/day)*		1944	(550)	1979	(544)	2003	(544)	1940	(527)	1754	(474)	1699	(475)	1939	(537)

*expressed as means (SD)

Table 2. Prevalence and odds ratios for metabolic syndrome (MetS) in bivariate and multivariate logistic models.

Independent variables		Subjects with MetS		Without MetS		Crude			Adjusted		
		N (%)	N (%)	N (%)	N (%)	B	p	OR (95% CI)	B	p	OR (95% CI)
Number of teeth	28-	62 (8.6)	657 (91.4)					1.00 (Reference)			1.00 (Reference)
	20-27	196 (14.4)	1166 (85.6)			0.577	<0.001	1.78 (1.32 - 2.41)	0.419	0.009	1.52 (1.11 - 2.09)
	10-19	121 (22.7)	411 (77.3)			1.138	<0.001	3.12 (2.24 - 4.34)	0.764	<0.001	2.15 (1.50 - 3.07)
	01-09	88 (25.5)	257 (74.5)			1.289	<0.001	3.63 (2.54 - 5.18)	0.878	<0.001	2.41 (1.61 - 3.59)
	0	60 (25.3)	177 (74.7)			1.279	<0.001	3.59 (2.43 - 5.32)	0.654	0.004	1.92 (1.23 - 2.99)
Age (years)	35-44	25 (5.0)	471 (95.0)					1.00 (Reference)			1.00 (Reference)
	45-54	61 (10.2)	537 (89.8)			0.761	0.002	2.14 (1.32 - 3.46)	0.624	0.013	1.87 (1.14 - 3.04)
	55-64	136 (15.8)	723 (84.2)			1.265	<0.001	3.54 (2.28 - 5.51)	0.967	<0.001	2.63 (1.67 - 4.15)
	65-74	194 (24.2)	607 (75.8)			1.795	<0.001	6.02 (3.90 - 9.29)	1.317	<0.001	3.73 (2.35 - 5.93)
	75-84	105 (26.9)	285 (73.1)			1.937	<0.001	6.94 (4.38 - 11.00)	1.287	<0.001	3.62 (2.17 - 6.06)
	85-	6 (11.8)	45 (88.2)			0.921	0.055	2.51 (0.98 - 6.44)	0.226	0.656	1.25 (0.46 - 3.39)
Gender	Female	198 (10.3)	1719 (89.7)					1.00 (Reference)			1.00 (Reference)
	Male	329 (25.7)	949 (74.3)			1.102	<0.001	3.01 (2.48 - 3.65)	1.076	<0.001	2.93 (2.26 - 3.81)
Alcohol consumption	Less or none	401 (15.6)	2173 (84.4)					1.00 (Reference)			1.00 (Reference)
	Habitual	126 (20.3)	495 (79.7)			0.322	0.005	1.38 (1.10 - 1.72)	-0.095	0.480	0.91 (0.70 - 1.18)
Smoking habit	Never	270 (13.1)	1797 (86.9)					1.00 (Reference)			1.00 (Reference)
	Former	145 (28.3)	368 (71.7)			0.964	<0.001	2.62 (2.08 - 3.30)	0.277	0.054	1.32 (0.99 - 1.75)
	Current	112 (18.2)	503 (81.8)			0.393	0.001	1.48 (1.16 - 1.89)	-0.041	0.782	0.96 (0.72 - 1.28)
Intensity of daily activity	I	318 (17.7)	1477 (82.3)					1.00 (Reference)			1.00 (Reference)
	II	148 (16.7)	740 (83.3)			-0.074	0.500	0.93 (0.75 - 1.15)	0.060	0.604	1.06 (0.85 - 1.33)
	III	54 (12.2)	389 (87.8)			-0.439	0.005	0.64 (0.47 - 0.88)	-0.273	0.105	0.76 (0.55 - 1.06)
	IV	7 (10.1)	62 (89.9)			-0.646	0.110	0.52 (0.24 - 1.16)	-0.593	0.158	0.55 (0.24 - 1.26)
Energy intake (kcal/day)	1st quartile	129 (16.1)	670 (83.9)					1.00 (Reference)			1.00 (Reference)
	2nd quartile	117 (14.7)	681 (85.3)			-0.114	0.412	0.89 (0.68 - 1.17)	-0.207	0.161	0.81 (0.61 - 1.09)
	3rd quartile	123 (15.4)	676 (84.6)			-0.057	0.680	0.95 (0.72 - 1.24)	-0.242	0.104	0.79 (0.59 - 1.05)
	4th quartile	158 (19.8)	641 (80.2)			0.247	0.059	1.28 (0.99 - 1.65)	-0.126	0.405	0.88 (0.66 - 1.19)