Lower Frequency of Daily Teeth Brushing Is Related to High Prevalence of Cardiovascular Risk Factors

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This study sought to investigate relationships between frequency of daily teeth brushing and prevalences of diabetes mellitus, hypertension and dyslipidemia. Subjects were 54,551 residents of Chiba City, Japan (20,155 men and 34,396 women) who underwent routine health examinations in 2004. Diabetes mellitus was defined as a fasting plasma glucose level ≥126 mg/dl or a non-fasting plasma glucose level ≥200 mg/dl and/or receiving treatment for diabetes. Hypertension was defined as systolic blood pressure (SBP) ≥140 mmHg, diastolic blood pressure (DBP) ≥90 mmHg and/or receiving treatment for hypertension. Dyslipidemia was defined according to the two criteria: high triglyceride and/or low high density lipoprotein cholesterol (TG ≥ 150 mg and/or HDL-C < 40 mg/dl), and high total cholesterol (TC ≥ 220 mg/dl). According to Pearson's chi-square tests and logistic regression analysis adjusted for age, BMI, smoking habit, alcohol consumption and daily walking time, lower frequency of teeth brushing is related to higher prevalences of diabetes mellitus, hypertension and high TG and/or low HDL-C, in both men and women. Total cholesterol status, however, showed no significant relationship. Maintaining good oral hygiene by regular teeth brushing may prevent type 2 diabetes, hypertension and dyslipidemia. Exp Biol Med 234:387–394, 2009

Key words: teeth brushing; diabetes; hypertension; dyslipidemia

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Introduction

Periodontitis, a chronic inflammatory disease of the periodontal tissues, is most prevalent in middle-aged and elderly populations worldwide. At least 35% of dentate adults aged between 30 and 90 years in the US were estimated to have periodontitis, with 21.8% having a mild form and 12.6% a moderate or severe form (1). Patients with periodontitis have shown increased levels of inflammatory cytokines such as tumor necrosis factor alpha (TNF-α) and interleukin-6 (IL-6) (2–4), which lead to insulin resistance (5–10), and insulin resistance itself is an important risk factor for type 2 diabetes, hypertension and dyslipidemia (11). Elevated levels of inflammatory cytokines and systemic inflammatory markers, such as C-reactive protein (CRP), which is induced by inflammatory cytokines, are reported to be associated with the development of type 2 diabetes (11–13), hypertension (14, 15) and cardiovascular disease (16, 17). Further, periodontal disease was found to be closely related to impaired glucose tolerance and type 2 diabetes in a cross-sectional study (18), and some studies have indicated that treating periodontitis in diabetic patients has a beneficial effect on their glucose control (19, 20). High triglycerides (21–23) and low HDL cholesterol (23) have been observed in subjects with periodontal disease compared with control subjects, and several epidemiological studies have reported significant associations between periodontitis and cardiovascular disease (24, 25). The main etiological factor in the development of periodontal disease is microbiological plaque, and regular and effective removal of plaque from all surfaces of the teeth, both above and below the gingival margin, is considered essential for preventing the disease (26).

Against this background, we hypothesized that teeth brushing can prevent cardiovascular risk factors such as type 2 diabetes, hypertension and dyslipidemia. Therefore, the aim of this cross-sectional study was to investigate the

relationship between frequency of daily teeth brushing and prevalences of cardiovascular risk factors.

Materials and Methods

Subjects. In the present study, we enrolled 101,209 Japanese subjects (35,200 men and 66,009 women) aged 40–79 years from among the residents of Chiba City who underwent routine health examinations in 2004 conducted by the local governments under the Health and Medical Service Law for the aged. We excluded 41,108 subjects (13,548 men and 27,560 women) who had missing data and 5,550 (1,497 men and 4,053 women) who were prescribed medication for dyslipidemia. After exclusion, the final number of subjects in this study was 54,551 (20,155 men and 34,396 women). To evaluate reliability of the questionnaire concerning the frequency of daily teeth brushing, the subjects were followed one year apart. Of the total 54,551 subjects, 29,402 (10,470 men and 18,932 women) received routine health examinations one year later in 2005. Because we used health examination data collected by the local governments under the Health and Medical Service Law for the aged and data was anonymized by Chiba City, informed consent was not obtained from subjects. This study was approved by Chiba University Institutional Review Board.

Measurements and Questionnaire. In the 2004 health examinations, height, weight, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. Plasma glucose, serum triglyceride (TG), high density lipoprotein cholesterol (HDL-C) and total cholesterol (TC) were also measured. A self-reported questionnaire was administered to ascertain the frequency of daily teeth brushing (after every meal, 1 or 2 times per day and hardly ever), smoking habit (never smoked, current smoker and past smoker), alcohol consumption (nondrinker and drinker (alcohol $\geq$ 23 g/day, which is equivalent to sake $\geq$180 ml/day)) and daily walking time (0–29 minutes/day, 30–59 minutes/day and $\geq$60 minutes/day).

Definition of Diabetes Mellitus, Hypertension and Dyslipidemia. Diabetes mellitus was defined as a fasting plasma glucose level $\geq$126 mg/dl or a non-fasting plasma glucose level $\geq$200 mg/dl and/or receiving treatment for diabetes. Hypertension was defined as SBP $\geq$140 mmHg, DBP $\geq$ 90 mmHg and/or receiving treatment for hypertension. Dyslipidemia was defined according to the following two criteria: (i) high TG and/or low HDL-C (TG $\geq$ 150 mg and/or HDL-C $<$ 40 mg/dl) and (ii) high TC (TC $\geq$ 220 mg/dl). Since we did not know whether the treatment for dyslipidemia targeted (i) or (ii), any subject receiving treatment for dyslipidemia was excluded from this study, as mentioned above.

Statistical Analysis. The subjects were categorized into four groups on the basis of BMI: $<$18.5 kg/m^2, 18.5–25.0 kg/m^2, 25.0–30.0 kg/m^2 and $\geq$30.0 kg/m^2 according to the Japan Society for the Study of Obesity (27). The subjects were also categorized into four age groups: 40–49, 50–59, 60–69 and 70–79 years. To evaluate agreement between the questionnaires concerning frequency of daily teeth brushing administered in 2004 and 2005, the Kappa coefficient was calculated. Pearson's chi-square tests were performed in order to estimate relationships between subject characteristics and prevalences of diabetes mellitus, hypertension, high TG and/or low HDL-C and high TC. Odds ratio for diabetes mellitus, hypertension, high TG and/or low HDL-C and high TC according to the frequency of daily teeth brushing were calculated using logistic regression analysis adjusted for age, BMI, smoking habit, alcohol consumption and daily walking time. The interaction between frequency of daily teeth brushing and sex on the prevalence of diabetes, hypertension and high TG and/or low HDL-C was also evaluated by logistic regression analysis adjusted for age, BMI, smoking habit, alcohol consumption and daily walking time. Results were considered significant when two-tailed α was $<$0.05. All data were analyzed using the SPSS version 15.0 software package (SPSS Inc., Chicago, IL, USA).

Results

Of the 54,551 subjects (20,155 men and 34,396 women), 4,250 (7.8%; 2,563 men (12.7%) and 1,687 women (4.9%)) were diagnosed with diabetes mellitus, 22,639 (41.5%; 10,200 men (50.6%) and 12,439 women (36.2%)) were diagnosed with hypertension, 13,143 (24.1%; 6,603 men (32.8%) and 6,540 women (19.0%)) were diagnosed with high TG and/or low HDL-C, and 22,279 (40.8%; 5,896 men (29.3%) and 16,383 women (47.6%)) were diagnosed with high TC. The Kappa coefficient used to evaluate agreement between the questionnaires concerning frequency of daily teeth brushing that were administered in 2004 and 2005 to 29,402 subjects who received routine health examinations in both 2004 and 2005 was 0.665 ($P <$ 0.001).

The proportions according to diabetes mellitus, hypertension, high TG and/or low HDL-C and high TC in relation to subject characteristics are shown in Tables 1 to 4. Lower frequency of daily teeth brushing was related to higher prevalence of diabetes mellitus in both men and women, higher prevalence of hypertension in women and higher prevalence of high TG and/or low HDL in both men and women. The proportion according to TC status did not differ significantly according to the frequency of daily teeth brushing.

The results of logistic regression analysis are shown in Table 5. All results were adjusted for age, BMI, smoking habit, alcohol consumption and daily walking time for both men and women. The odds ratio for diabetes mellitus was higher among subjects who hardly ever brush their teeth than among those who brush after every meal. The odds

Table 1. Comparison of Subject Characteristics Between Non-Diabetes and Diabetes[a]

Characteristic	Men					Women				
	Non-diabetes		Diabetes			Non-diabetes		Diabetes		
	Number	Proportion (%)	Number	Proportion (%)	*P* value[b]	Number	Proportion (%)	Number	Proportion (%)	*P* value[b]
Frequency of daily teeth brushing										
After every meal	3,994	(88.1)	539	(11.9)	<0.001	9,550	(95.5)	446	(4.5)	<0.001
1 or 2 times per day	12,912	(87.3)	1,874	(12.7)		22,969	(95.0)	1,207	(5.0)	
Hardly ever brush teeth	686	(82.1)	150	(17.9)		190	(84.8)	34	(15.2)	
Age categories (years)										
40–49	1,433	(94.8)	79	(5.2)	<0.001	6,164	(99.2)	50	(0.8)	<0.001
50–59	2,011	(89.1)	247	(10.9)		9,677	(97.0)	304	(3.0)	
60–69	7,943	(86.8)	1,205	(13.2)		11,495	(94.2)	705	(5.8)	
70–79	6,205	(85.7)	1,032	(14.3)		5,373	(89.5)	628	(10.5)	
BMI categories (kg/m^2)										
<18.5	620	(89.2)	75	(10.8)	<0.001	2,544	(96.3)	97	(3.7)	<0.001
18.5–25.0	12,003	(87.9)	1,655	(12.1)		23,980	(96.0)	989	(4.0)	
25.0–30.0	4,673	(86.2)	746	(13.8)		5,439	(92.0)	475	(8.0)	
≥30.0	296	(77.3)	87	(22.7)		746	(85.6)	126	(14.4)	
Smoking habit										
Never smoked	9,194	(87.2)	1,354	(12.8)	0.593	29,101	(95.1)	1,508	(4.9)	0.382
Current smoker	4,869	(87.2)	717	(12.8)		2,537	(95.0)	134	(5.0)	
Past smoker	3,529	(87.8)	492	(12.2)		1,071	(96.0)	45	(4.0)	
Alcohol consumption										
Non drinker	7,913	(86.4)	1,241	(13.6)	0.001	28,710	(94.8)	1,564	(5.2)	<0.001
Drinker	9,679	(88.0)	1,322	(12.0)		3,999	(97.0)	123	(3.0)	
Daily walking time (minutes per day)										
0–29	5,704	(87.9)	785	(12.1)	0.013	11,387	(95.7)	515	(4.3)	0.001
30–59	7,080	(87.5)	1,008	(12.5)		14,646	(94.9)	787	(5.1)	
≥60	4,808	(86.2)	770	(13.8)		6,676	(94.5)	385	(5.5)	

[a] Diabetes mellitus was defined as a fasting plasma glucose level ≥126 mg/dl or a non-fasting plasma glucose level ≥200 mg/dl and/or receiving treatment for diabetes. BMI, body mass index.
[b] *P* value calculated by Pearson's chi-square test.

Table 2. Comparison of Subject Characteristic Between Non-Hypertension and Hypertension[a]

	Men					Women				
	Non-hypertension		Hypertension			Non-hypertension		Hypertension		
Characteristic	Number	Proportion (%)	Number	Proportion (%)	*P* value[b]	Number	Proportion (%)	Number	Proportion (%)	*P* value[b]
Frequency of daily teeth brushing										
After every meal	2,264	(49.9)	2,269	(50.1)	0.134	6,583	(65.9)	3,413	(34.1)	<0.001
1 or 2 times per day	7,305	(49.4)	7,481	(50.6)		15,338	(63.4)	8,838	(36.6)	
Hardly ever brush teeth	386	(46.2)	450	(53.8)		99	(44.2)	125	(55.8)	
Age categories (years)										
40–49	1,131	(74.8)	381	(25.2)	<0.001	5,535	(89.1)	679	(10.9)	<0.001
50–59	1,358	(60.1)	900	(39.9)		7,131	(71.4)	2,850	(28.6)	
60–69	4,426	(48.4)	4,722	(51.6)		6,960	(57.0)	5,240	(43.0)	
70–79	3,040	(42.0)	4,197	(58.0)		2,394	(39.9)	3,607	(60.1)	
BMI categories (kg/m^2)										
<18.5	459	(66.0)	236	(34.0)	<0.001	2,099	(79.5)	542	(20.5)	<0.001
18.5–25.0	7,248	(53.1)	6,410	(46.9)		16,986	(68.0)	7,983	(32.0)	
25.0–30.0	2,133	(39.4)	3,286	(60.6)		2,661	(45.0)	3,253	(55.0)	
≥30.0	115	(30.0)	268	(70.0)		274	(31.4)	598	(68.6)	
Smoking habit										
Never smoked	5,061	(48.0)	5,487	(52.0)	<0.001	19,310	(63.1)	11,299	(36.9)	<0.001
Current smoker	2,883	(51.6)	2,703	(48.4)		1,915	(71.7)	756	(28.3)	
Past smoker	2,011	(50.0)	2,010	(50.0)		795	(71.2)	321	(28.8)	
Alcohol consumption										
Non drinker	5,071	(55.4)	4,083	(44.6)	<0.001	19,272	(63.7)	11,002	(36.3)	<0.001
Drinker	4,884	(44.4)	6,117	(55.6)		2,748	(66.7)	1,374	(33.3)	
Daily walking time (minutes per day)										
0–29	3,335	(51.4)	3,154	(48.6)	<0.001	7,999	(67.2)	3,903	(32.8)	<0.001
30–59	3,942	(48.7)	4,146	(51.3)		9,488	(61.5)	5,945	(38.5)	
≥60	2,678	(48.0)	2,900	(52.0)		4,533	(64.2)	2,528	(35.8)	

[a] Hypertension was defined as SBP ≥ 140 mmHg, DBP ≥ 90 mmHg and/or receiving treatment for hypertension. BMI, body mass index.
[b] *P* value calculated by Pearson's chi-square test.

Table 3. Comparison of Subject Characteristics According to Triglyceride and HDL Cholesterol Status[a]

Characteristic	Men					Women				
	TG < 150 and HDL ≥ 40		TG ≥ 150 and/or HDL < 40			TG < 150 and HDL ≥ 40		TG ≥ 150 and/or HDL < 40		
	Number	Proportion (%)	Number	Proportion (%)	*P* value[b]	Number	Proportion (%)	Number	Proportion (%)	*P* value[b]
Frequency of daily teeth brushing										
After every meal	3,147	(69.4)	1,386	(30.6)	<0.001	8,325	(83.3)	1,671	(16.7)	<0.001
1 or 2 times per day	9,615	(65.0)	5,171	(35.0)		19,376	(80.1)	4,800	(19.9)	
Hardly ever brush teeth	490	(58.6)	346	(41.4)		155	(69.2)	69	(30.8)	
Age categories (years)										
40–49	885	(58.5)	627	(41.5)	<0.001	5,608	(90.2)	606	(9.8)	<0.001
50–59	1,331	(58.9)	927	(41.1)		8,122	(81.4)	1,859	(18.6)	
60–69	5,992	(65.5)	3,156	(34.5)		9,520	(78.0)	2,680	(22.0)	
70–79	5,044	(69.7)	2,193	(30.3)		4,606	(76.8)	1,395	(23.2)	
BMI categories (kg/m^2)										
<18.5	610	(87.8)	85	(12.2)	<0.001	2,471	(93.6)	170	(6.4)	<0.001
18.5–25.0	9,580	(70.1)	4,078	(29.9)		20,804	(83.3)	4,165	(16.7)	
25.0–30.0	2,895	(53.4)	2,524	(46.6)		4,021	(68.0)	1,893	(32.0)	
≥30.0	167	(43.6)	216	(56.4)		560	(64.2)	312	(35.8)	
Smoking habit										
Never smoked	7,290	(69.1)	3,258	(30.9)	<0.001	24,913	(81.4)	5,696	(18.6)	<0.001
Current smoker	3,262	(58.4)	2,324	(41.6)		2,033	(76.1)	638	(23.9)	
Past smoker	2,700	(67.1)	1,321	(32.9)		910	(81.5)	206	(18.5)	
Alcohol consumption										
Non drinker	5,872	(64.1)	3,282	(35.9)	<0.001	24,326	(80.4)	5,948	(19.6)	<0.001
Drinker	7,380	(67.1)	3,621	(32.9)		3,530	(85.6)	592	(14.4)	
Daily walking time (minutes per day)										
0–29	4,105	(63.3)	2,384	(36.7)	<0.001	9,581	(80.5)	2,321	(19.5)	0.239
30–59	5,338	(66.0)	2,750	(34.0)		12,545	(81.3)	2,888	(18.7)	
≥60	3,809	(68.3)	1,769	(31.7)		5,730	(81.1)	1,331	(18.9)	

[a] BMI, body mass index; TG, triglyceride; HDL, high density lipoprotein cholesterol.
[b] *P* value calculated by Pearson's chi-square test.

Table 4. Comparison of Subject Characteristics According to Total Cholesterol Status[a]

Characteristic	Men					Women				
	TC < 220		TC ≥ 220			TC < 220		TC ≥ 220		
	Number	Proportion (%)	Number	Proportion (%)	*P* value[b]	Number	Proportion (%)	Number	Proportion (%)	*P* value[b]
Frequency of daily teeth brushing										
After every meal	3,217	(71.0)	1,316	(29.0)	0.800	5,164	(51.7)	4,832	(48.3)	0.223
1 or 2 times per day	10,444	(70.6)	4,342	(29.4)		12,728	(52.6)	11,448	(47.4)	
Hardly ever brush teeth	598	(71.5)	238	(28.5)		121	(54.0)	103	(46.0)	
Age categories (years)										
40–49	1,005	(66.5)	507	(33.5)	<0.001	4,713	(75.8)	1,501	(24.2)	<0.001
50–59	1,483	(65.7)	775	(34.3)		4,699	(47.1)	5,282	(52.9)	
60–69	6,324	(69.1)	2,824	(30.9)		5,317	(43.6)	6,883	(56.4)	
70–79	5,447	(75.3)	1,790	(24.7)		3,284	(54.7)	2,717	(45.3)	
BMI categories (kg/m^2)										
<18.5	546	(78.6)	149	(21.4)	<0.001	1,602	(60.7)	1,039	(39.3)	<0.001
18.5–25.0	9,793	(71.7)	3,865	(28.3)		13,057	(52.3)	11,912	(47.7)	
25.0–30.0	3,677	(67.9)	1,742	(32.1)		2,909	(49.2)	3,005	(50.8)	
≥30.0	243	(63.4)	140	(36.6)		445	(51.0)	427	(49.0)	
Smoking habit										
Never smoked	7,444	(70.6)	3,104	(29.4)	<0.001	15,724	(51.4)	14,885	(48.6)	<0.001
Current smoker	4,063	(72.7)	1,523	(27.3)		1,635	(61.2)	1,036	(38.8)	
Past smoker	2,752	(68.4)	1,269	(31.6)		654	(58.6)	462	(41.4)	
Alcohol consumption										
Non drinker	6,466	(70.6)	2,688	(29.4)	0.752	15,551	(51.4)	14,723	(48.6)	<0.001
Drinker	7,793	(70.8)	3,208	(29.2)		2,462	(59.7)	1,660	(40.3)	
Daily walking time (minutes per day)										
0–29	4,595	(70.8)	1,894	(29.2)	0.165	6,468	(54.3)	5,434	(45.7)	<0.001
30–59	5,670	(70.1)	2,418	(29.9)		7,918	(51.3)	7,515	(48.7)	
≥60	3,994	(71.6)	1,584	(28.4)		3,627	(51.4)	3,434	(48.6)	

[a] BMI, body mass index; TC, total cholesterol.
[b] *P* value calculated by Pearson's chi-square test.

Table 5. Relationship Between Frequency of Daily Teeth Brushing and Prevalence of Type 2 Diabetes, Hypertension and Dyslipidemia

Frequency of daily teeth brushing / Dependent variable	After every meal		1 or 2 times per day			Hardly ever brush teeth		
	Odds ratio (95% CI)[a]		Odds ratio (95% CI)[a]		*P* value[b]	Odds ratio (95% CI)[a]		*P* value[b]
Men								
Diabetes	1.00	(reference)	1.10	(1.00–1.22)	0.062	1.61	(1.32–1.97)	<0.001
Hypertension	1.00	(reference)	1.10	(1.03–1.18)	0.007	1.24	(1.06–1.45)	0.006
TG ≥ 150 or HDL < 40	1.00	(reference)	1.08	(1.00–1.16)	0.042	1.29	(1.10–1.51)	0.002
TC ≥ 220	1.00	(reference)	0.98	(0.91–1.06)	0.617	0.96	(0.82–1.14)	0.652
Women								
Diabetes	1.00	(reference)	1.09	(0.97–1.22)	0.136	2.27	(1.53–3.37)	<0.001
Hypertension	1.00	(reference)	1.10	(1.04–1.16)	0.001	1.52	(1.14–2.03)	0.005
TG ≥ 150 or HDL < 40	1.00	(reference)	1.13	(1.06–1.20)	<0.001	1.49	(1.10–2.01)	0.009
TC ≥ 220	1.00	(reference)	0.98	(0.93–1.02)	0.319	0.91	(0.70–1.20)	0.514

[a] Odds ratios were calculated by logistic regression analysis adjusted for age, BMI, smoking habit, alcohol consumption and daily walking time. CI, confidence interval.
[b] *P* values were calculated by the logistic regression analysis, which showed the comparison with the group of "after every meal."

ratios for hypertension and high TG and/or low HDL-C were higher among subjects who brush 1 or 2 times per day and those who hardly ever brush than among those who brush their teeth after every meal. There was no significant relationship between frequency of daily teeth brushing and TC status. The interaction between frequency of teeth brushing and sex on the prevalence of diabetes, hypertension and high TG and/or low HDL-C adjusted for age, BMI, smoking habit, alcohol consumption and daily walking time was not significant ($P = 0.068$, $P = 0.269$ and $P = 0.643$, respectively). Thus, sex difference had likely no influence on the effect of teeth brushing even though the odds ratios tended to be higher in women than in men.

Discussion

In this study, lower frequency of daily teeth brushing was related to higher prevalence of diabetes mellitus, hypertension and high TG and/or low HDL-C.

Obesity is one of the most important risk factors for type 2 diabetes, hypertension and dyslipidemia. Adipose tissue is known to secrete inflammatory cytokines, such as TNF-α and IL-6 (28), both of which are the main inducers of acute-phase hepatic protein production, including CRP (28), and both of which have been shown to impair intracellular insulin signaling, which may lead to insulin resistance (5–7, 28). In humans, plasma levels of TNF-α, IL-6 and CRP are closely related to obesity and insulin resistance (8–10, 29), and the latter is an important risk factor for type 2 diabetes (12, 13) and hypertension (14, 15). Weight loss through lifestyle changes was found to be associated with a reduction in markers of inflammation such as CRP, IL-6 and adiponection (30), and also to lead to decreased fasting plasma glucose, serum insulin, homeostatic model assessment (HOMA), systolic blood pressure, diastolic blood pressure and serum triglycerides as well as increased serum HDL cholesterol (30). Inflammatory markers are known to be increased in patients with periodontal disease, a common chronic subclinical inflammation (8–10), and it is suggested that periodontal disease is closely related to type 2 diabetes (18–20), dyslipidemia (21–23) and metabolic syndrome (23). Teeth brushing is effective for removing the main etiologic factor in periodontal disease, plaque, from all surfaces of the teeth and decreasing mean pocket depth (26). Despite such a body of findings, to the authors' knowledge, the present study is the first to examine directly the relationships between teeth brushing habit and the cardiovascular risk factors of diabetes mellitus, hypertension and dyslipidemia. Our results demonstrate that lower frequency of daily teeth brushing is related to higher prevalence of diabetes mellitus, hypertension and high TG and/or low HDL-C adjusted for age, BMI, smoking habit, alcohol consumption and daily walking time. In other words, relationships exist between teeth brushing habit and prevalences of cardiovascular risk factors independent of obesity.

The Kappa coefficient of 0.665 indicated that the questionnaires concerning frequency of daily teeth brushing that were administered one year apart were in "good agreement" (31). In this study, potential confounding factors related to the prevalences of type 2 diabetes mellitus, hypertension and dyslipidemia (age, BMI, smoking habit, alcohol consumption and daily walking time) were adjusted by logistic regression analysis. Although other factors such as socioeconomic status, dietary intake, lifestyles involving eating habits of sweets and so on may confound the relationship, we could not analyze this point since information was unavailable. A longitudinal study or an intervention study would be necessary to determine the effectiveness of teeth brushing in the prevention of type 2 diabetes, hypertension and dyslipidemia.

In conclusion, the current study showed that lower frequency of daily teeth brushing was related to higher prevalences of diabetes mellitus, hypertension and high TG

and/or low HDL-C adjusted for multiple potential confounding factors.

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