

# Association between the frequency of toothbrushing and lifestyle in people with type 2 diabetes mellitus: at the baseline date of the Kamogawa-DM cohort study

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It has been reported that oral health is associated with some co-morbid conditions, including cardiovascular disease, in people with type 2 diabetes mellitus. The present study investigated the association between the frequency of toothbrushing and lifestyle in people with type 2 diabetes mellitus. This cross-sectional study included 624 outpatients at the Kyoto Prefectural University of Medicine in Kyoto, Japan from January 2014 to January 2016. Lifestyle was evaluated using a self-administered questionnaire. The average age and hemoglobin A1c level were  $67.6 \pm 10.9$  years and  $7.2 \pm 1.1\%$ , respectively. The number of patients who brushed their teeth twice or more a day was 189 (50.3%) in men and 198 (79.8%) in women. Among men, the proportion of patients living alone was lower in those who brushed their teeth twice or more a day than those who brushed their teeth never/rarely or once a day. The logistic regression analysis, after adjusting for confounding factors, revealed that living alone (odds ratio 2.88; 95% confidence interval 1.53–5.66) was associated with the increased odds of the low frequency of toothbrushing (never/rarely or once a day) in men, but not in women. In conclusion, the results of our study suggest that living alone was associated with the low frequency of toothbrushing in people with type 2 diabetes mellitus, particularly in men.

**Key Words:** frequency of toothbrushing, living alone, type 2 diabetes

Cardiovascular disease (CVD) is the primary cause of mortality and morbidity in people with type 2 diabetes mellitus, and several risk factors, such as hypertension, smoking, and dyslipidemia have been proven to prompt the progression of CVD.<sup>(1,2)</sup> Several studies have reported the association between oral health, specifically periodontal disease, and CVD.<sup>(3)</sup> Periodontal disease results from a chronic inflammation of the tissue surrounding the teeth. Oral infections due to periodontal disease may contribute to the inflammatory burden and increase the risk of CVD.<sup>(4)</sup>

As we already know, diabetes is in close relationship with periodontal disease.<sup>(5)</sup> A previous study has shown that diabetes is positively correlated with the risk of periodontal disease after adjusting for several confounding factors.<sup>(5)</sup> The study<sup>(5)</sup> reported that the rate of periodontal disease in people with type 2 diabetes mellitus was 10% higher than those without. Demmer *et al.*<sup>(6)</sup> have reported that periodontal status was associated with the levels of hemoglobin A1c in patients without diabetes.

Kobayashi *et al.*<sup>(7)</sup> have suggested that frequent toothbrushing is linked to a lower prevalence and incidence of metabolic syndrome. Further, self-reported oral hygiene behavior, such as the frequency of toothbrushing, has been reported to be associated with CVD.<sup>(8)</sup> It follows from these reports that encouraging patients to brush their teeth might help them achieve better glycemic control. A few studies<sup>(8)</sup> have reported the relation between oral health and lifestyle habits, such as smoking, in general population. It is important to investigate what kind of patients we should pay more attention to and what we need to know about the patients' backgrounds, which in turn helps us provide a better quality of care. As far as we know, there is no study that reports the association between the frequency of toothbrushing and lifestyle in people with type 2 diabetes mellitus. Therefore, we are the first to look into this association, including lifestyle parameters like marital status and living alone, in those patients.

## Materials and Methods

**Ethics.** This study was approved by the local research ethics committee of Kyoto Prefectural University of Medicine (approval number RBMR-E-466-1) and has been conducted in accordance with the ethical principles of the Declaration of Helsinki. All patients provided written informed consent prior to the enrolment in the study.

**Patients and study design.** We started the KAMOGAWA-DM cohort study in 2014 to investigate the natural history of patients with diabetes. This was a cross-sectional study conducted in 624 outpatients at the Kyoto Prefectural University of Medicine (Kyoto, Japan) from January 2014 to January 2016. All data for the present study were retrieved from the database. We excluded the following patients from our study: (i) those who used steroid treatment, (ii) those who attended a hospital for psychosis, (iii) patients with malignancy, (iv) patients with severe renal dysfunction (estimated glomerular filtration rate  $<30$  ml/min/1.73 m<sup>2</sup>), (v) patients who had undergone a renal or liver transplantation, and (vi) patients with the missing data.

**Questionnaire and measurements.** We collected the information on preferences and lifestyle using the self-administered questionnaire, which was standardized and has been previously

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validated. Five items regarding lifestyle were included. For example, a positive answer to the question of “Are you living alone?” is defined as living alone. Patients were classified into non-smokers, past smokers, or current smokers; and into coffee, tea, or alcohol drinkers, who daily drank coffee, tea, or alcohol, respectively. The patients who did any sport once a week regularly were defined as regular exercisers.<sup>(9)</sup> Fasting blood samples were collected in the morning to assess blood glucose, hemoglobin A1c, total cholesterol, triglycerides, uric acid, and creatinine. Total serum cholesterol and triglyceride levels were measured using the standard enzymatic methods. Diagnosis of diabetes was based on the report issued by the expert committee on the diagnosis and classification of diabetes.<sup>(10)</sup> Calculation of BMI was based on participant self-report by the questionnaire.

**Statistical analyses.** To evaluate the association between the patients’ characteristics and the frequency of toothbrushing, we categorized the patients according to the frequency of toothbrushing (never/rarely, once a day, or twice or more a day), referring to the criteria adopted in a previous study.<sup>(8)</sup> We defined hypertension as taking medication for hypertension. We defined hyperlipidemia as total cholesterol level  $\geq 220$  mg/dl and/or triglycerides’ level  $\geq 150$  mg/dl, or taking medication for hyperlipidemia. Owing to the differences in the lifestyle between men and women, the patients were stratified by sex to evaluate the association between lifestyle and the frequency of toothbrushing. The associations among the variables were assessed by an unpaired Student’s *t* test, ANOVA or the chi-square test. We defined never/rarely or once a day as low frequency of toothbrushing according to previous study.<sup>(8)</sup> Logistic regression analysis was conducted to examine the effects of preference and lifestyle on low frequency of toothbrushing (never/rarely or once a day). The following confounding factors were taken into consideration: smoking habit, alcohol consumption, and living alone (Model 1). In addition to all variables in Model 1, Model 2 included age, body mass index, hemoglobin A1c level, hypertension, and hyperlipidemia as the cofounding factors.

All continuous variables are presented as mean (SD) or absolute number. *P* value  $< 0.05$  was considered as statistically

significant. The size, direction, and statistical significance of relationships were estimated by the odds ratio with 95% confidence interval (CI). Statistical analyses were performed using JMP 10 (SAS Institute, Cary, NC).

## Results

The characteristics of 624 patients enrolled in this study are shown in Table 1. The average age and hemoglobin A1c level were  $67.6 \pm 10.9$  years and  $7.2 \pm 1.1\%$ , respectively. The number of patients who brushed their teeth twice or more a day was 189 (50.3%) in men and 198 (79.8%) in women. The women brushed their teeth more frequently than the men ( $p < 0.0001$ ). The proportion of low frequency of toothbrushing was higher in men than women ( $p < 0.0001$ ).

Table 2 shows the characteristics and Table 3 shows the preferences and lifestyle of the participants, stratified by the frequency of toothbrushing. Among men, the proportion of patients who consumed alcohol and lived alone was lower in patients who brushed their teeth twice or more a day than that in patients who brushed their teeth once a day. Among women, the total cholesterol level was higher in patients who brushed their teeth twice or more a day than that in patients who brushed their teeth once a day. The frequency of toothbrushing was similar in married persons and single persons among both men and women. No association was observed between the frequency of toothbrushing and lifestyle in women.

The logistic regression analysis (Table 4), after adjusting for the confounding factors, revealed that living alone (odds ratio 2.88; 95% CI: 1.53–5.66) was associated with the increased odds of the low frequency of toothbrushing (never/rarely or once a day) in men, but not in women.

## Discussion

Recently, periodontal disease has drawn more attention than ever as it has been reported to be a risk factor for a wide variety of diseases, including CVD, dementia, and some types

**Table 1.** Characteristics of patients

	All	Men	Women	<i>p</i>
<i>n</i>	624	376	248	
Age (years)	67.6 (10.9)	67.3 (11.2)	68.1 (10.4)	0.35
Duration of diabetes (years)	14.3 (10.3)	14.7 (10.8)	13.8 (9.7)	0.32
Body mass index (kg/m <sup>2</sup> )	23.5 (3.7)	23.6 (3.3)	23.2 (4.3)	0.15
Glucose (mM)	8.1 (2.7)	8.2 (2.7)	8.0 (2.7)	0.28
Hemoglobin A1c (%)	7.2 (1.1)	7.2 (1.2)	7.2 (0.9)	0.94
Total cholesterol (mM)	4.8 (0.8)	4.7 (0.8)	5.0 (0.8)	$< 0.0001$
Triglycerides (mM)	1.4 (0.9)	1.5 (1.0)	1.3 (0.7)	0.06
Uric acid ( $\mu$ M)	309.3 (83.3)	333.1 (77.3)	279.6 (77.3)	$< 0.0001$
Creatinine ( $\mu$ M)	79.6 (79.6)	88.4 (88.4)	70.7 (61.9)	0.0004
Smoking habit (past or current); <i>n</i> (%)	372 (59.6)	312 (83.0)	60 (24.2)	$< 0.0001$
Hypertension; <i>n</i> (%)	292 (46.8)	178 (47.3)	114 (46.0)	0.74
Hyperlipidemia; <i>n</i> (%)	225 (36.1)	138 (36.7)	87 (35.1)	0.68
College education; <i>n</i> (%)	220 (35.3)	175 (46.5)	45 (18.1)	$< 0.0001$
Employed; <i>n</i> (%)	258 (41.3)	193 (51.3)	65 (26.2)	$< 0.0001$
Shift worker; <i>n</i> (%)	31 (5.0)	22 (5.9)	9 (3.6)	0.21
Married; <i>n</i> (%)	405 (64.9)	260 (69.1)	145 (58.4)	0.006
Living alone; <i>n</i> (%)	87 (13.9)	52 (13.8)	35 (14.1)	0.92
Frequency of toothbrushing (never or rarely/once a day/ $\geq$ twice a day)	43/194/387	29/158/189	14/36/198	$< 0.0001$

Data are expressed as the mean (standard deviation) or absolute number.

**Table 2.** Characteristics according to frequency of toothbrushing

	Men				Women			
	Never/rarely	Once a day	≥Twice a day	<i>p</i>	Never/rarely	Once a day	≥Twice a day	<i>p</i>
<i>n</i>	29	158	189		14	36	198	
Age (years)	68.8 (12.9)	67.3 (10.6)	68.8 (12.9)	0.74	70.3 (8.3)	69.8 (10.6)	67.7 (10.5)	0.37
Duration of diabetes (years)	17.6 (12.2)	14.1 (10.3)	14.7 (10.9)	0.29	14.7 (10.4)	16.9 (9.5)	13.2 (9.6)	0.10
BMI (kg/m <sup>2</sup> )	24.7 (4.3)	23.5 (3.2)	23.6 (3.2)	0.17	24.3 (5.3)	24.1 (4.5)	22.9 (4.1)	0.20
Glucose (mM)	8.3 (2.9)	8.1 (2.4)	8.2 (3.0)	0.91	9.3 (3.7)	8.4 (2.6)	7.8 (2.6)	0.09
Hemoglobin A1c (%)	7.3 (1.2)	7.2 (1.0)	7.3 (1.4)	0.88	7.6 (0.9)	7.4 (1.2)	7.2 (0.9)	0.13
Total cholesterol (mM)	4.4 (0.6)	4.7 (0.8)	4.7 (0.9)	0.06	5.2 (0.6)	4.6 (0.8)*	5.0 (0.8)	0.01
Triglycerides (mM)	1.4 (0.6)	1.5 (1.3)	1.4 (0.9)	0.62	1.6 (0.8)	1.4 (0.6)	1.3 (0.6)	0.32
Uric acid (μM)	345.0 (77.3)	327.1 (71.4)	333.1 (77.3)	0.49	267.7 (65.4)	309.3 (83.3)	279.6 (77.3)	0.08
Creatinine (μM)	79.6 (17.7)	97.2 (114.9)	88.4 (53.0)	0.74	61.9 (17.7)	70.7 (26.5)	70.7 (61.9)	0.84
Hypertension; <i>n</i> (%)	15 (51.7)	71 (44.9)	92 (48.7)	0.70	5 (35.7)	20 (55.6)	89 (45.0)	0.37
Hyperlipidemia; <i>n</i> (%)	9 (36.7)	66 (41.8)	63 (33.3)	0.22	6 (42.9)	13 (36.1)	68 (34.3)	0.80

Data are expressed as the mean (standard deviation) or absolute number (percentage). BMI, body mass index. *P* values are from ANOVA (for continuous data) or from chi-square tests (for categorical data). \**p*<0.05, vs ≥twice a day.

**Table 3.** Preference and lifestyle according to frequency of toothbrushing

	Men				Women			
	Never/rarely	Once a day	≥Twice a day	<i>p</i>	Never/rarely	Once a day	≥Twice a day	<i>p</i>
<i>n</i>	29	158	189		14	36	198	
Smoking habit past or current; <i>n</i> (%)	24 (82.8)	135 (85.4)	153 (80.9)	0.54	4 (28.6)	13 (36.1)	43 (21.7)	0.17
Coffee drinking; <i>n</i> (%)	16 (55.2)	108 (68.4)	134 (70.9)	0.24	10 (71.4)	20 (55.6)	122 (61.6)	0.57
Tea drinking; <i>n</i> (%)	14 (48.3)	69 (43.7)	83 (43.9)	0.90	8 (57.1)	17 (47.2)	115 (58.1)	0.48
Alcohol consumption; <i>n</i> (%)	4 (13.8)	41 (26.0)*	30 (15.9)	0.045	0 (0)	4 (11.1)	8 (4.0)	0.13
College education; <i>n</i> (%)	11 (37.9)	71 (44.9)	93 (49.2)	0.46	2 (14.3)	6 (16.7)	37 (18.7)	0.89
Employed; <i>n</i> (%)	14 (48.3)	80 (50.6)	99 (52.4)	0.89	3 (21.4)	7 (19.4)	55 (27.8)	0.53
Shift worker; <i>n</i> (%)	0 (0)	10 (6.3)	12 (6.4)	0.38	0 (0)	0 (0)	9 (4.6)	0.31
Physical exercise; <i>n</i> (%)	13 (44.8)	78 (49.4)	115 (60.9)	0.05	5 (35.7)	93 (47.0)	13 (36.1)	0.38
Married; <i>n</i> (%)	150 (51.7)	109 (69.0)	136 (72.0)	0.09	9 (64.3)	21 (58.3)	115 (58.1)	0.90
Living alone; <i>n</i> (%)	4 (13.8)	32 (20.3)*	16 (8.5)	0.007	3 (21.4)	5 (13.9)	27 (13.6)	0.72

Data are expressed as the absolute number (percentage). *P* values are from chi-square tests \**p*<0.05, vs ≥twice a day.

**Table 4.** Unadjusted odds ratios and multivariate adjusted odds ratios for low frequency of toothbrushing (never/rarely or once a day)

Men	Smoking (Ref. never)	<i>p</i>	Alcohol consumption	<i>p</i>	Living alone	<i>p</i>
Crude	1.34 (0.78–2.31)	0.29	1.68 (1.01–2.83)	0.048	2.58 (1.40–4.95)	0.002
Model 1	1.36 (0.78–2.41)	0.28	1.66 (0.98–2.83)	0.06	2.75 (1.48–5.34)	0.001
Model 2	1.31 (0.74–2.35)	0.35	1.63 (0.96–2.80)	0.07	2.88 (1.53–5.66)	0.0009
Women	Smoking (Ref. never)	<i>p</i>	Alcohol consumption	<i>p</i>	Living alone	<i>p</i>
Crude	1.86 (0.93–3.62)	0.08	2.07 (0.53–6.86)	0.25	1.21 (0.48–2.74)	0.67
Model 1	1.80 (0.89–3.54)	0.10	1.86 (0.46–6.43)	0.36	1.01 (0.39–2.38)	0.98
Model 2	1.89 (0.90–3.90)	0.09	1.94 (0.47–7.03)	0.34	1.07 (0.40–2.61)	0.89

Model 1 is adjusted for smoking habit, alcohol drinking, and living alone. Model 2 includes all variables in Model 1 plus age, body mass index, hemoglobin A1c, hypertension, and hyperlipidemia.

of cancers.<sup>(3,11,12)</sup> In addition, several studies have revealed that diabetes is reciprocally associated with periodontal disease.<sup>(5,6,13,14)</sup> The data suggest that better oral hygiene may contribute to better glycemic control, and *vice versa*.<sup>(6,13,15,16)</sup> There are some studies showing the association between the frequency of toothbrushing and oral health.<sup>(17,18)</sup> Moreover, it has

been reported that the frequency of toothbrushing is associated with the risk of CVD and diabetes.<sup>(8,15,19)</sup> Taken together, these reports suggest that good oral hygiene, which can be maintained by brushing the teeth on a daily basis, may be important for preventing co-morbid conditions, including CVD, in patients with diabetes. Concerning the frequency of toothbrushing, there

are several characteristics worth pay attention to. According to the previous studies, those who brushed their teeth less often than twice a day were more likely to have diabetes and obesity, smokers and leading a sedentary life.<sup>(8)</sup> In the present study, alcohol consumption was associated with the low frequency of toothbrushing on univariate analysis in men. However, smoking habit was not associated with the low frequency of toothbrushing on univariate analysis in men and women. With reference to a previous study, we have chosen smoking habit and alcohol consumption as co-factors over other lifestyle factors on multivariate analysis.<sup>(8)</sup> Even more importantly, living alone significantly increased the odds of the low frequency of toothbrushing in men. To the best of our knowledge, this is the first study to report that living alone may be a characteristic associated with the low frequency of toothbrushing in men.

It has not yet been clear how living alone affected the practice of self-care. However, some studies have suggested that living alone affects both the physical and mental health.<sup>(20–23)</sup> Holt-Lunstad *et al.*<sup>(22)</sup> have reported that living alone is one of the risk factors for mortality. Hanna *et al.*<sup>(21)</sup> have suggested that the persons who live alone have a lower diversity of food intake; lower consumption of fruits, vegetables, and fish; and a higher likelihood of having an unhealthy dietary pattern than those who do not live alone. In our study, living alone was associated with the low frequency of toothbrushing in men, but not in women. It has been generally considered that there are several differences in lifestyle between men and women. A previous study<sup>(21)</sup> has reported that the men living alone were more often observed to have unhealthy diet than the women.

Of note, marital status had little association with the frequency of toothbrushing in our study. Therefore, the marital status may not be a matter of concern, but living alone is. There are some possible reasons why people live alone. Some might be forced to live apart from their family due to job transfer, whereas others might voluntarily choose to live alone. Even if someone is married, it does not always mean that he or she lives with their spouse or their family. Living with someone would encourage one to stick to the habits which help us stay healthy. Some people living alone might be less careful about their oral hygiene because there is no one at home who can warn them of their oral health. There were no studies which reported association between living alone and time for self-care. Previous studies<sup>(21,24)</sup> have reported that people living alone tended to have poor healthy life. Therefore, we postulated that even if people living alone have more time for self-care, they may not spend spare time for self-care. These tendencies may be particularly strong in men. In any case, living alone is associated with unhealthy lifestyle, including the frequency of toothbrushing.

Our study has a few limitations. First, there are many factors which can influence the motivation toward self-care; and every conceivable factor should ideally be identified and included in the analyses. We should evaluate the effect of other factors, such as economic status, the size of social network ties, and the frequency of going out or meeting someone else in our future studies. Second, a certain degree of recall bias might have crept in due to the use of self-administered questionnaire. However, this method is common, and the findings of our study are comparable to the results of other studies using the same method. One study using self-administered questionnaire reported a sex difference in the frequency of toothbrushing, which was consistent with our study.<sup>(8)</sup> Third, the frequency of flossing is an important part of oral hygiene. Therefore, we may need to address this association as well. Unfortunately, however, we have no data regarding the frequency of flossing.

We suggested the importance of oral hygiene to prevent CVD. However, previous studies demonstrated an association only, and could not show a causative relationship between oral hygiene and the risk of CVD. There is currently no data demonstrating that

intervening to improve oral health leads to reduced cardiovascular risk in not only people with diabetes but healthy people. It would be important to research whether oral health care can lead to prevent CVD. Further investigation using a larger population is crucial to prove and promote the importance of toothbrushing in those who have diabetes and healthy people.

In conclusion, we have deduced from the findings of our study that living alone is associated with the low frequency of toothbrushing in people with type 2 diabetes mellitus in men. It is important to focus on the frequency of toothbrushing and lifestyle in people with type 2 diabetes mellitus in clinical scene to reduce the risk of CVD. We might pay more attention to men living alone to provide a better oral health.

## Author Contributions

YS researched data and wrote manuscript, HO and MH researched data and contributed to discussion, TO, YH, SM, TS, NN, EU, MA, and MY researched data, MF researched data and reviewed/edited manuscript.

## Funding

None.

## Abbreviations

CI confidence interval  
CVD cardiovascular disease

## Conflict of Interest

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