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Dental caries experience, rather than toothbrushing, influences the incidence of dental caries in young Japanese adults

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A dose–response relationship between toothbrushing frequency and the incidence of dental caries has not been confirmed. Furthermore, no longitudinal study about this relationship has considered dental caries experience at baseline, which is an important factor influencing the frequency of future caries. ***Objective:*** To elucidate the association between the incidence of dental caries and toothbrushing frequency after adjusting for dental caries experience at baseline in a Japanese population. ***Basic research design:*** The 92 recruits of the Japan Maritime Self-Defense Force in Kure, Japan, in 2011 were followed up for 3 years. They underwent oral examination at the annual checkups and answered questions about toothbrushing frequency. ***Main outcome measures:*** The multiple logistic regression analysis was used to analyze the incidence of dental caries and to identify independent effects of toothbrushing frequency and dental caries experience at baseline. Furthermore, the relative importance of the incidence of dental caries was investigated among other independent variables using the partial adjusted R^2 score. ***Results:*** Logistic regression analysis showed that toothbrushing frequency alone did not influence the increment in decayed, missing, and filled teeth (DMFT). However, DMFT at baseline alone was associated with the increment in DMFT (crude odds ratio, OR, 1.20, 95% confidence interval, CI, 1.08,1.33). In the fully adjusted model, only DMFT at baseline was associated with the increment in DMFT (adjusted OR 1.23, 95%CI 1.09,1.38). ***Conclusion:*** After three years, the incidence of dental caries in young adult Japanese males was influenced by DMFT at baseline, rather than toothbrushing frequency.

Key words: *public dental health, epidemiology, toothbrushing, DMFT, risk factors, males, Japan*

Introduction

Toothbrushing with fluoride toothpaste is the principal method for helping prevent dental caries and periodontitis. Toothbrushing removes dental plaque mechanically and helps prevent demineralization of tooth enamel by reducing the concentration of caries-causing pathogens (Kidd and Fejerskov, 2004). Since a 1986 review (Fransden, 1986), dentists and dental associations have recommended brushing twice daily with fluoride toothpaste (Brothwell *et al*., 1998; Löe, 2000). Referring to this recommendation, most studies investigating the effects of toothbrushing frequency have evaluated the effects of brushing either "twice or more daily" or "once or less than once daily" (Bernabé *et al*., 2012; Chestnutt *et al*., 1998).

Sattelmair *et al*. (2011) showed that a relationship exists between preventive factors and incidence of disease and described it as a dose–response relationship. To the best of our knowledge, a dose–response relationship between toothbrushing frequency and the incidence of dental caries has not been clarified. To determine the most effective ways of preventing tooth decay, it is necessary to investigate this relationship.

Furthermore, the prevention of dental caries may be affected by lifestyle (Selwitz *et al*., 2007). This should be separately investigated in each country because of the lifestyle diversity. Although toothbrushing frequency correlated positively with the incidence of dental caries in the Caucasian populations, Ekuni *et al*. (2013) showed that toothbrushing frequency was not associated with dental caries experience in Japanese university students. However, this Japanese study did not consider the time course. Thus, this discrepancy in results may be explained by differences in study design. A longitudinal study would be required to establish the effect of toothbrushing on the incidence of dental caries in a Japanese population. Longitudinal studies generally consider the baseline variables. Evans *et al*. (2016), have shown that previous dental caries experience at baseline increased the likelihood of future caries. However, existing studies investigating the association between the incidence of dental caries and the toothbrushing frequency have not considered previous dental caries experience at baseline.

The objective of this longitudinal study was to elucidate the association between the incidence of dental caries and toothbrushing frequency after adjusting for the dental caries experience at baseline and smoking habits in a Japanese cohort.

Methods

Participants were recruited from the Japan Maritime Self-Defense Force in Kure, in April 2011, for oral examination during annual checkup and to answer the questionnaire described below. After a 3-year observation period, data from retained participants were again collected. The study was approved by the Ethics Committee of National Defense Medical College (approval number 2572).

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At baseline, all recruits answered a questionnaire on self-reported toothbrushing frequency and smoking. The question, "How often do you brush your teeth?" had the following possible answers: less than once per day, once per day, twice per day, or three or more times per day. Smoking was categorized as never, former, and current.

Clinical oral examinations were included at the annual checkup. Two trained dentists examined the oral health status of each of the participants. Subjects were examined supine on a dental treatment chair. The dentists used a mouth mirror and a WHO periodontal probe to record how many permanent teeth were decayed, missing, and filled teeth (DMFT). This information was entered into an online data capture system. Nineteen dentists practicing for five years or more and working to a common protocol in Japan Maritime Self-Defense Force performed follow-up examinations using the same method. Dental caries increment from baseline to follow-up was computed by subtracting the DMFT at baseline from the DMFT at follow-up. Dentists also assessed the presence of visible plaque in each subject and used this as a proxy indicator of whether toothbrushing was sufficient or insufficient.

This was a longitudinal analysis. The 3-year increment in DMFT was dichotomized into zero and more than zero and was called "unchanged" and "increased in DMFT," respectively. Multiple logistic regression analysis was used to calculate odds ratios (ORs) and 95%CI for the incidence of dental caries to identify the effects of toothbrushing frequency, dental caries experience at baseline, toothbrushing sufficiency and smoking. Furthermore, the relative importance of the incidence of dental caries was investigated among independent variables using the partial adjusted R^2 score. Analyses were performed using SAS software (v9.4; Cary, NC, USA) with $P<0.05$ was taken to indicate statistical significance.

Results

Of 133 recruits, 128 underwent oral examination during annual checkup and answered the questionnaire. After three years, data from 92 recruits were collected and analyzed. The mean age of participants was 21.0 years (SD 2.9) at baseline. Mean numbers of teeth present (SD), DMFT at baseline, and increment in DMFT at follow-up were 28.9 (1.5), 5.3 (4.8), and 1.4 (2.1), respectively. Figure 1 shows the frequency distribution of participants' DMFT increments.

No effect of toothbrushing frequency was observed on the DMFT at baseline. There were no differences in the toothbrushing frequency between subjects with increased and unchanged DMFT (Table 1). Participants with increased DMFT had higher DMFT at baseline than those with unchanged DMFT ($P<0.001$).

Logistic regression analysis (Table 2) showed that the increment in DMFT was associated with DMFT at baseline (crude OR 1.20, 95%CI 1.08,1.33) but not with toothbrushing frequency. In the fully adjusted model, again only DMFT at baseline was associated with increment in DMFT (adjusted OR 1.23, 95%CI 1.09,1.38). Furthermore, the effect of DMFT at baseline was greater than the effect of toothbrushing frequency on the increment in DMFT (partial adjusted R^2 scores were 16.4% and 3.3%, respectively).

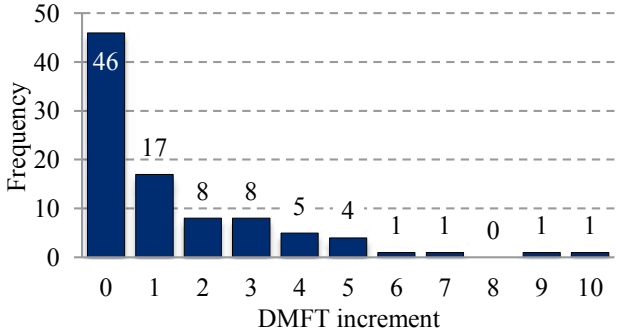

Figure 1. *The frequency distribution of participants' DMFT increments (n=92)*

Table 1. The characteristics of participants according to DMFT increment

Variable	*Number (%)*		*P value*
	unchanged (n = 46)	*increased DMFT (n = 46)*	
Tooth brushing frequency			0.34[1]
Once per day or less	14 (30.4)	9 (19.6)	
Twice per day	29 (63.1)	31 (67.4)	
More than twice per day	3 (6.5)	6 (13.0)	
Baseline DMFT, mean,*SD*	3.5, *3.6*	7.0, *5.1*	<0.001[2]
Toothbrushing sufficiency			0.13[1]
Sufficient	33 (71.7)	25 (54.4)	
Insufficient	13 (28.3)	21 (45.6)	
Smoking habit			0.82[1]
Never	39 (84.8)	36 (78.3)	
Former	2 (4.3)	2 (4.3)	
Current	5 (10.9)	8 (17.4)	

[1]Fisher's exact test; [2]Mann–Whitney–Wilcoxon test

Table 2. OR and 95% CI for participants with DMFT incre-

Variables	*Unadjusted*			*Fully adjusted (for age) model*			
	crude OR	*(95%CI)*	*P value*	*OR*	*(95%CI)*	*P value*	*partial adjusted R^2*
Toothbrushing frequency							3.3
Once per day or less (n=23)	1.00			1.00			
Twice per day (n=60)	1.66	(0.63, 4.42)	0.31	1.34	(0.43, 4.15)	0.62	
More than twice per day (n=9)	3.11	(0.62,15.71)	0.17	4.33	(0.70, 26.44)	0.11	
DMFT at baseline (unit increase)	1.20	(1.08, 1.33)	**<0.001**	1.23	(1.09, 1.38)	**<0.001**	16.4
Toothbrushing sufficiency							1.2
Sufficient (n=58)	1.00			1.00			
Insufficient (n=34)	2.13	(0.90, 5.07)	0.09	1.65	(0.62, 4.34)	0.31	
Smoking habit							1.8
Never (n=75)	1.00			1.00			
Former (n=4)	1.08	(0.15, 8.10)	0.94	0.80	(0.08, 8.41)	0.85	
Current (n=13)	1.73	(0.52, 5.79)	0.37	2.48	(0.60, 10.32)	0.21	

Discussion

We found that DMFT at baseline, rather than toothbrushing frequency, was associated with the increment in DMFT, and the dose–response relationship between toothbrushing frequency and the incidence of dental caries was not clear in young adult Japanese males.

Brushing teeth twice or more per day reduced the incidence of dental caries in Caucasian populations; therefore, there appears to be a consensus among dental professionals on the recommended toothbrushing frequency. Bernabé *et al*. (2012) reported a reduced 4-year net increment in tooth decay by brushing teeth twice a day or more compared with once a day or less in a Finnish population. Similarly, Rothen *et al*. (2014) demonstrated that brushing teeth with a fluoride toothpaste twice daily reduced the incidence of caries in northwest American dental patients. However, in this study, the frequency of toothbrushing was not associated with increased dental caries over a 3-year period. This is in agreement with a previous cross-sectional study of a Japanese population (Ekuni *et al*., 2013). Our non-significant finding of greater DMFT increment with increased brushing frequency was in the opposite direction from that expected, but probably occured by chance. These findings led us to hypothesize that the association between toothbrushing frequency and dental caries differs depending on the country. This may be explained by different health insurance systems (Shimazaki *et al*., 2001). In most western countries a preventive program including caries risk assessment, education in self-care, and dental prophylaxis (Axelsson *el al*., 2004) is covered under private dental insurance and public health programs. However, in Japan, a preventive program is not covered under public health insurance; therefore, this treatment is less affordable. The Japanese tend to give little importance to preventive care. This may explain why the finding that toothbrushing frequency did not influence the incidence of dental caries in Japan was inconsistent with that of other Caucasian studies.

DMFT at baseline was associated with the 3-year increase in dental caries. This finding was supported by a previous study (Evans *et al*., 2016), which reported that increased risk of dental caries was associated with DMFT at baseline (OR 1.17) but did not comment on the importance of this association. In epidemiology, baseline adjustments eliminate confounding variables and avoid bias (Glymour *et al*., 2005). DMFT at baseline was representative of the previous lifestyle and, therefore, was adjusted in this logistic regression analysis. In our study, the OR of the association with DMFT at baseline is the rate of increase per unit, and this result was statistically significant even if other variables were adjusted. In other words, those with more teeth with dental caries in the past will have a higher risk of future dental caries, and this risk increases exponentially. Furthermore, the DMFT at baseline had the greatest effect on incidence of dental caries. This suggests that previous dental caries experience is a high risk factor for future dental caries in young adult Japanese males. Similarly, a study of US Navy personnel found that participants with previous caries at entry into the US Navy required more restorations even after receiving complete restorative treatment, compared with patients who had no previous caries (Simecek and Diefenderfer, 2010). The researchers suggested that prevention is more important than restoration for maintaining oral health, although they did not clearly define DMFT at baseline. We did not examine preventive measures in our study; changes in preventive behavior would be difficult to monitor in this population. Limited studies have investigated preventive measures in young adults. Therefore, further study is needed to determine which changes would improve oral health and reduce the incidence of future dental caries.

This study had some limitations. First, the loss of 28% of participants to follow-up, though the baseline characteristics of those lost did not differ from those retained. Although small sample sizes can reduce certainty, baseline DMFT was found to be associated with increased DMFT. Another limitation was that fluoride use (Ismail and Hasson, 2008), sugar exposure (Moynihan and Kelly, 2014), and regular dental examinations (Aldossary *et al*., 2015) were not monitored. These factors can influence the incidence of dental caries, but we do not know how they affected the clinical outcome in this study. More than 90% of toothpastes in Japan contain fluoride (Ekuni *et al*., 2013); therefore, there should be limited bias regarding fluoride use.

Conclusion

We conclude that the increment in dental caries experience was influenced over three years by previous DMFT at baseline, rather than toothbrushing frequency, in young adult Japanese males.

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