Original Article

Sugary Snack Consumption and Tooth Retention among Middle-aged Thai Adults

Supawadee Naorungroj[1,2,3]

[1]Department of Conservative Dentistry, [2]Common Oral Diseases and Oral Epidemiology Research Center, [3]Prosthodontics and Occlusion Rehabilitation Research Unit, Faculty of Dentistry, Prince of Songkla University, Hat Yai, Thailand

Received : 04-05-20
Revised : 09-05-20
Accepted : 29-05-20
Published : 06-08-20

ABSTRACT

Objectives: This study investigated whether the habit of consuming sugary snacks was independently associated with the loss of permanent teeth. **Materials and Methods:** Eight hundred ninety-seven adults aged 35–65 from four communities in the lower regions of Southern Thailand completed a structured questionnaire interview and dental examinations. The independent variable was frequency of sweet snack consumption between meals in the previous week and coded as: never (0 days), occasionally (1–4 days), *or* frequently (≥5 days). The outcome was the number of permanent teeth (1–19 vs. ≥20 teeth). Multivariate logistic regression was used to examine the adjusted associations between sugary snack consumption and the number of retained teeth. Odds ratio (OR) and 95% confidence intervals (CI) were calculated. **Results:** Approximately 23% of participants retained fewer than 20 permanent teeth. Approximately 30% of participants reported sugary snack intake most days. Fewer teeth were positively associated with high-frequency sugary snack consumption, older age, Muslim, ≤ 6 years of education, universal healthcare, infrequent tooth brushing, smoking, and alcohol consumption, but not sugar-sweetened beverages. After adjusting for sociodemographic characteristics and other potential confounders, the odds of having fewer teeth were higher among participants who frequently consumed sugary snacks (OR = 2.03, 95% CI = 1.21–3.39), but was not significantly different from those who occasionally consumed sugary snacks (OR = 0.93; 95% CI = 0.58–1.50) compared to nonsugary snack consumers. **Conclusion:** In this study, habitual sugary snack intake was associated with fewer teeth among middle-aged Thai adults. To improve oral health and prevent further tooth loss, efforts to reduce sugary snack consumption would be needed.

Keywords: *Diets, middle-aged adults, sugar, sweet snacks, tooth loss*

Introduction

Oral health is an integral part of overall health and well-being. Evidence supports the importance of the number of natural teeth associated with an individual's nutritional, physical, and psychological status.[1,2] Thus, the number of retained teeth is an important monitoring indicator of overall health at the population level. The prevalence in Thailand of retaining 20 or more teeth has slightly increased from 96.2% in 2007 to 98.1% in 2017 for adults aged 35–44 and from 54.8% in 2007 to 56.1% in 2017 for elderly individuals (aged 65–74). However, tooth loss prevalence differs by geographic regions and is somewhat higher in the south.[3] Maintaining good oral health in the general population, especially retaining

Access this article online

Quick Response Code:

Website: www.jispcd.org

DOI: 10.4103/jispcd.JISPCD_249_20

Address for correspondence: Dr. Supawadee Naorungroj, Department of Conservative Dentistry, Faculty of Dentistry, Prince of Songkla University, Hat Yai, Songkhla 90112, Thailand.
E-mail: supawadee.n@psu.ac.th

How to cite this article: Naorungroj S. Sugary snack consumption and tooth retention among middle-aged Thai adults. J Int Soc Prevent Communit Dent 2020;10:394-401.

sufficiently functional teeth throughout an individual's life, is a challenging task for all policy makers.

Several risk and predisposing factors for tooth loss have been identified. The major causes for tooth loss in adults are periodontal disease and dental caries, both of which are preventable.[3-7] Unfortunately, there are many individuals who lose teeth during the course of their lives. Oral habits and several lifestyle-associated factors can be modified to reduce the risk of tooth loss. Practicing routine and proper oral hygiene with regular dental check-ups and having a healthy diet are essential for the prevention of oral diseases and tooth loss.[5,8]

Dietary behavior which includes high sugar and starch consumption is a common etiological risk factor for obesity, chronic metabolic disease, and oral diseases.[9-13] Previous studies showed evidence for a positive association between the amount of free sugar consumption and the risk of dental caries,[11,14] periodontal disease,[13,15] and tooth loss.[6,10] Sugar-sweetened beverages are a more likely source of free sugar among adolescents and young adults. In contrast, high-sugar snacks, such as confectionery items, cakes, and biscuits, make a greater contribution to the intake of free sugars and energy than sugar-sweetened beverages in middle-aged or older adults.[16-18] In Thailand, table sugar, sugar-sweetened beverages, and sweet snacks (baked products, crispy snacks, and traditional desserts) were the main food sources of sugar.[18] Reducing consumption of high-sugar snacks, therefore, has been suggested as having the potential to make a greater impact on population health and oral health.[11,12] However, the extent to which sugary snack consumption may affect tooth loss has not been well-described.

Gaining greater insight into the habitual consumption of sweet snacks and its influence on tooth retention can guide the design of targeted interventions. Therefore, the aim of this study is to examine whether a habit of sugary snack consumption is independently associated with having fewer than 20 teeth among Thai middle-aged adults.

Materials and Methods

Setting

The study project was approved by the Institutional Review Board of the Faculty of Dentistry, Prince of Songkla University (EC5801-01-L-LR). This study used baseline data gathered between 2015 and 2017 from a longitudinal study of tooth loss incidence and risk factors among middle-aged adults. We invited male and female adults aged 35–65 who had at least one natural tooth and were from four communities in southern Thailand: (1) La-Ngu District, Satun Province, (2) Na-yong District, Trang Province, (3) Papayom, Patthalung Province, and (4) Klong-Hoi-Khong District, Songkhla Province to participate in the study. Approximately 200–250 potential participants from each community were contacted by health volunteers. The participants who volunteered to participate in the study signed an informed consent form. Subsequently, they were given appointments for interviews and oral examinations. A total of 943 participants consented to this study.

Data collection

Data collection consisted of interviews and clinical examinations. Exposure and covariate variables were assessed via a face-to-face interview conducted by trained interviewers. The questionnaire was developed by modification of Thai national oral health survey form[3] and tested in a small focus group of adult men and women (5–8 participants of each study site) to assess comprehensiveness and understandability of the questions. A structured questionnaire comprised of sociodemographic data (e.g., age, gender, religion, years of education attained, and health insurance), health status (e.g., hypertension or diabetes), and behaviors (e.g., smoking, alcohol drinking, tooth brushing, and dietary habits). The questions inquired about the consumption from the previous week of dietary behaviors that can contribute to dental caries and erosion, which were grouped as acidic drinks (e.g., lemon juice, orange juice), acidic fruit and food, coffee/tea drinks, sugar-sweetened beverages, and sweet snacks between meals (e.g., candy, baked products, crispy snacks, and traditional desserts). The participants answered the questions with yes or no. If yes, the subjects indicated how many intakes they had in the past week. Respondents reported an "average frequency" as *never*, *1–2 days*, *3–4 days*, and *5 days or more*. On the same visit, oral examinations were carried out by a dentist. The number of teeth present, excluding root fragments and retained roots, was recorded.

Statistical analysis

In this study, we restricted the analysis to those with completed data (n = 897). The exposure variable was the frequency of consumption of sugary snacks. The responses were recategorized as: *never, occasionally* (1–4 days), and *frequently* (5 days or more). The main outcome variable was having retained teeth 1–19 vs. 20 or more teeth. The following variables were considered as potential confounders in the construction of multivariate logistic regression models: age in years (35–44, 45–54, and 55–65), gender (female, male), religion (Buddhism, Islam), years of educational attainment (≤

6, > 6), health insurance (universal healthcare, others), hypertension (yes, no), diabetes (yes, no), smoking status (current/former smoker, never smoked), alcohol drinker (current/former, nondrinker), consumption of soft drinks (frequently, occasionally, never), and tooth brushing (1 or none, 2, > 2 times/day).

Frequency distributions were calculated for dichotomy and categorical variables. Bivariate associations for sociodemographic, health status, and behaviors with the main exposure (sugary snack consumption) and the outcome of interest (the number of teeth) were examined using the chi-square test. Multivariate analysis using binary logistic regression was carried out to examine whether the consumption of sugary snacks was independently associated with the number of teeth after adjusting for other covariates. A hierarchical model adjustment was used. Variables entered in the first model were sociodemographic factors. In the fully adjusted model, health status and behavioral factors were subsequently added. Adjusted odds ratio (OR) and corresponding 95% confidence intervals were computed. The significance level used was set at $P < 0.05$. All analyses were performed using STATA version 13.1.

Results

Of 943 participants who agreed to participate in the study, 46 were excluded from the analysis due to incomplete data. The characteristics of the study samples in association with the frequency of sugary snack consumption are shown in Table 1. Nearly three quarters (74%) of study participants reported they had had sugary snacks at least once in the past week. Males comprised 27.7% of the analyzed samples and a greater proportion of them reported more frequent sugary snack consumption than did females (34.7% vs. 27.9%, respectively; $P = 0.027$). The prevalence of sugary snack intake on most days (≥ 5 days) was higher among Muslim participants (65.1%), former/current smokers (39.0%), and nonalcohol drinkers (30.6%). Approximately 21% reported tooth brushing >2 times daily and, interestingly, they were more likely to report frequent sugary snack consumption (40.1%).

Approximately 23% of these study samples had 1–19 teeth. Overall, having fewer teeth was more prevalent among older participants (55–65 years), Muslims, those with low educational attainment, and universal healthcare insurance groups. Participants with hypertension and diabetes were more likely to have fewer teeth. There was no significant difference concerning the number of retained teeth with respect to smoking, alcohol drinking, and consumption of soft drinks in the previous week. Having fewer teeth was positively associated with less frequent tooth brushing and frequent consumption of sugary snacks [Tables 2 and 3].

Crude associations and adjusted associations of sugary snack consumption and having less than 20 teeth are presented in Table 3. Compared with those on nonsugary snack consumption, the crude odds of having 1–19 teeth were higher among adults with frequent consumption of sugary snacks (OR = 3.14; 95% CI = 2.05–4.81), whereas there was no significant difference between those who occasionally consumed sugary snacks and none at all (OR = 1.03; 95% CI = 0.67–1.60). The odds of having fewer teeth among participants who frequently consumed sugary snacks were attenuated after adjusting for sociodemographic factors (OR = 2.01; 95% CI = 1.21–3.33). In the fully adjusted model, the key finding was slightly changed (OR = 2.03; 95% CI = 1.21–3.39).

Discussion

In this study, having less than 20 teeth (22.8%) and sugary snack intake between meals on most days (29.8%) were common. Social inequalities in tooth loss among middle-aged Thai adults were evidence especially for adults aged 55–65 years and Muslim participants. However, in our analyses, high-frequency consumption of sugary snacks between meals was independently associated with having fewer teeth after controlling for the sociodemographic, health status, and behavioral factors.

Loss of permanent teeth in adults and later in life was influenced by the accumulation of two common oral diseases, caries and periodontal disease, and sociobehavioral determinants. Previous epidemiological studies have identified many risk factors for tooth survival, for example, low-income and educational status, smoking, poor oral hygiene, diets high in carbohydrates, and, in particular, sugar consumption.[4,19,20] In fact, sugar plays a significant role in the occurrence and progression of caries. The fermentation of carbohydrate diets including sugar by the cariogenic bacteria in dental biofilm leads to acidic production and subsequent tooth demineralization. The causal relationship between the frequency of sugar intake and the consistency of sugar consumption and caries is well understood.[21] The intake of sweet snack in between main meals and before bedtime was associated with increased cariogenic effect as lower salivary flow rate and more frequent tooth exposure to low pH. In addition, exposure to fluoride toothpaste and oral hygiene can modify the association between the amount of sugar intake and dental caries.[22-24]

Table 1: Associations of sociodemographic, health status, and behaviors with consumption of sugary snacks in the past week (*N* = 897)

Characteristics	All *N* = 897	Consumption of sugary snacks in the past week, *n* (%)			*P* Value*
		Never *n* = 234	Occasionally *n* = 396	Frequently *n* = 267	
Sociodemographic					
Age (years)					
35–44	254 (28.3)	74 (29.1)	111 (43.7)	69 (27.2)	0.226
45–54	360 (40.1)	82 (22.8)	171 (47.5)	107 (29.7)	
55–65	283 (31.6)	78 (27.6)	114 (40.3)	91 (32.1)	
Gender					
Female	649 (72.3)	164 (25.3)	304 (46.8)	181 (27.9)	0.027*
Male	248 (27.7)	70 (28.2)	92 (37.1)	86 (34.7)	
Religion					
Buddhism	665 (74.1)	209 (31.4)	340 (51.1)	116 (17.5)	<0.001*
Islam	232 (25.9)	25 (10.8)	56 (21.1)	151 (65.1)	
Educational levels (years)					
>6 years	401 (44.7)	108 (26.9)	181 (45.1)	112 (27.9)	0.554
≤6 years	496 (55.3)	126 (25.4)	215 (43.4)	155 (31.2)	
Health insurance					
Universal healthcare	725 (80.8)	544 (75.0)	134 (18.5)	47 (6.5)	0.788
Others†	172 (19.2)	46 (26.7)	72 (41.9)	54 (31.4)	
Health status and behaviors					
Hypertension					
No	751 (83.7)	191 (25.4)	332 (44.2)	228 (30.4)	0.520
Yes	146 (16.3)	43 (29.5)	64 (43.8)	39 (26.7)	
Diabetes					
No	817 (91.1)	211 (25.8)	359 (43.9)	247 (30.2)	0.607
Yes	80 (8.9)	23 (28.8)	37 (46.2)	20 (25.0)	
Smoking					
None	715 (79.7)	183 (25.6)	336 (47.0)	196 (27.4)	0.001*
Former/current	182 (20.3)	51 (28.0)	60 (33.0)	71 (39.0)	
Alcohol drinking					
None	759 (84.6)	184 (24.2)	343 (45.2)	232 (30.6)	0.013*
Former/current	138 (15.4)	50 (36.2)	53 (38.4)	35 (25.4)	
Consumption of soft drink in the past week					
No	670 (74.7)	184 (27.4)	294 (43.9)	192 (28.7)	0.217
Yes	227 (25.3)	50 (22.0)	102 (44.9)	75 (33.1)	
Frequency of tooth brushing (per day)					
>2	187 (20.9)	43 (23.0)	69 (36.9)	75 (40.1)	0.014*
2	636 (70.9)	173 (27.2)	292 (45.9)	171 (26.9)	
1 or none	74 (8.2)	18 (24.3)	35 (47.3)	21 (28.4)	

†Civil servant medical benefit scheme and social security scheme

*$P < 0.05$, statistically significant. Chi-square testing was used to test bivariate associations between sociodemographic, health status, and behavioral variables with self-reported consumption of sugary snacks in the past week

However, the roles of sugar intake in periodontal disease are still not clearly established.[13,15] A previous report of the NHANES III study (1988–1994), showed that consumption of added sugar was positively associated with periodontal disease prevalence in adults aged 18–25.[15] It has been explained that periodontal disease is related to systemic inflammation, which may be a consequence of hyperglycemia resulting from high sugar intake.[15,20] A 6-year longitudinal study in Japan reported that the intake of cereals, nuts and seeds, sugar and other sweeteners, and confectioneries was positively associated with periodontal disease events in an elderly population. These food items may be related to dental plaque formation.[13]

Table 2: Associations of sociodemographic, health status, and behaviors with the number of teeth (N = 897)

Characteristics		All N = 897	Number of teeth, n (%)		P Value*
			≥ 20 teeth n = 692	1–19 n = 205	
Sociodemographic					
Age (years)					
	35–44	254 (28.3)	237 (93.3)	17 (6.7)	<0.001*
	45–54	360 (40.1)	286 (79.4)	74 (20.6)	
	55–65	283 (31.6)	169 (59.7)	114 (40.3)	
Gender					
	Female	649 (72.3)	501 (77.2)	148 (22.8)	0.954
	Male	248 (27.7)	191 (77.0)	57 (23.0)	
Religion					
	Buddhism	665 (74.1)	555 (83.5)	110 (16.5)	<0.001*
	Islam	232 (25.9)	137 (59.0)	95 (41.0)	
Educational levels (years)					
	>6 years	401 (44.7)	344 (85.8)	57 (14.2)	<0.001*
	≤6 years	496 (55.3)	348 (70.2)	148 (29.8)	
Health insurance					
	Universal healthcare	725 (80.8)	544 (75.0)	181 (25.0)	<0.002*
	Others†	172 (19.2)	148 (86.1)	24 (13.9)	
Health status and behaviors					
Hypertension					
	No	751 (83.7)	589 (78.4)	162 (21.6)	0.038*
	Yes	146 (16.3)	103 (70.5)	43 (29.5)	
Diabetes					
	No	817 (91.1)	638 (78.1)	179 (21.9)	0.031*
	Yes	80 (8.9)	54 (67.5)	26 (32.5)	
Smoking					
	None	715 (79.7)	557 (77.9)	158 (22.1)	0.285
	Former/current	182 (20.3)	135 (74.2)	47 (25.8)	
Alcohol drinking					
	None	759 (84.6)	582 (76.7)	177 (23.3)	0.435
	Former/current	138 (15.4)	110 (79.7)	28 (20.3)	
Consumption of soft drink in the past week					
	No	670 (74.7)	515 (76.9)	155 (23.1)	0.731
	Yes	227 (25.3)	177 (78.0)	50 (22.0)	
Consumption of sugary snacks in the past week					
	Never	234 (26.1)	196 (83.8)	38 (16.2)	<0.001*
	Occasionally	396 (44.1)	330 (83.3)	66 (16.7)	
	Frequently	267 (29.8)	166 (62.2)	101(37.8)	
Frequency of tooth brushing (per day)					
	>2	187 (20.9)	150 (80.2)	37 (19.8)	0.005*
	2	636 (70.9)	496 (78.0)	140 (22.0)	
	1 or none	74 (8.2)	46 (62.2)	28 (37.8)	

†Civil servant medical benefit scheme and social security scheme

*P < 0.05, statistically significant. Chi-square testing was used to test bivariate associations between sociodemographic, health status, and behavioral variables with the number of teeth

Findings from previous studies include a systematic review regarding the associations between sugar consumed and oral health outcomes (i.e., dental caries, periodontal diseases, or tooth loss) that were from children, adolescents, and young adults.[10,15,16,24] Excess added sugar was a strong factor with tooth decay in US children; sugar-sweetened beverages were the main source of added sugar there.[14] A study of US young adults (18–39 years) showed that increased tooth loss was associated with a higher frequency of sugar-sweetened beverages.[16] In contrast to our study, the consumption of sugary snacks between meals, but not soft drinks, was significantly associated with the number of retained teeth among middle-aged adults (35–65 years) even after controlling for all covariates. However, interpretation of the study results should be made with caution due

Table 3: Multivariate logistic regression for sugary snacks consumptions associated with having less than 20 natural teeth (*N* = 897)

Characteristics		OR (95% CI)*		
		Crude estimate	Adjusted for sociodemographic status	Fully adjusted
Consumption of sugary snacks in the past week				
	Never	Ref	Ref	Ref
	Occasionally	1.03 (0.67–1.60)	0.97 (0.61–1.55)	0.93 (0.58–1.50)
	Frequently	3.14 (2.05–4.81)	2.01 (1.21–3.33)	2.03 (1.21–3.39)
Age (years)				
	35–44	Ref	Ref	Ref
	45–54	3.61 (2.07–6.28)	3.94 (2.20–7.05)	4.09 (2.26–7.41)
	55–65	9.40 (5.44–16.24)	10.26 (5.67–18.59)	10.06 (5.44–18.60)
Gender				
	Female	Ref	Ref	Ref
	Male	1.01 (0.71–1.43)	0.78 (0.52–1.16)	0.70 (0.40–1.26)
Religion				
	Buddhism	Ref	Ref	Ref
	Islam	3.50 (2.51–4.88)	3.24 (2.13–4.93)	3.66 (2.34–5.73)
Educational levels (years)				
	>6	Ref	Ref	Ref
	≤6	2.57 (1.83–3.61)	1.51 (1.01–2.25)	1.47 (0.98–2.20)
Health insurance				
	Universal healthcare	Ref	Ref	Ref
	Others†	2.05 (1.29–3.26)	1.79 (1.06–3.05)	1.55 (0.90–2.66)
Hypertension				
	No	Ref		Ref
	Yes	1.52 (1.02–2.26)		1.00 (0.62–1.62)
Diabetes				
	No	Ref		Ref
	Yes	1.72 (1.04–2.82)		1.40 (0.77–2.55)
Smoking				
	None	Ref		Ref
	Former/current	1.23 (0.84–1.79)		0.97 (0.49–1.91)
Alcohol drinking				
	None	Ref		Ref
	Former/current	0.84 (0.53–1.31)		0.84 (0.44–1.61)
Consumption of soft drink in the past week				
	No	Ref		Ref
	Yes	0.94 (0.65–1.35)		1.20 (0.78–1.83)
Frequency of tooth brushing (per day)				
	>2	Ref		Ref
	2	1.14 (0.76–1.72)		1.70 (1.04–2.79)
	1 or none	2.47 (1.36–4.46)		3.19 (1.51–6.73)

*OR (95% CI): odds ratio and 95% confident intervals of having less than 20 teeth. Crude OR and OR adjusted for sociodemographic factors and other variables were computed using multivariate logistic regression

†Civil servant medical benefit scheme and social security scheme

to the limitations of a cross-sectional study design. There is a possibility of bidirectional associations between high-sugar consumption and dental health. As discussed previously, individuals who consumed more sugary food would have increased caries risk and then lost more teeth. Consequently, the loss of permanent teeth may limit an individual's chewing ability and food choices. Softer and soft-to-chew food as high sugar or fat-containing food may be a preference for participants with fewer teeth in another way. Healthy foods, for example, fruits, vegetables, and meat, are often more difficult to masticate for those with poor dentition. However, inconsistent results were reported.[25]

In this study, we did not collect information regarding levels and sources of sugar intake. A review by Kriengsinyos *et al.*[18] reported that frequently consumed sources of added sugar for Thai adults were table sugar, sugar-sweetened beverages, and sweet snacks (baked

products, crispy snacks, and traditional desserts). However, there is inconsistent evidence addressing intake levels and sources of added sugar. Several studies suggested reducing food containing sugar may help to decrease the risk of dental caries, periodontal disease, and tooth loss.[13,16] The latest World Health Organization (WHO) guidelines on sugar in diets for adults and children include a recommendation to limit the daily intake of free sugar to less than 10% of total energy intake. A further restriction to below 5% (i.e., 25 g) of total energy intake would protect oral health throughout a life span.[9,24,26] In these study samples, a considerable number of adults with diabetes (8.9%) and hypertension (16.3%) were also observed. The epidemic of dental caries, tooth loss, and metabolic diseases[3] shares common dietary causes. Promoting healthy nutrition and limiting the intake of added sugar from sweetened beverages and sugar-rich foods would be a key public health approach to reduce the risk of diseases and improving general health in Thailand. Dental health professionals should have knowledge of nutrition and possess the skills to educate their patients concerning the consumption of generally healthier food choices and the limiting of foods containing refined sugar and starch.[26]

We observed significant disparities in tooth loss, a finding that was consistent with that of previous studies.[5,27,28] Groups that included older participants, Muslims, those with low educational attainment, under universal health care, those who consumed sugar snacks frequently, and who brushed their teeth infrequently were more likely to experience greater loss of teeth. Permanent tooth loss prevalence in Thai adults is decreasing[3]; however, it is still a common oral health problem and can substantially impair quality of life and daily functioning throughout remaining life.[2,29] Low educational attainment appears to be associated with health and oral literacy and health-related outcomes. Individuals with low health literacy are more likely to have difficulty in the understanding and interpretation of nutrition-related information[30] and may have an unhealthy dietary style.[31] Limited oral health literacy was also associated with poor oral health behaviors, for example, a low frequency of tooth brushing, dental care for emergencies only, untreated dental caries, all of which impacts the quality of life.[32] Such result highlights the importance of improving health generally and oral health literacy specifically to maintain natural teeth and general good health.

This study is subject to some limitations. First, the use of a convenience sample may result in the possibility of selection bias. Accordingly, the association of sugary snack consumption and the number of teeth is only applicable to this study group. Second, this study collected self-reported data of the main exposure and covariates which are subject to recall bias. There was a lack of detailed information on levels and sources of added sugar and other dietary intakes; therefore, the estimated associations concerning sugary snack consumption may be under- or overestimated. Third, the cross-sectional design of the study would not allow us to draw causal inferences in relation to tooth loss. Also, information on the onset and cause of tooth loss was not available. To minimize the effects of ambiguous recall on retrospective dietary assessments, further studies with more comprehensive food frequency questionnaires should be conducted to improve understanding of the relationship with tooth loss.

Conclusion

In conclusion, habitual sugary snack consumption is common among middle-aged Thai adults. The risk of retaining fewer teeth (1–19 teeth) in participants with frequent sugary snack consumption between meals is twice that of those who reported never consuming sugary snacks in the previous week. Efforts to reduce sugary snack consumption would help prevent oral diseases and further tooth loss.

Ethical policy and institutional review board statement

The study was approved by the Institutional Review Board of the Faculty of Dentistry, Prince of Songkla University (EC5801-01-L-LR) on April 9, 2015. All the procedures have been performed as per the ethical guidelines laid down by the Declaration of Helsinki (2000) to be mentioned for all articles.

Acknowledgement

We are grateful for the support of dental staff from the La-Ngu, Na-yong, Papayom, Klong Hoi-Khong public hospitals, and health promoting hospital centers for subject recruitment. We greatly appreciate the support and data collection work of Dr. Wilailak Nurit, Dr. Pimwipa Setthaworaphan, Dr. Siriwan Apilapanon, and Dr. Worawit Sakulthai. Lastly, we are very thankful for the participation and important contributions of the study subjects.

Financial support and sponsorship

Data collection and the analysis of this project were supported by the Thailand Research Fund (grant TRF 5880169).

Conflicts of interest

There are no conflicts of interest.

Patient declaration of consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Authors contributions

Study conception, data acquisition and analysis, data interpretation, and manuscript writing (SN).

Data availability statement

The data that support the findings of this study are available on request from the corresponding author, upon reasonable request.

References

1. Tan H, Peres KG, Peres MA. Retention of teeth and oral health-related quality of life. J Dent Res 2016;95:1350-7.
2. Haag DG, Peres KG, Balasubramanian M, Brennan DS. Oral conditions and health-related quality of life: A systematic review. J Dent Res 2017;96:864-74.
3. Bureau of Dental Health. Department of Public Health. Report of the 8th Thailand National Oral Health Survey. Bangkok, Thailand: Samcharoen Panich Co. Ltd., 2017. pp. 1-330.
4. Similä T, Virtanen JI. Association between smoking intensity and duration and tooth loss among Finnish middle-aged adults: The northern Finland birth cohort 1966 project. BMC Public Health 2015;15:1141.
5. Kayama T, Iino M, Kubota I, Konta T, Ishikawa S, Ueno Y, *et al*. Risk factors for tooth loss in community-dwelling Japanese aged 40 years and older: The Yamagata (Takahata) study. Clin Oral Investig 2019;23:1753-60.
6. Tiwari T, Scarbro S, Bryant LL, Puma J. Factors associated with tooth loss in older adults in rural Colorado. J Community Health 2016;41:476-81.
7. Hassel AJ, Safaltin V, Grill S, Schröder J, Wahl HW, Klotz AL, *et al*. Risk factors for tooth loss in middle and older age after up to 10 years: An observational cohort study. Arch Oral Biol 2018;86:7-12.
8. Al-Shammari KF, Al-Khabbaz AK, Al-Ansari JM, Neiva R, Wang HL. Risk indicators for tooth loss due to periodontal disease. J Periodontol 2005;76:1910-8.
9. World Health Organization. Guideline: Sugars Intake for Adults and Children. Geneva, Switzerland: WHO; 2015. Available from: https://www.who.int/publications-detail/9789241549028. [Last accessed on 2020 Apr 20].
10. Wiener RC, Shen C, Findley PA, Sambamoorthi U, Tan X. The association between diabetes mellitus, sugar-sweetened beverages, and tooth loss in adults: Evidence from 18 states. J Am Dent Assoc 2017;148:500-509.e4.
11. Kaye EK, Heaton B, Sohn W, Rich SE, Spiro A 3rd, Garcia RI. The dietary approaches to stop hypertension diet and new and recurrent root caries events in men. J Am Geriatr Soc 2015;63:1812-9.
12. Sheiham A, James WP. Diet and dental caries: The pivotal role of free sugars reemphasized. J Dent Res 2015;94:1341-7.
13. Yoshihara A, Watanabe R, Hanada N, Miyazaki H. A longitudinal study of the relationship between diet intake and dental caries and periodontal disease in elderly Japanese subjects. Gerodontology 2009;26:130-6.
14. Chi DL, Scott JM. Added sugar and dental caries in children: A scientific update and future steps. Dent Clin North Am 2019;63:17-33.
15. Lula EC, Ribeiro CC, Hugo FN, Alves CM, Silva AA. Added sugars and periodontal disease in young adults: An analysis of NHANES III data. Am J Clin Nutr 2014;100:1182-7.
16. Kim S, Park S, Lin M. Permanent tooth loss and sugar-sweetened beverage intake in U.S. Young adults. J Public Health Dent 2017;77:148-54.
17. Lei L, Rangan A, Flood VM, Louie JC. Dietary intake and food sources of added sugar in the Australian population. Br J Nutr 2016;115:868-77.
18. Kriengsinyos W, Chan P, Amarra MSV. Consumption and sources of added sugar in Thailand: A review. Asia Pac J Clin Nutr 2018;27:262-83.
19. Van der Velden U, Abbas F, Armand S, Loos BG, Timmerman MF, Van der Weijden GA, *et al*. Java project on periodontal diseases. The natural development of periodontitis: Risk factors, risk predictors and risk determinants. J Clin Periodontol 2006;33:540-8.
20. Hujoel PP, Lingström P. Nutrition, dental caries and periodontal disease: A narrative review. J Clin Periodontol 2017;44:79-84.
21. Krasse B. The vipeholm dental caries study: Recollections and reflections 50 years later. J Dent Res 2001;80:1785-8.
22. Bernabé E, Vehkalahti MM, Sheiham A, Lundqvist A, Suominen AL. The shape of the dose-response relationship between sugars and caries in adults. J Dent Res 2016;95:167-72.
23. van Loveren C. Sugar restriction for caries prevention: Amount and frequency. Which is more important? Caries Res 2019;53:168-75.
24. Moynihan PJ, Kelly SA. Effect on caries of restricting sugars intake: Systematic review to inform WHO guidelines. J Dent Res 2014;93:8-18.
25. Gaewkhiew P, Sabbah W, Bernabé E. Does tooth loss affect dietary intake and nutritional status? A systematic review of longitudinal studies. J Dent 2017;67:1-8.
26. Moynihan P, Makino Y, Petersen PE, Ogawa H. Implications of WHO guideline on sugars for dental health professionals. Community Dent Oral Epidemiol 2018;46:1-7.
27. Srisilapanan P, Korwanich N, Lalloo R. Associations between social inequality and tooth loss in a household sample of elderly Thai people aged ≥60 years old. Gerodontology 2016;33:201-8.
28. Tsai SJ, Lin MS, Chiu WN, Jane SW, Tu LT, Chen MY. Factors associated with having less than 20 natural teeth in rural adults: A cross-sectional study. BMC Oral Health 2015;15:158.
29. Naorungroj S, Thitasomakul S. Negative impacts of self-reported five-year incident tooth loss and number of teeth on oral health-related quality of life. J Int Oral Health 2020;12:S5-12.
30. Malloy-Weir L, Cooper M. Health literacy, literacy, numeracy and nutrition label understanding and use: A scoping review of the literature. J Hum Nutr Diet 2017;30:309-25.
31. Persoskie A, Hennessy E, Nelson WL. US consumers' understanding of nutrition labels in 2013: The importance of health literacy. Prev Chronic Dis 2017;14:E86.
32. Batista MJ, Lawrence HP, Sousa MDLR. Oral health literacy and oral health outcomes in an adult population in Brazil. BMC Public Health 2017;18:60.