ASSESSING ASSOCIATIONS BETWEEN CARIES PREVALENCE AND BODY MASS INDEX AND NUTRITIONAL DATA AMONG CHILDREN AGED 6-12 YEARS

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Abstract. The purpose of this cross sectional study was to examine associations between dental caries and body mass index (BMI) and diet in 6 to 12 year old children. One hundred subjects were included in the study. The number of decayed, missing and filled teeth (DMFT), height and weight were examined in each subject. The primary caregiver for each subject completed a diet questionnaire. The data were analyzed using a chi-square test, a Fisher's exact test, a Kruskal-Wallis test and an independent sample *t*-test. Associations between variables and caries were examined using a Spearman's correlation with significance set at a *p*-value <0.05. The mean age, BMI and number of DMFT were 9.21±2.1 years old, 18.52±4.8 kg/m², and 4.03±4.36, respectively. Sixty-seven percent of subjects had a normal BMI, 24% were overweight, and 9% were underweight. Twenty-three percent of subjects had no dental caries (DMFT score=0), 23% had moderate to many caries (DMFT scores = 3.1-6.9), 22% had very many caries (DMFT scores≥ 7), 17% had few caries (DMFT scores<3). Overweight and underweight children did not have a significantly different number of DMFT than normal weight children. The number of DMFT did not correlate with reported sugar (*R*=-0.128) or carbohydrate (*R*=-0.174) consumption. There was no significant association between BMI and dental caries and amount of sugar and carbohydrate consumption and dental caries.

Keywords: dental caries, body mass index, diet, carbohydrate, sugar

INTRODUCTION

Dental caries have a high prevalence among children (Low *et al*, 1999). Dental caries cause pain, interfere with childhood growth and development, can cause children to be underweight, can cause a child to have low self-esteem (Low *et al*, 1999) and may lead to psychological problems (Vania *et al*, 2011). Even though a recent survey done in Thailand in 2012 found a decrease in caries prevalence among children compared with previous data (Dental Health Division, 2008), more than 50% of children aged 5-6 years still had a high rate of dental caries (mean DMFT scores=7.5±5.76) (Dental Health Division, 2012).

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Frequent consumption of food containing high fat, sugar, and sodium contributes to chronic diseases (Nunn *et al*, 2009). Unfavorable eating habits, frequent intake of sugary snacks and drinks (Ismail, 1998; Sohn *et al*, 2006), failure to eat breakfast daily and eating fewer than 6 servings of fruit or vegetables a day contribute to the development of dental caries (Dye *et al*, 2004; Nunn *et al*, 2009).

The relationship between dental caries and body mass index (BMI) in children has been evaluated in different countries. Some studies from developed countries, (Edalat *et al*, 2014) found snacking between meals, drinking things containing high-fructose corn syrup or sucrose, and consuming high carbohydrate foods are associated with an increase in dental caries and obesity (Neumark-Sztainer *et al*, 2003; Champagne *et al*, 2004; Hong *et al*, 2008; Oliveira *et al*, 2008; Creske *et al*, 2013; Heyden *et al*, 2013). However, in some developing countries, dental caries resulted in malnutrition and inability to consume food adequately (Macek and Mitola, 2006; Granville-Garcia *et al*, 2008; Oliveira *et al*, 2008; Hooley *et al*, 2012). Some studies have found no association between food and caries and investigated social factors (Hooley *et al*, 2012; Bagherian and Sadeghi, 2013; Shahraki *et al*, 2013).

In Thailand, studies of food and caries associations are limited. Narksawat *et al* (2009) found Thai children with a normal BMI had fewer decayed, missing and filled teeth (DMFT) than underweight children; in that study children with the fewest DMFT had a high BMI.

Diet counseling is part of preventive advice given by pediatric dentists. The US Department of Agriculture developed the Healthy Eating Index (HEI) to provide a measure of the overall quality of an individual's diet based on recommendations in "Dietary Guidelines for Americans" (Nunn *et al*, 2009). They reported consumption of a diet high in fruit, dairy products and grains reduced early childhood caries (ECC).

The INMUCAL program, a dietary analysis computer program developed for Thailand by the Institute of Nutrition, Mahidol University, is capable of analyzing nutritional data among Thais (Supasyndh *et al*, 2009). The objective of this study was to examine the association between dental caries and 2 factors: BMI and diet. This study was conducted among children aged 6-12 years. The diet was evaluated using the INMUCAL program.

MATERIALS AND METHODS

The minimal sample size was calculated based on the McNemar test using the nQuery Advisor program (Statistical Solution, Saugus, MA). The minimum number of subjects was calculated to be 100 in order to achieve a type I error=5%; Type II error = 15%; power=85% (Nunn *et al*, 2009).

Subject selection

We conducted a cross sectional study of randomly selected 3rd to 5th grade students aged 6-12 years attending Suan Missakawan or Rujiseriwitthaya School, Bangkok, Thailand. A medical history was obtained for each subject and those who had a systemic disease, were taking antibiotics, had professional fluoride application or a dental treatment during the previous 3 months were excluded from the study.

The questionnaire and nutritional recording

Participant parents or caregivers were asked to complete a questionnaire with close-ended answers. This questionnaire had been tested and used in a previous study (Mitrakul *et al*, 2013). The ques-

tions were divided into 3 categories: 1) caregiver general information (age, career, education level, monthly income, caregiver relationship with subject and subject's oral hygiene care); 2) child's general information (age, gender, dental insurance coverage, time watching television per day; 3) caregiver attitude about subject's diet (how many times a day does the subject brush their teeth, does the subject use fluoride toothpaste, when was the subject last seen by a dentist frequency of snacks, type of snack such as meat, fresh fruit, fruit juice, sugary beverages, candies, gum, crispy crackers, bread, Thai desserts, sugar coated crackers, and whether the subject eat snacks while watching television).

Caregivers were asked to retrospectively record the child's diet detail for 3 days. Nutritional data were analyzed using the INMUCAL program. This program gives nutritional information about Thai food, desserts and an analysis of daily nutrients. Nutrients of interest in this study were: total sugar intake, total carbohydrate intake, total protein intake and total cholesterol intake.

Oral examination and BMI measurement

Two undergraduate dental students were taught how to diagnose dental caries and plaque deposition. These two students conducted all the dental exams on the study subjects using natural light following World Health Organization criteria (Ismail, 1998). The inter-examiner reliability test showed high agreement between the two examiners (kappa co-efficiency=0.848). The gingiva was examined for signs of inflammation and calculus formation. Other oral problems were also recorded. The subject's weights and heights were measured using a calibrated digital scale (SECA 888 Digital Scale, Hamburg, Germany) and a standing wall measure. BMI was calculated and plotted on a graph by age (Department of Nutrition 2000). The children were categorized by BMI using WHO criteria: 1) BMI < 13.25: underweight; 2) BMI 13.26-17.5: normal; 3) BMI 17.5-18.5: overweight; 4) BMI > 18.5: obese (Mohammadi *et al*, 2012). Primary and permanent DMFT were identified and recorded. DMFT scores were calculated for each child. The scores were categorized into 4 groups based on WHO criteria: 1) DMFT < 3: few caries; 2) DMFT=3.1-4.5: moderate caries; 3) DMFT=4.6-6.9: many caries; 4) DMFT > 7: very many caries (Mohammadi *et al*, 2012).

This study was approved by the Ethics Committee on Human Research, Faculty of Pharmacy and Faculty of Dentistry, Mahidol University (MU-DT/PY-IRB 2014/044.0710). Parents of the subjects gave written informed consent prior to the subject participating in this study and prior to filling out the questionnaires. All subjects were free to withdraw from the study at any time.

Statistical analysis

Variables from the questionnaire and subject and parental demographics were analyzed using the Fisher's exact test, Kruskal-Wallis test and Independent sample *t*-test (p=0.05). Associations between variables were analyzed using the Spearman's correlation (p=0.05).

RESULTS

One hundred subjects was included in the study; there were no drop out. The mean age, BMI and DMFT were 9.21±2.1 years old, 18.52±4.8 kg/m², and 4.03±4.36, respectively. Sixty-seven percent of subjects had a normal BMI, 24% were overweight and 9% were underweight. Twenty-three percent of subjects had no

Table 1
Weight and DMFT score distribution among study subjects.

	Mean ± SD or percentage
Age (years)	0.21 ± 2.1
BMI (kg/m^2)	18.52 ± 4.8
Underweight	9%
Normal	67%
Overweight	24%
Caries (DMFT scores)	4.0 ± 4.4
No caries (0)	23%
Few caries (<3)	17%
Many caries (3.1-6.9)	23%
Very many caries (≥7)	22%

DMFT, decayed, missing and filled teeth; BMI, body mass index; SD, standard deviation.

Table 2
Selected characteristics of study subjects and their families.

Studied characteristic	Number	Mean DMFT score±SD	*p*-value
Age (years)			
6	12	4.42 ± 6.39	0.44
7	19	5.47 ± 5.76	
8	10	3.30 ± 2.71	
9	11	5.00 ± 3.87	
10	7	5.00 ± 3.74	
11	25	2.64 ± 3.12	
12	16	3.56 ± 3.56	
Total monthly family income (Baht)			
< 10,000	10	3.10 ± 1.67	0.42
10,001 - 20,000	45	3.53 ± 4.32	
20,001 - 30,000	22	4.64 ± 5.74	
30,001 - 40,000	10	6.40 ± 4.27	
40,001 - 50,000	6	3.83 ± 3.55	
> 50,000	4	3.75 ± 2.63	
Parental education level			
Primary school	16	2.19 ± 1.76	0.385
High school	40	8.53 ± 3.91	
Bachelor degree	39	4.77 ± 4.76	
Master degree	2	7.00 ± 4.24	
Eat snacks while watching TV			
Yes	42	3.40 ± 3.73	0.415
No	40	4.20 ± 5.00	
Subject gender			
Male	49	4.47 ± 4.36	0.242
Female	51	3.61 ± 4.37	

Kruskal-Wallis test and independent sample *t*-test at $p<0.05$.

Table 3
Mean BMI among study subjects by history of eating snacks while watching TV.

Eat snacks while watching TV	Number	Mean BMI±SD	*p*-value
Yes	42	18.4 ± 4.10	0.924
No	40	18.3 ± 5.37	

Independent sample *t*-test at $p<0.05$.

Table 4
Nutrients consumed per day reported by parents of study subjects.

Nutrient	DMFT score, Mean ± SD	*R*	*p*-value
Sugar (mg/day)	40.73 ± 34.69	-0.128	0.205
Carbohydrate (mg/day)	204.1 ± 66.4	-0.174	0.084
Fat (mg/day)	62.55 ± 26.11	-0.059	0.562
Protein (mg/day)	68.65 ± 28.98	-0.081	0.421
Calcium (mg/day)	534.9 ± 369.0	-0.211	0.035
Fe (mg/day)	10.13 ± 8.11	-0.002	0.986
Vitamin A (RAE)	453.2 ± 774.7	-0.054	0.596
Vitamin B1 (mg/day)	1.02 ± 1.38	-0.012	0.908
Vitamin B2 (mg/day)	1.20 ± 0.90	-0.141	0.162
Vitamin C (mg/day)	32.47 ± 67.88	-0.064	0.526
Niacin (mg/day)	11.82 ± 8.07	-0.026	0.794

dental caries (DMFT score=0), 23% had moderate to many caries (DMFT scores = 3.1-6.9), 22% had very many caries (DMFT scores ≥ 7), 17% had few caries (DMFT scores<3, Table 1). We analyzed the association between DMFT and BMI among study subjects using the Fisher's exact test and found no association.

We found no association between subject age, parental monthly income, parental education levels or gender and DMFT using the Kruskal-Wallis test and the independent sample *t*-test (Table 2).

For the association between snack eating during watching TV and BMI using independent sample *t*-test, result showed no association (Table 3). We found no association between DMFT scores and the following: BMI, amount of sugar consumed, or carbohydrate and protein consumption per day using the Spearman's correlation (Table 4, Fig 1, Fig 2 A-D).

DISCUSSION

In this study, we found no significant association between DMFT scores and carbohydrate, sugar consumption and BMI. Previous studies showed being overweight was not associated with an increased prevalence of dental caries in primary or permanent teeth nor was associated with high DMFT scores in primary dentition (Oliveira *et al*, 2008). These findings imply the relationship between being overweight and dental caries in children is complex and may not be explained by carbohydrate consumption alone (Mohammadi *et al*, 2012).

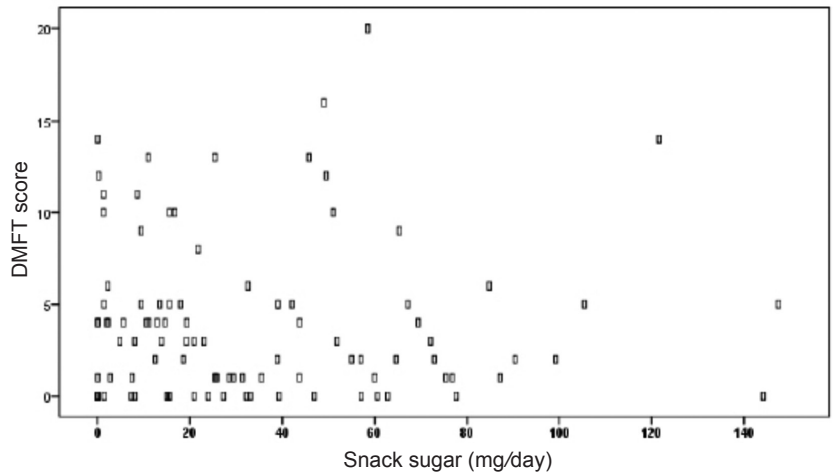

Fig 1–Scatter plot of decayed, missing and filled teeth (DMFT) score by amount of sugar consumed per day.

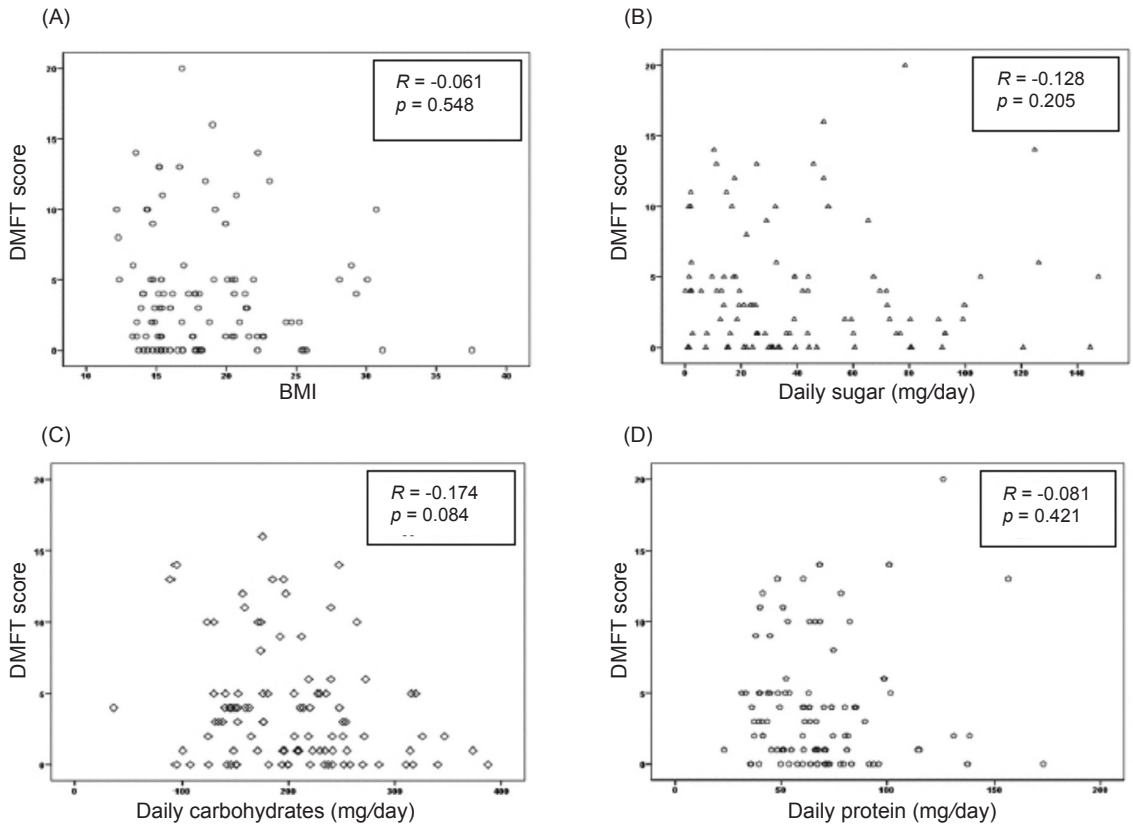

Fig 2–Scatter plots comparing the decayed, missing and filled teeth (DMFT) score with body mass index BMI (A), amount of sugar consumed (B), amount of carbohydrate consumed (C) and amount of protein consumed (D) per day.

A systematic review of the associations between obesity and dental caries among children, adolescents and adults reported in 33 papers published in English during 1984-2004 found the association (Heyden *et al*, 2013): children with either an overweight BMI or an underweight BMI had more caries and higher mean DMFT scores than children with a normal BMI (Oliveira *et al*, 2008, Mohammadi *et al*, 2012). When further categorized into permanent and primary teeth, childhood obesity was significantly associated with dental caries in permanent teeth in children (Hong *et al*, 2008).

Our study findings differ from those of Narksawat *et al* (2009) who found Thai children with a normal BMI had a lower DMFT score than those with an underweight BMI, and those with the lowest DMFT score were children with a high BMI. Previous studies in populations with high levels of nutritional deficiency found underweight children had more caries in their primary teeth (Sisson *et al*, 2009; Matheson *et al*, 2004).

There were some limitations in this study. First, no cause-effect relationship can be deduced from a cross sectional study. Second limitation of this study was missing data from the questionnaires. Parents of study subjects often did not provide data regarding parental education and income. Part of the data were obtained from self-reports and subject to recall bias. This study used convenience sampling, which did not represent the population. A larger sample size, random sampling and a diet journal for longer than 3 days would have provided more nutritional data.

Our study findings of no significant associations between caries and either BMI or diet suggests these relationships are more complex. A longitudinal study with a larger sample size is needed to better evaluate these relationships in the study population.

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