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Dietary Intake Assessment in Adults and its Association with Weight Status and Dental Caries

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Abstract: This cross-sectional study was designed to determine the relationship between dietary intake with body composition and dental caries experience among adults at the dental clinic in Universiti Kebangsaan Malaysia (UKM). The dietary compositions of the participants were estimated by using a multiple-pass 24-hour recall method. A sugar checklist was used to determine the most popular sugary food/beverages categories consumed. Anthropometric measurements (height and weight measurements) were taken. Dental caries experience was charted clinically and was reported using the Decayed/Missing/Filled Teeth Index (DMFT). Participant's consumption for cereal groups, meat groups, fruits and vegetables group met the recommendation of the Malaysian food pyramid. Male participants consumed significantly higher energy, carbohydrate, fat and sugar than female participants. The total daily added sugar intake among the caries-free group was significantly lower than that in the group with caries. There was no significant difference in energy intake, protein intake, fat intake and total sugar intake between BMI classes; however the carbohydrate intake was significantly different. A significant correlation was found between carbohydrate consumption and BMI. There was also a significant correlation between BMI and DMFT score. The most popular sugary food/beverages category among participants was sugar and sweeteners added to beverages followed by biscuits and pastry. The least popular choice was breakfast cereal. The results indicated that adults with caries consumed significantly higher amounts of added sugar in their daily diet. The study shows that sugar remains an undeniable risk for dental caries and highlights that sugary foods and beverages remains a favorite of participants.

Key words: Dietary intake, body mass index, dental caries, obesity, overweight

INTRODUCTION

A balanced diet composition is vital for attaining a healthy body. A diet that contains a high amount of fat has often been related to an increase in energy consumption and body weight (Warwick *et al*., 2002). Furthermore, a high sugar intake will lead to energy imbalance disturbances which affect postprandial metabolism, the feeling of satiety and caloric intakes (Van Baak and Astrup, 2009). The intake of fat among Malaysian adults has been reported to be increasing over the years (23% to 29%) while carbohydrate intake has decreased (63% to 59%) over the same period (Mirnalini *et al*., 2008). In addition, sugared beverages are popular in Malaysia. Almost 59% of the Malaysians reported adding sugar to beverages such as tea, coffee and chocolate-based drinks (Norimah *et al*., 2008). The consumption of high calorie and high sugar foods such as local snacks (local traditional pastry) is a part of the dietary culture among Malaysians. More than half of Malaysians (63.5%) report consuming local traditional pastry more than twice times per week (Norimah *et al*., 2008). Therefore it is not surprising to see the prevalence of overweight and obesity among Malaysians is alarmingly high (NHMS, 2006).

Another condition that is caused by frequent sugar intake is dental caries. The development of dental caries by the action of food in the mouth is the most significant effect of nutrition on the teeth. The cariogenic process consists of the progressive destruction of enamel, dentine and cementum initiated by specific cariogenic bacteria (Ann, 2009). Oral bacteria ferment dietary carbohydrates including sugar, as an energy source and produce lactic acid which can cause demineralization on the susceptible tooth surface (Slavkin, 1999). Despite very comprehensive school dental service programmes and fluoridation of the piped water supply made available and at no additional cost to the consumer, approximately nine out of ten Malaysian adults have been reported to have at least one carious tooth (NOHSA, 2000).

In Malaysia, studies have related dietary patterns with dental caries among children (Zahara *et al*., 2010), but such studies not established a relationship among adults. While teeth at the eruption stage are considered at high-risked for developing caries, adults may also develop new carious lesions due to the various lifestyle factors. Exploring the relationships between total dietary intake and dental caries experience of Malaysian adults

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will provide a foundation for more customized dietary advice for the local population.

The main aim of this study was to investigate the dietary intake of adults in dental clinic and to evaluate their dental caries experience using DMFT scores. The relationship between total dietary intake and dental caries experience was also investigated. In addition, study also identified participant's preference towards different categories of sugary beverages and food.

MATERIALS AND METHODS

Study participants: This cross-sectional study received its ethics clearance from the UKM's Research and Ethics Committee. All of the participants were approached and recruited from patients attending dental clinics at the Faculty of Dentistry at the Universiti Kebangsaan Malaysia. The inclusion criteria were Malaysian adults aged 20-59 years old who visited the UKM dental clinic. The exclusion criteria included patients who were edentulous, were pregnant, were on antibiotics, had Sjogren's syndrome or were undergoing head-neck radiation treatment. Patients who consented to participate in the study were asked to undergo the three phases of this study: the anthropometric measurements, dietary intake assessment and a clinical dental examination.

Data collection: Anthropometric measurements in this study included the body weight and height. Height was measured using a Seca Body Meter (model SECA 206 Body Meter Scale) to the nearest 0.1cm while weight was measured using an Omron Karada Scan (model HBF-356) to the nearest 0.1 kg respectively. During the measurement, participants were only allowed to wear light clothing with no shoes. The Body Mass Index (BMI) was calculated and classified according to the WHO criteria as normal (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2) and obese ($\geq$30 kg/m^2) (WHO, 2004).

The assessment of diet/nutrient intake was performed by using Multiple Pass 24-Hour Diet Recall (Moshfegh *et al*., 2001). The recall began with the first meal or beverage consumed at waking and continued until midnight of the reporting day. The participants were asked to recall the details of the food and beverages that they normally consume in a week during the interview session with the researchers. The mean of the intake of macronutrients (carbohydrate, protein, fat and total added sugar) were calculated together with the mean total calorie intake. A sugar checklist was used in the study to help to identify the highest sugary food and beverages groups consumed by the participants. According to the checklist, sugary food/beverages are divided into 8 groups. During the interview session, participants are questioned regarding which food group they normally consume; each participant is allowed to make more than one choice. Dental caries was assessed by a qualified dentist using the DMFT index and according to WHO Oral Health Basic methods (WHO, 1987).

Statistical analysis: The data were entered and analyzed using the SPSS version 18.0 (Statistical Products and Service Solution) software. Descriptive analysis was conducted using appropriate parametric tests for normally distributed data and non-parametric tests for other data. Comparisons were made between groups were done by using an independent t-test, a One Way-ANOVA, the Kruskal-Wallis test and Mann-Whitney U-Test. A p-value of <0.05 was considered statistically significant. Correlations between variables (e.g., energy intake, macronutrients intake, total daily sugar intake, BMI and DMFT index) were assessed using Spearman's rho correlation test and the Pearson correlation test.

RESULTS

Fifty-one male participants and 117 female participants agreed to participate in this study. Of the 168 participants, the majority of them were Malays (89%) followed by Chinese (9%) and Indians (2%). Among these participants, 19 participants (11.3%) were smokers but none of them consumed alcohol.

Table 1 shows that the dietary intake, anthropometric assessments and dental caries experience of the participants. The table also shows difference in energy intake and percentage of macronutrients according to gender. An independent t-test indicated that there were significant differences between male and female participants in energy and carbohydrate intake while the Mann-Whitney test showed the intake of fat and sugar of the men was significantly higher compared with that of the women. The result of the study share the similarities with MANS (2003) where the intake of energy, carbohydrate and fat was higher in men than in women; the intake of protein was the exception.

The mean carbohydrate intake of the participants was 193.9±52.4 g/day which contributed approximately 51% of the total energy intake. Participants in this study recorded a protein intake of 56.5±18.5 g/day which contributed approximately 15% of the total energy intake. The mean fat intake of the participants was 59.6±18.3 g/day which contributed 35% of the total energy intake. In addition, the mean BMI of the participants was 25.6±6.0 kg/m^2 while mean for DMFT score was 5.7±5.9.

Table 2 shows that the comparison between the dietary intake of the participants and the latest Malaysian Food Pyramid developed in year 2010. In this study, the mean serving intake of carbohydrates together with fruits and

Table 1: Participant's dietary intake, body composition and dental caries experience

Parameters	Male (n=51) Mean±SD	Female (n=117) Mean±SD	Overall (n=168) Mean±SD
Dietary intake energy			
(kcal/day)	1685.0±326*	1464.0±356	1531.0±361
Carbohydrate			
(g/day)	221.8±53.6**	181.7±47.1	193.9±52.4
% Energy	52.5±07.3	50.0±07.9	50.7±07.9
Protein			
(g/day)	58.0±16.7	55.8±19.3	56.5±18.5
% Energy	13.4±02.5	15.0±03.1	14.6±03.0
Fat			
(g/day)	64.1±17.2[a]	57.6±18.4	59.6±18.3
% Energy	34.1±06.0	35.0±06.9	34.7±06.5
Sugar			
(g/day)	56.9±27.5[a]	37.9±23.4	43.7±26.2
% Energy	13.5±06.6	10.3±05.6	11.3±06.1
Anthropometric assessment			
Weight (kg)	73.3±14.2	62.7±15.8	65.9±16.0
Height (cm)	170.1±07.1	156.4±05.1	160.5±08.6
Body mass index (kg/m^2)	25.3±04.9	25.7±06.4	25.6±06.0
Dental caries experience			
Decayed	2.0±03.5	1.2±02.2	1.4±02.7
Missing	1.1±02.2	1.7±03.5	1.5±03.1
Filled	2.5±03.1	2.8±03.8	2.7±03.6
Total DMFT Score	5.6±05.4	5.7±06.0	5.7±05.9

*Independent T test ($p<0.05$), **Independent T test ($p<0.01$), [a]Mann-Whitney U test ($p<0.05$)

Table 2: A comparison between the recommended serving to be taken per day and actual serving consumed by participants

Food group	Malaysian food pyramid recommendation No. of serving per day	No. of serving consumed by participants per day	Meet the recommendation
Cereal, cereal products and tubers	4-8[1]	6.5	Yes
Fruit and vegetables	5	5.5	Yes
Fish, poultry and meat	2-4	4.1	Yes
Milk and milk products	1-3	0.5	No

[1]Based on 30 g carbohydrates/serving

vegetables meet the recommendations. The mean serving intake of fish, poultry and meat also meets the recommendations while the mean serving intake of milk and milk products was below the recommendations.

Table 3 shows the mean dietary intake and the mean DMFT score according to different BMI categories. There were 10 participants in this study in the underweight category (6%). The percentage of participants in the overweight and obesity categories (47%) was similar to the findings of the Malaysia National Health and Morbidity Survey III (NHMS III) conducted in 2006, where 43.1% of the participants were overweight or obese.

There were significant differences in carbohydrate intake among BMI categories with the overweight and obese category had the highest carbohydrate intake. Although One Way ANOVA test (for energy) and Kruskal Wallis test (protein and fat) failed to show significant differences among BMI categories, results do show increasing trend on energy intake across BMI categories. Overall, the participants in this study averagely intake 50.9±7.9% carbohydrate, 14.7±3.0% protein, 34.9±6.5% fat to the total energy intake.

Kruskal Wallis test was done to compare dietary intake, anthropometric assessments and dental caries experience between BMI categories. Statistical analysis results show that there were no significant differences in (I) total sugar intake ($p=0.224$) (ii) DMFT index ($p=0.265$) between BMI classes (underweight, normal weight, overweight, obese).

When participants were divided into a caries-free group (DMFT=0) and into a with-caries group (DMFT≠0), the Mann-Whitney U-test showed that total added sugar intake among the caries-free group (35.2±20.6 g/day) was significantly lower than that in the with-caries group (45.9±27.1 g/day) in Table 4.

Using the sugar checklist, the participants were interviewed to identify the sugary food beverages groups normally consumed by them. Figure 1 shows the majority of the total participants (156 participants; 92.9% of total participants) consume added sugar and sweeteners as a part of their daily diet. The participants usually add sugar or sweet condensed milk to beverages such as tea, coffee or chocolate drinks. The second highest sweet food/beverages group intake was biscuits, bun, cake and pastry with 82 participants (48.8% of total participants) consuming food from this category every day. In addition, almost the same number of the participants (76 participants; 45.2% of total participants) consumed carbonated drinks and squash/cordial. The least-common food/beverage group

Table 3: Participant's dietary intake and dental caries experience according to BMI category

Parameters	BMI Categories		
	Underweight (n=10)	Normal (n=79)	Overweight and obese (n=79)
Dietary intake energy			
Mean±SD (kcal/day)	1446.0±394	1501.0±365	1573.0±353
Carbohydrate*			
Mean±SD (g/day)	174.1±47.9[a]	186.4±48.8[ac]	203.8±55.0[b]
% Energy	48.8±06.7	50.0±08.3	51.7±07.6
Protein			
Mean±SD (g/day)	52.8±13.6	56.4±19.7	57.0±17.9
% Energy	14.8±02.9	14.8±03.2	14.3±03.0
Fat			
Mean±SD (g/day)	60.0±23.5	59.7±19.9	59.4±16.0
% Energy	36.4±05.8	35.2±06.9	34.0±06.1
Sugar			
Mean±SD (g/day)	28.2±20.0	44.1±27.7	45.2±24.8
% Energy	8.0±05.8	11.7±06.4	11.4±05.9
Dental caries experience**			
Decayed	2.9±05.9	1.3±02.4	1.4±02.3
Missing	0.1±00.3[a]	0.7±01.9[b]	2.5±03.9[c]
Filled	2.9±05.1	2.5±03.1	2.9±03.8
Total DMFT Score	5.9±07.3	4.5±04.6	6.8±06.5

*Kruskal Wallis Test ($p<0.05$), **Kruskal Wallis Test ($p<0.01$). [abc]Different alphabets indicate significant difference

Table 4: Participant's dietary intake, body composition and dental caries experience according to dental caries experience

Parameters	With caries (n=133) Mean±SD	Caries free (n=35) Mean±SD
Dietary intake energy		
(kcal/day)	1540.0±378	1500.0±289
Carbohydrate		
(g/day)	196.0±55.0	185.8±40.8
% Energy	49.4±05.6	51.1±08.4
Protein		
(g/day)	57.0±19.4	54.6±14.8
% Energy	14.4±02.8	14.5±03.1
Fat		
(g/day)	59.3±19.1	60.5±14.8
% Energy	36.2±04.6	34.4±06.9
Sugar		
(g/day)	45.9±27.1[a]	35.2±20.6
% Energy	9.3±05.0	11.9±06.3
Anthropometrric assessment		
Weight (kg)	65.9±15.7	65.9±17.6
Height (cm)	160.5±08.8	160.7±07.9
Body mass index (kg/m^2)	25.6±05.8	25.5±06.9
Dental caries experience		
Decayed	1.80±2.87	0.00
Missing	1.89±3.42	0.00
Filled	3.45±3.68	0.00
Total DMFT Score	7.14±5.71	0.00

[a]Mann-Whitney U test ($p<0.05$)

choice was breakfast cereal with only 10 participants (6.0%) of total participants consume food from this category daily. Another finding was that 31% of the total participants (52 participants) ate confectionery foods as snack. Surprisingly, the traditional pastry group which is an important part of Malaysian food culture, was only the fifth-highest among the eight groups with 41 participants (24.4%) consuming food from this category daily.

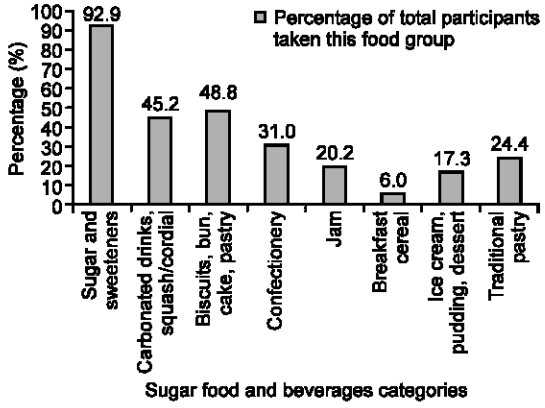

Fig. 1: Participant's choices in sugary food/beverages group

According to Table 5, there were similarities in sugary food/beverages group choices for caries-free group and with-caries group. The most popular sugary food/beverages group for both groups were sugar and sweeteners followed by biscuits, bun, cake and pastry. The least-popular sugary food choices for both groups were breakfast cereal. The intake percentage of with-caries group in certain food groups such as confectionary, jam, ice cream, dessert and traditional pastry was higher than the intake percentage of caries-free group.

The relationship between BMI as well as dental caries and the intake of energy and macronutrients were analyzed by using correlation test. Among intake of energy and macronutrients, only carbohydrates showed a significant but weak correlation with BMI ($r=0.034$)($p=0.016$). The Spearman's rho correlation test

Table 5: Participant's choices in sugary food/beverages group according to dental status group

	With-caries group (n=133)		Caries-free group (n=35)	
Sugary food/beverages group	No.	Percentage (%)	No.	Percentage (%)
Sugar and sweeteners	123	92.5	33	94.3
Carbonated drinks, squash/cordial	62	46.6	14	40.0
Biscuits, bun, cake, pastry	66	49.6	16	45.7
Confectionery	44	33.1	8	24.2
Jam	30	22.6	4	11.4
Breakfast cereal	9	6.8	1	3.0
Ice cream, pudding, dessert	26	19.5	3	8.6
Traditional pastry	37	27.8	4	11.4

indicated that there were no significant correlations between total daily sugar intakes and (I) Body Mass Index (r=0.069)(p=0.374) or (ii) DMFT index (r=0.055)(p=0.476). However, a significant but very weak correlation was found between BMI and DMFT index (r=0.156)(p=0.044).

DISCUSSION

The mean energy intake per day in this study was 1531±361 kcal. Several studies of various communities throughout the country reported that Malaysian energy intake ranged from 1600kcal to 2000kcal (Mirnalini *et al*., 2008). The mean energy intake reported in this study was lower compared with previous reports. However, previous studies might not be comparable to this study because the study population and dietary assessment methods were different. This study used dietary data in the central zone from the Malaysian Adult Nutrition Survey (MANS) (2003) for comparison because the location of the study; the Dental Clinic UKM is located near the city centre of Kuala Lumpur, the capital of the country. The MANS (2003) reported mean total daily energy intake for adults in the Central Zone of Malaysia of 1577 kcal±17 kcal (Mirnalini *et al*., 2008). One sample T-test indicated that there was no significant difference in the energy intake between MANS 2003 and this study, t(167) = -1.658, p=0.099.

The quality of the diet and the distribution of macronutrients for individuals can be assessed by using the proportion of energy derived from macronutrients (Mattison *et al*., 2001). This study reported changes in the relative contribution of the macronutrients to the daily energy intake. Using the Recommended Nutrient Intakes (RNIs) for Malaysian (NCCFN, 2005) as reference, it was clear that the carbohydrate intake (51%) among participants was below the recommended level (55%-70% of total energy intake) while the fat intake (35%) was above the recommended level (20%-30% of total energy intake). Protein intake remained in the recommended range (15% of total energy intake). Compared with Mirnalini *et al*. (2008) and Chee *et al*. (1997), participants had increased their fat energy-derived intake from 23% to 35% while on the same time their carbohydrate energy derived intake decreased from 63% to approximately 51%. Decrease in the intake of certain nutrients will definitely increase the intake of other diet components. According to the latest Malaysian food pyramid (NCCFN, 2010), there are five food groups situated in four levels. Cereal, tubers and grain group located at the base of the pyramid. The numbers of serving for this group is 4 to 8 serving per day. However size of serving for this group is different compared with the previous food pyramid. One serving of food contains 30 g carbohydrates while in the previous dietary guideline (NCCFN, 1999), one serving of food only contains 15 g carbohydrates. In this study, the intake of cereal group met the recommendations as well as the intake of fruits and vegetables group. The consumption of the meat group was also met the recommendation while the consumption of the milk group was below the recommendation. This study shares similarity with MANS (2003) (Norimah *et al*., 2008) where participant's consumption in certain food groups such as cereal group, fruits and vegetables group met the recommendation while the consumption of milk group was below the recommendation.

Distinct differences between gender in the intake of energy and certain macronutrients (carbohydrate and fat) might be due to differences in metabolic rate. Differences in metabolic rate are primary due to differences in body size and body composition (Mahan and Escott, 2004). The metabolic rates of women, who usually have more fat than men, are approximately 5% to 10% lower than men of the same weight and height. This difference may be a powerful explanation for why men are eating more than women. Increases in energy intake will automatically bring increases in the intake of dietary components which is mainly made up by the major macronutrient classes such as carbohydrate and fat.

The finding of this study also indicates that male participants consumed higher amounts of added sugar than female participants. These results are similar to NHANES data (1999-2004) from the USA where 20 to 44 year-old males consumed significantly greater quantities of sugar-sweetened beverages than women. The expected relationships between added sugars intake by gender were also found among adults

(Frances *et al*., 2009). The current study failed to demonstrate any significant relationship between the intake of other macronutrients and body mass index, except for the intake of carbohydrates. These results are similar to Ahluwalia *et al*. (2009) who showed that the intake of carbohydrates among adults had a significant relationship with BMI and waist circumference.

Relationship between sugar and dental caries remains complex because "side effects" such as plaque status, saliva, bacteria level and host factor also play a roles in caries formation. Because of the exposure to fluoride in the modern age (water and dentifrice fluoridation), the relationship between sugar consumption and caries is much weaker than it was historically (Burt and Pai, 2000). Some studies have shown significant relationships between the amount of sugar consumed and caries status, while others have not (Edwina, 2004). On the other hand, the DMFT score represents a lifetime of caries experiences and this may not correspond to a 'snapshot' dietary recall (Edwina, 2004). Dietary recall only records participant's current eating habits while the DMFT score accumulates as the participant matures. In our study, there were significant differences between caries groups in the amount of added sugar amount consumed, although a correlation between sugar and dental caries was not established. In conclusion, controlling sugar consumption remains a justifiable part of caries prevention efforts as attempts over the past 100 years to make safe foods and drinks in a modern diet have not been overly successful (Burt and Pai, 2000).

In this study, significant correlation was found between BMI and DMFT score but Kruskal Willis test failed to show any significant difference in DMFT score among BMI categories. Overweight and obesity may indirectly affect dental caries status through reduction of saliva secretion rate (Flink *et al*., 2008). But this study didn't involve any saliva examination to prove the theory. Although obesity and caries share some common risk factors, the association remains elusive. There are limited studies to link overweight, obesity with dental caries (Kantovitz *et al*., 2006). In future, saliva examination can be included in studies to investigate relationship between overweight, obesity and dental caries.

Conclusion: The findings from this study provide important baseline information on dietary intake, body composition and dental caries in a group of Malaysian adults regardless of its limitations. The study found that carbohydrate intake was below recommendations while fat intake was above recommendation. The mean intake of the energy, carbohydrate and sugar were higher among male participants than among the female participants. Correlations were reported between energy, carbohydrate and fat with body weight, as well as carbohydrate with BMI. The study failed to report any significant relationship between sugar intake and body weight, body mass index and DMFT score. However, BMI was correlated with dental caries experience. With these preliminary data, this study can facilitate future study throughout Malaysia, to obtain a better picture of the associations of diet with body composition and dental caries and to monitor public adherence towards dietary and dental recommendations.

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