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Correlation between carbohydrate intake and dental caries in obese individuals

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ABSTRACT

Background: *Nowadays, obesity is one of the biggest public health problems. Obesity is an excessive accumulation of fat that can occur when fat-producing foods, such as carbohydrates or sugar, are over-consumed. Sucrose is a type of carbohydrate contained in food and is a medium for bacterial growth. Therefore, the consumption of sucrose can increase the risk of dental caries.* **Purpose:** *This study aims to analyse the correlation between carbohydrate intake and dental caries in obese individuals.* **Methods:** *This study was an observational analytic study with a cross-sectional design. In this study, 50 participants aged 18–40 were selected from an obese community in Jakarta using a quota sampling technique. The carbohydrate intake was assessed using the food frequency questionnaire (FFQ), the body fat percentage was measured with the bioelectrical impedance analysis method, and the dental caries index was assessed using the decayed, missing and filled teeth (DMF-T) index. The data obtained were tested with a simple linear regression statistical test at a significance level of 5%.* **Results:** *The results showed that the average carbohydrate daily intake value of obese individuals was 1209.84 g, while the average value of the DMF-T index for obese individuals was 7.98. The results of the statistical tests revealed that there was a strong and positive correlation between carbohydrate intake and the DMF-T index. The effect of carbohydrate intake on the DMF-T index was 50.98%.* **Conclusion:** *A positive correlation means that the larger the carbohydrate intake, the higher the DMF-T index. Hence, controlling carbohydrate intake can prevent dental caries.*

Keywords: *carbohydrate intake; DMF-T index; FFQ; obesity*

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INTRODUCTION

Oral disease, especially dental caries, is one of the most common diseases worldwide. Dental caries in permanent teeth was found in about 30% of the world's population.[1] It can be caused by various factors, such as host factors, oral microbes, food intake, oral hygiene and other environmental factors.[2] Food intake is a critical factor that plays a role in caries' incidence.[3] Previous studies have shown that obese individuals often have a higher dental caries index and a higher periodontal index than normal individuals.[4–6]

According to the results of basic health research (RISKESDAS), the prevalence of obesity among adults in Indonesia was 10.5% in 2007, increasing to 15.4% in 2013 and 21.8% in 2018.[7–9] Obesity is defined as an abnormal or excessive accumulation of fat, which can damage health. It is a condition occurring due to an imbalance between energy intake and energy expenditure.[10] Excessive fat accumulation can occur if we over-consume fat-producing foods, such as carbohydrates or sugar. Excessive carbohydrate intake can cause an increase in body weight, which can then develop into obesity.[11]

The foods consumed the most by Indonesians are grains (41.11%), processed foods and beverages (21.09%), and oil and coconuts (12.24%).[12] Sugar or glucose is classified as a simple carbohydrate composed of carbon, hydrogen and oxygen elements. Simple carbohydrates are easily absorbed by the intestines for energy use.[13] Excess glucose is then stored in the liver and muscle cells in the form of glycogen. When the body needs glucose, the liver will release glucose into the bloodstream to be distributed to the body parts that need it, including the brain, nervous system, heart and other organs. When glucose enters the cells, enzymes will break it down into small pieces to produce energy, carbon dioxide and water. Excess carbohydrates are converted into fat and then stored in fat tissue.[14]

Carbohydrates are also cariogenic ingredients. Processed sugars, such as glucose and sucrose, will cause a drastic drop in the oral pH to below 5.5, which increases the occurrence of demineralisation.[15] If demineralisation is higher than remineralisation, dental caries will develop.[16] High carbohydrate intake in obese individuals may be associated with the prevalence of dental caries.[3] The increasing prevalence of caries in obese individuals can also be caused by a decreased salivary flow rate, which decreases the anti-bacterial effect of saliva.[17] The expansion of adipose tissue in obese individuals significantly influences the physiological response and can interfere with salivary gland function.[18]

The food frequency questionnaire (FFQ) can be used to conduct a nutritional study to assess individuals' nutrition and energy intake habits. The FFQ is designed to elicit information on some specific aspects of the diet, such as carbohydrate intake. Since obesity is related to the type and amount of nutritional intake, the appropriate FFQ to use is the semi-quantitative FFQ, which adds estimated food serving sizes.[19,20]

As far as the authors know, there are limited studies analysing carbohydrate intake and dental caries in obese individuals in Indonesia. By understanding the correlation between carbohydrate intake and dental caries in obese individuals, we can prevent the incidence of dental caries and obesity by controlling carbohydrate intake. Therefore, this study aims to analyse the correlation between carbohydrate intake and dental caries in obese individuals.

MATERIALS AND METHODS

This study is an observational analytic study with a cross-sectional study design. Since the population's proportion is unknown, the minimum sample size was calculated using the modified Lemeshow et al. formula.[21] According to the study conducted by Mathur et al. in 2011, the prevalence of obese people who also experience periodontal disease is 88%, and in people who are not obese, the prevalence of periodontal disease is 74.4%.[22] Based on these data using a significance level of 95%, it can be calculated that the minimum sample size is 30 people. In this study, 50 obese

individuals were selected as participants using the quota sampling technique. All participants were members of an obese community in Jakarta.

The body mass index (BMI) does not differentiate between body weight and muscle or body fat, so two individuals with the same BMI score could have a significant difference in fat mass and free fat mass.[19] Therefore, in this study, obesity was determined based on the BMI and body fat percentage measured using a body composition monitor (BC-601, Tanita Corp, Japan). Bioelectrical Impedance Analysis (BIA) is a method that can be used to measure a person's body fat percentage. The BIA method measures electrical conductivity by circulating electrical signals in human body fluids. Thus, the muscle mass, body fat mass, water content of the body and even individual bone mass can be measured.[20]

The participants' inclusion criteria are 18–40 years old, BMI score >30 and body fat percentage >25% for men and >33% for women.[23] On the other hand, the exclusion criteria are individuals who have conditions that may affect the result of the study (such as mental disorders, illnesses with a high risk of infection and conditions that interfere with the BMI) and the body fat percentage (such as pregnant women, sportsmen and people who have run a weight loss programme in the last one year).

Dental caries was measured using the decayed, missing and filled teeth (DMF-T) index. The DMF-T index is the most widely used and universally accepted index of dental caries. It can be used for individuals or groups. The DMF-T index is based on the fact that damage done to the tooth's hard tissue cannot heal on its own and will leave lasting marks.[16,24] D stands for a tooth affected by caries, M stands for a tooth that has been lost or extracted due to caries, and F stands for a tooth that is affected by caries but has been filled. All teeth are examined except for the third molars. The DMF-T index has rules that apply to scoring an individual tooth. Each tooth may be counted only once.[24] The DMF-T scores were divided into five categories: Very Low (0.0–1.1), Low (1.2–2.6), Medium (2.7–4.4), High (4.5–6.5) and Very High (> 6.6).[25] The dental caries examination was carried out using an intraoral clinical examination by four examiners with equal competence and knowledge.

Carbohydrate intake was assessed using the semi-quantitative FFQ. The FFQ is a self-reporting method of measuring food intake by filling out a questionnaire. Each study participant reports how often each type of food and drink is consumed during a specific period.[23,26] In the semi-quantitative FFQ, the amount of nutrient present in each type of food consumed can be calculated based on a questionnaire's result. The list of foods used in the FFQ is obtained from a preliminary study using a food record.[19] All participants filled in the frequency and portion of consumption of each food on the food list.

The FFQ assessment procedure was as follows: participants were required to fill in the list provided in the questionnaire regarding the frequency of their intake. There were five categories of intake frequency: daily (D),

weekly (W), monthly (M), yearly (Y) and rarely/never (N). The participants wrote the number of times each food was consumed in the column for the most appropriate category. The participants were also required to mark the list provided in the questionnaire regarding the intake portion. There were three categories of intake portion, which indicated the quantity of food usually consumed: small (S), medium (M) and large (L).[19] The food book photo from the Ministry of Health was used as the standard measure of food portion.[27] To measure the daily nutrient intake, all categories of frequency were converted into a daily basis, which meant once a day (1). The daily frequency was multiplied by the selected portion (in grams) to obtain the weight in grams consumed each day. The carbohydrate content in the weight of the food consumed was determined based on the Indonesian food composition table (TKPI).[28]

The data obtained in this study were analysed using several statistical tests. The Pearson correlation coefficient is used to measure the strength and direction of correlation between variables. Both variables were measured on an interval scale. A linear regression analysis was used to identify the strength of the effect that the carbohydrate intake had on dental caries in obese individuals. The statistic was analysed using SPSS version 19 for Windows (IBM, Chicago, USA).

First, the t-count value and t-table value were determined. The t-count was first determined using this formula:

$$t_{-count} = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

With df = 48 and the level of significance of 5%, the t-table value was 1.677. Then, the t-count value was compared with the t-table value. If the t-count value was bigger than the t-table value, it would mean that carbohydrate intake had a significant effect on the incidence of dental caries. The coefficient of determination was indicated by the R^2 value of the regression model. The percentage value of the coefficient of determination showed the amount of variability of the prevalence of dental caries, which could be explained with the carbohydrate intake in the study, while the rest is explained by other variables outside the study model.[29]

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and was approved by the Health Research Ethics Committee, Faculty of Medicine, Maranatha Christian University – Immanuel Hospital, Bandung, Indonesia (No.008/.KEP/II/2019). Written informed consent was obtained from all participants.

RESULTS

This study's participants were 39 women (78%) and 11 men (22%). The average BMI score of the participants was 35.84. The largest age group, consisting of 21 people, was 25–29 years old. Table 1 shows the characteristics of the participants based on body weight. A total of 16 participants weighed 81–90 kg (32%), and 15 participants weighed 91–100 kg (30%).

As a result of this study, 12% of obese individuals had a DMF-T index in the high category, and 66% of obese individuals had a DMF-T index in the very high category. Only 4% of participants had a DMF-T index in the very low category (Table 2). The average DMF-T index score of participants in this study was 7.98. The highest DMF-T score in this study was 15, while the lowest DMF-T score was 1 (Table 3).

The average body fat percentage of all participants was 45.5%. The average value of daily carbohydrate intake assessed using the FFQ was 302.46 g or 1209.84 kcal. The highest value of daily carbohydrate intake in this study was 2408.2 kcal, while the lowest value of carbohydrate intake was 291.7 kcal. Table 3 displays the values of BMI scores, body fat percentage, carbohydrate intake and DMF-T index in this study.

Regarding each DMF-T index element (D, M and F elements), D had the highest average score at 4.62. On the other hand, M and F had similar scores. In this study, the median and mean values of the DMF-T index were similar – the median value was 8.00, and the mean value was 7.98. This showed that there was no extreme value in the data set.

The result of the Pearson correlation coefficient test showed that the correlation coefficient value of carbohydrate

Table 1. Characteristics of participants based on body weight[30]

Body weight (kg)	f (n = 50)	Percentage (%)
70–80	5	10%
81–90	16	32%
91–100	15	30%
101–110	9	18%
>110	5	10%

Table 2. The category of the DMF-T index of participants

Category of DMF-T index	f (n = 50)	Percentage
Very Low (0.0–1.1)	2	4%
Low (1.2–2.6)	2	4%
Medium (2.7–4.4)	7	14%
High (4.5–6.5)	6	12%
Very High (> 6.6)	33	66%

Table 3. The values of BMI scores, body fat percentage, carbohydrate intake and DMF-T index

Value	BMI	Body fat percentage (%)	Carbohydrate intake (kcal)	D	M	F	DMF-T
Mean	35.84	45.59	1209.84	4.62	1.70	1.66	7.98
Median	35.64	45.95	1150.05	4.50	1.00	1.00	8.00
Range	30.36–46.71	31.80–58.70	291.7–2408.20	1–11	0–7	0–10	1–15

intake was 0.714, which is between 0.60–0.799. This shows a strong and positive correlation between the carbohydrate intake and the DMF-T index of obese individuals. A positive correlation shows that the higher the carbohydrate intake, the higher the DMF-T index.

For the calculations' result, the t-count value was 7.065, and the t-table value was 1.677. From these results, it could be seen that the t-count value was bigger than the t-table value. In addition, the significance level was 0.000 (<0.1). The result showed that carbohydrate intake has a significant effect on the DMF-T index.

The value of the coefficient of determination, which is indicated by the R^2 value of the regression model, was used to determine the amount of variability of the DMF-T index, which can be explained with the carbohydrate intake. In this Study, r = 0.714, and R^2 = 50.98%. This means that the variability of the DMF-T index in this study, which could be explained with the carbohydrate intake, was 50.98%. The remaining 49.02% was explained with other variables outside the study model.

DISCUSSION

In this study, most of the participants had a BMI score >30, which is categorised as level II obesity by the WHO.[19] All participants had a body weight beyond the Indonesian Health Ministry's recommendation, which is 60 kg for men aged 18–29 and 55 kg for women of the same age.[31] BMI measurement is the most frequently used indicator to identify individuals' nutritional status. However, the BMI, which assesses the ratio of body weight to height, cannot always reflect whether a person is overweight or obese or not. One of the more specific methods of determining obesity is by calculating the percentage of body fat.[20] The average body fat percentage of all participants was 45.5%. This figure far exceeds the limit for the percentage of normal body fat and is even much higher than the limit for the percentage of body fat in obesity. The normal body fat percentage is 8–15% for men and 13–23% for women.[19]

A total of 78% of the DMF-T index of obese individuals in this study were in the high and very high categories. Similar results were obtained in several studies looking for a correlation between caries incidence and BMI scores.[6,32] A high D score of the DMF-T index showed that most of the dental caries of participants in this study had not been treated. Many factors influenced this condition, some of which are knowledge, attitude and behaviour.[33] Dental caries is caused by the association of several factors over a period. It is related to several factors that are categorised into host susceptibility, microorganism and substrate. All these factors must intersect during a defined period, along a continuum, for caries to occur.[24] Dental caries is caused by a decrease in the oral cavity's pH associated with food intake, oral bacteria, oral hygiene and saliva. Social factors, such as education level and income level, also affect knowledge, attitudes and behaviour related to dental caries.[16]

The recommended nutritional adequacy value for Indonesian people can be found in the Regulation of the Minister of Health of the Republic of Indonesia No. 28, 2019.[31] According to this regulation, men aged 19–29 need 430 g of carbohydrates, 65 g of protein, 75 g of fat and 2650 kcal of total energy. Women aged 19–29 need 360 g of carbohydrates, 60 g of protein, 65 g of fat and 2250 kcal of total energy.[31] However, these values are higher than the recommendation of the Dietary Guidelines for Americans 2015–2020.[2] The average carbohydrate intake of participants in this study far exceeded the recommended daily carbohydrate intake for adults, which is 130 g/day or 520 kcal.[34] Large nutritional intake of obese individuals can also be influenced by biological factors, where the control of food intake by the brain is an integral part of nutritional intake. The hormone that plays a role in regulating food intake by controlling appetite is leptin. Leptin is produced by adipose tissue and provides signals to the brain centre via leptin receptors to regulate food intake and increase energy metabolism.[35,36] Fermented carbohydrate and dental plaque should not remain on the tooth surface for a long time because it will increase the demineralisation process of tooth enamel. These carbohydrates help oral bacteria produce acids that cause the demineralisation of enamel. Complex carbohydrates are less harmful because they are not completely digested in the oral cavity, but simple carbohydrates, such as sugar, dissolve easily into dental plaque and are then metabolised by oral bacteria, thereby rapidly lowering the oral cavity's pH.[16]

Based on the statistical analysis in this study, the high DMF-T index in obese individuals is influenced by carbohydrate intake. Obesity can occur if we excessively consume fat-producing foods, one of which is carbohydrates or sugar.[12] Carbohydrates consist of simple carbohydrates (sugar) and complex carbohydrates (starch and fibre). Simple carbohydrates are chemically divided into monosaccharides, consisting of glucose, fructose and galactose, and disaccharides, consisting of maltose, sucrose and lactose. Complex carbohydrates consist of polysaccharides (large molecules composed of monosaccharide chains). The recommended carbohydrate intake for adults is 130 g per day, based on the average amount of glucose used by the brain.[37] The amount of complex carbohydrates intake is 50–70% of the total carbohydrate intake, while the amount of processed sugars allowed is only 0–10% of the total carbohydrate intake.[37] The carbohydrates we consume are then metabolised by bacteria, which are involved in the formation of biofilms. The bacteria then produce acids that decrease the oral cavity's pH to <5 within 2–5 minutes. Meanwhile, the time required for the oral cavity to neutralise acids is 60 minutes. If sugary foods are continuously consumed, the oral cavity's condition will remain acidic, leading to the demineralisation of the tooth structure, which can lead to dental caries.[6,16]

Overweight and obese individuals also experience changes in size, distribution, cell composition and

adipose tissue function. The expansion of adipose tissue significantly influences physiological responses and can impair the function of this tissue.[38] Adipose tissue experiences hypertrophy, ectopic fat deposition, hypoxia and chronic stress in this obese state.[38] Enlargement of the parotid glands, caused by increased adipocyte storage, was found in overweight individuals.[32] One of the endocrine organs that play a role in the physiological regulation of the body is adipocytes. Enlarged adipocytes in obese individuals activate macrophages, which then secrete pro-inflammatory mediators, resulting in an imbalance between anti-inflammatory adipokines and pro-inflammatory adipokines.[18,39] The presence of these inflammatory cells impairs the function of the salivary glands, which results in decreased salivary flow.[32] The decreased salivary flow rate can be one of the factors causing dental caries.[17]

However, this study has several limitations. The participants in this study do not represent the obesity community in Indonesia. There are other factors besides carbohydrate consumption that can influence the occurrence of dental caries, which were not discussed in this study. The limitations of this study can be addressed in future studies.

Based on the study's results and the discussion above, it is concluded that there is a strong and positive correlation between carbohydrate intake and the DMF-T index. A positive correlation shows that the higher the carbohydrate intake, the higher the DMF-T index. The statistical test results also show that carbohydrate intake affects the DMF-T index as much as 50.98%. Controlling carbohydrate intake can prevent dental caries and obesity. Education and monitoring of carbohydrate intake in the community are small prevention steps that can have a significant impact on the community's health, especially community oral health.

ACKNOWLEDGEMENTS

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