original article

Influence of body mass index on severity of dental caries: cross-sectional study in healthy adults

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BACKGROUND: The relationship between body mass index (BMI) and dental caries is still undetermined.
OBJECTIVE: This study aimed to assess the relationship between the dental status by decayed, missed, filled teeth index (DMFT), and BMI by age and gender among healthy adults.
DESIGN: Analytical, cross-sectional study.
SETTINGS: University dental hospital in Riyadh.
SUBJECTS AND METHODS: Healthy adults aged between 18 and 35 years were recruited during the 10-month period from March 2015 to December 2015. Dental caries severity was estimated using the DMFT index.
MAIN OUTCOME MEASURE: The prevalence of overweight/obesity and the association of BMI category with the DMFT index.
RESULTS: The mean age of 502 subjects was 24.3 (4.9) years. The caries severity of the study population was considered moderate according to the WHO caries severity scale (mean [standard deviation] DMFT 13.3 [3.8]). The mean (SD) DMFT of male and female subjects was 13.1 (4.0) and 13.36 (3.7), respectively. No significant association was seen between dental caries and BMI. Logistic regression analysis showed that males had two times more risk of developing dental caries compared to females. In addition, the risk of caries development was increased by about 5 times for every year of age.
CONCLUSION: Dental caries was not associated with BMI but age significantly influenced the DMFT index and gender was associated with more missing teeth. Further longitudinal studies with larger cohorts from several geographic regions are warranted.
LIMITATION: Convenience sampling and recruitment from a single dental center may have some impact on the generalization of data.

Obesity and overweight according to the World Health Organization (WHO) are characterized by an abnormal and excessive accumulation of fat that may impair health.[1] The primary cause of this condition is an imbalance between calorie intake and calorie consumption. A recent report demonstrated that the global prevalence of obesity and overweight doubled between 1980 and 2014.[1] Interestingly, the WHO stated in 2014, that nearly 2.5 billion adults aged ≥18 years suffer from obesity and overweight.[1] This equals approximately one-third of the world's population. Furthermore, overweight is considered the fifth leading cause of mortality worldwide and has been identified as a major risk factor for several non-communicable diseases such as cardiovascular diseases, musculoskeletal diseases and certain types of cancer like breast, prostate, liver, and colon cancer.[2]

Dental caries is the most prevalent disease globally,[3] and has been considered historically the most important global oral health burdens, affecting about 60% to 90% of schoolchildren, and about 100% of the adult population.[4] Dental caries has a complicated etiology and pathobiology; however, the role of nourishment, in addition to oral hygiene, nutrients, saliva, and oral flora,

play a significant role in caries initiation and progression.[5] The association between oral health status and weight of patients is a subject of controversy.[6] This debate is partially attributed to the nature of the published studies as population sampling has focused on schoolchildren.[6] Interestingly, Thippeswamy et al[7] reported a significant association between overweight/obesity and caries rates among school children; the obese children had more caries than both the overweight and normal weight children. Likewise, Modéer et al[8] revealed that obese subjects exhibited a higher number of decayed surfaces compared to non-obese subjects. Additionally, Willershausen et al[9] examined 2071 primary school pupils aged 6 to 10 years, and reported a significant correlation between body mass index (BMI) and caries frequency; a low BMI showed a correlation with the absence of carious lesions, and a high BMI was linked to a high number of caries lesions. Most recently, a significant association between dental caries and BMI in young adult subjects was reported.[10] In contrast, in a recent study that examined adult subjects, BMI was not associated with dental caries, but had a significant association with periodontitis.[11] On the other hand, the findings of a study by Sede et al[12] revealed that BMI related to neither dental caries, nor periodontitis; however, the study supported a strong link between the gingival bleeding index and BMI. In addition, several studies failed to demonstrate a significant relationship between childhood obesity and dental caries.[13-15] Given the current debate, this study, therefore, aimed to assess the relationship between teeth status represented by decayed, missed, filled teeth index (DMFT), and BMI among healthy adults.

SUBJECTS AND METHODS

In this cross-sectional study conducted at the dental hospital of Al-Farabi Colleges in Riyadh, Saudi Arabia, patients who visited the dental clinics during the period from March 2015 to December 2015 were eligible to participate. Subjects were selected based on convenience and the criteria of being healthy (without systemic disease, even if controlled) and being an adult ≥18 years and ≤35 years of age. This study was prepared in accordance with the STROBE statement (*www.strobe-statement.org*). The study was ethically approved by the Institutional Review Board of Al-Farabi College for Dentistry and Nursing. All subjects were asked to sign a consent form, and all procedures were undertaken in accordance with the principles of the Helsinki Declaration. Subjects were excluded if they had genetic or acquired teeth anomalies such as fluorosis or amelogenesis imperfecta, any chronic medical condition that might adversely affect either oral and/or systemic health status (e.g. diabetes), had undergone orthodontic treatment, were female patients who were pregnant or taking an oral contraceptive. A detailed medical and drug history was taken.

Subjects meeting the inclusion criteria were subject to a standard dental inspection that was performed by a calibrated and experienced dental specialist using sterile dental examination instruments on a dental unit with the standard white headlight. Two bilateral bitewing radiographs were taken for each participant to diagnose the presence of hidden proximal caries in the posterior teeth.

Dental caries severity was diagnosed and recorded according to the WHO criteria, the DMFT.[16] The index indicates the number of decayed (D), missed (M) and filled (F) teeth in each patient. Any tooth with caries or tooth with a filling and recurrent caries is considered a decayed tooth (D). The number of teeth with restorative fillings is referred to as filled teeth (F). The number of teeth removed due to dental caries is considered missing teeth (M).[16] Any tooth that was extracted as a result of trauma or hereditary malformation was not counted as missing teeth.[16]

BMI was measured to classify the obesity and overweight of study subjects.[1] The weight and height of subjects were quantified by a calibrated digital scale (Beurer, Germany). Participants were divided into groups depending on their BMI according to WHO criteria into four groups: 1 obese (BMI >30 kg/m^2), overweight (BMI 25-30 kg/m^2), normal weight (BMI 18.5-25 kg/m^2, or underweight (BMI <18.5 kg/m^2).

Data was analyzed using IBM SPSS version 22.0, Armonk, NY: IBM Corp. A *P* value of <.05 was considered statistically significant. Tests of normality were done to check the distribution of dental variables (DMFT, DT, MT and FT) by the Kolmogorov test. Quantitative variables were presented as means and standard deviations, whereas qualitative variables were presented as frequencies and percentages. The Mann-Whitney test and Kruskal-Wallis test were used for the non-parametric quantitative variables. The chi-square test was used for dichotomous variables. A multinomial logistic regression model was performed to detect significant predictors of DMFT score.

RESULTS

Of 578 patients that initially examined for study enrollment, 502 subjects met the inclusion criteria and were subject to full examination and subsequent analysis. The 502 subjects included 192 males (38.2%) and 310 females (61.8%) with a mean ages of 26.5 (4.8) and 22.8

(4.5), respectively (**Table 1**). The mean DMFT of the study subjects was 13.28 (3.8) and the mean DMFT of male and female subjects was 13.1 (4.0) and 13.4 (3.7), respectively. No significant relationship was found between the DMFT, DT, and FT and subjects' gender, except for MT (**Table 2**). Furthermore, older age subjects had significantly more missing and filled teeth compared with younger subjects, while the younger group had slightly more decayed teeth (**Table 2**).

There was no statistically significant relation between BMI categories and either gender or age of subjects (**Table 3**) (Chi-square test, *P*=.23) and no statistically significant correlation between BMI categories and dental caries severity (**Table 4**). However, after taking the age and gender into consideration, the relationship between the dental variables and body mass index categories showed that the mean value of DMFT was significantly greater among underweight older males compared with other age groups (*P*<.001) (**Table 5**). A multiple regression model found that gender and age were significant in relationship to DMFT (odds ratio 2.3, confidence interval=0.13 , 1.56, *P*=.021), and (odds ratio 4.94, 95% confidence interval (CI)=0.11, 0.26, *P*<.001) with an adjusted R-square of 0.042, respectively. A multiple regression model found that gender and age were significant in relationship to DMFT, male subjects had more than 2 times risk for caries development compared to females, while the risk of caries development was increased by about 5 times for each year of age (odds ratio 2.3, confidence interval=0.13, 1.56, P=.021), and (odds ratio 4.94, 95% confidence interval (CI)=0.11, 0.26, *P*<.001), respectively, with an adjusted R-square of 0.042.

Table 1. Distribution of study subjects by gender and age.

Age range	Gender		Total
	Male N (%)	Female N (%)	
18–24 years	82 (26.2)	231 (73.8)	313
25–35 years	110 (58.2)	79 (41.8)	189
Total	**192 (38.2%)**	**310 (61.8%)**	**502**

Table 2. The relationship between dental and demographic variables.

Variable	DMFT	DT	MT	FT
Gender				
Male	13.2 (3.9)	8.9 (4.1)	0.8 (]1.3)	3.4 (3.9)
Female	13.4 (3.7)	8.3 (4.0)	1.2 (1.7)	3.9 (3.8)
P value	0.597	0.116	0.029	0.088
Age categories				
18–24 years	12.9 (3.8)	8.8 (4.1)	0.8 (1.5)	3.3 (3.6)
25–35 years	13.9 (3.6)	8.1 (4.0)	1.3 (1.7)	4.6 (4.1)
P value	.006	.046	<.001	<.001

Data are mean (standard deviation). DMFT: decayed, missed, filled teeth index; DT: decayed teeth; MT: missing teeth; FT: filled teeth. Statistical analysis by Mann-Whitney test

Table 3. Distribution of gender and age by category of body mass index.

BMI category	Males by age group		Female by age group		Total n (%) (number male, female)
	18-24	25-35	18-24	25-35	
Underweight	7 (63.6)	4 (36.4)	20 (87)	3 (13)	34 (6.8) (11, 23)
Normal	36 (46.2)	42 (53.8)	124 (81.6)	28 (18.4)	230 (45.8) (78, 152)
Overweight	19 (33.3)	38 (66.7)	56 (70)	24 (30)	137 (27.3) (57, 80)
Obese	20 (43.5)	26 (56.5)	31 (56.4)	24 (43.6)	101 (20.1) (46, 55)

Data are number (percentage). Age groups in years. Underweight <18.5 kg/m^2, normal 18.5-25 kg/m^2, overweight 25-30 kg/m^2, obese >30 kg/m^2

DISCUSSION

Caries severity and prevalence are significantly affected by several factors including age, educational backgrounds, socioeconomic status, genetic susceptibility, fluoride percentage in drinking water, and level of dental awareness.[5] Consequently, study of caries-related factors is complex. These variables explain the inequality in the dental caries scale among various studies. The severity of dental caries worldwide ranges greatly, from less than 5 to more than 20 (DMFT index).[17,18] The mean of DMFT in this study was 13.3, which is considered moderate according to the WHO caries severity scale.[17] Our findings were similar to those reported in other countries, such as United States, Russia, and Australia.[17]

The objective of this study was to determine the association between BMI category and dental caries among adults, but it is well known that being older than 35 years is considered a risk factor for tooth loss as a result of periodontal diseases.[19] Therefore, to exclude any external age-related factors that might influence the oral health status negatively of study subjects, our study subjects were limited to adults aged 35 years and younger.[10]

The relationship between BMI and dental caries is indecisive. A 2012 systematic review that included

48 papers that assessed the potential relationship between BMI and dental caries in children and adolescents, found no association in 23 studies, while the remaining 25 studies found the opposite, making a decisive conclusion impossible.[20] However, it is important to note that most of the previous studies that found a relationship between dental caries and BMI, either positive or negative, were conducted on children or adolescents aged less than 18 years.[20-22] On the other hand, few studies were conducted to test this relationship among adult subjects. Moreover, a systematic review conducted in 2006 demonstrated that only one study with a high level of evidence showed a direct and significant association between dental caries and obesity.[21]

A study in 2016 on adults aged between 18 to 35 years revealed a strong association between high BMI and DMFT, but the number of study subjects in that study was limited to 200; in addition, no logistic regression model was performed to test the effect of confounders.[10] On the other hand, the present study found a statistically significant relationship between dental caries and males who were underweight and older. The same results were found in a previous study and were attributed to the negative impact of caries lesions in childhood development.[22] Nevertheless, these results could not be applied to our study for many reasons. First, the study was conducted in children aged 8 years, not on adults. In addition, a logistic regression model of our data showed that age and gender played a significant role in this relationship, not BMI.

In our opinion, the diversity and contradiction of results among the studies could be attributed to variations in genetic susceptibility to caries and obesity, lifestyle, and dietary habits, which are unique for each community and population. However, all of these variables must be included in the future in a longitudinal study with larger cohorts from several geographic regions to get a more precise estimation of the relationship between BMI and dental caries.

Like other published studies, the present paper has some limitations. The cross-sectional nature prevented the discovery of any cause and effect relationship between the variables. Another limitation was lack of information on the nutritional behavior of subjects. Yet another limitation was the single center design. However, the age and gender of our participants was close to that published by the Saudi National Office of Statistics;[23] thus, our study probably represents the healthy Saudi adult population. Furthermore, the reported obesity rate in our study was similar to that previously reported in published studies from Saudi cohorts.[24,25] Specifically, our study found that the obesity rate in males and females was 23.9% and 17.8%, respectively, which is similar to that reported in Al-Hazzaa et al study in the Riyadh region. They reported an obesity rate of 22.7% and 13.8% in males and females, respectively.[24] The lack of detailed information on the socioeconomic status of participants could be considered an additional limitation to the present study, though 95% of the participants labeled themselves as middle class.

Finally, according to our results, being male means that the risk of caries development is increased by more than two times compared to females, and this could be attributed to a poor attitude towards oral health, dietary habits, and potentially genetic variations. In addition, our previous study examined the gingival and plaque indices (GI and PI) in adults,[26] where males were shown to have significantly higher indices than females, and therefore, were more susceptible to dental caries than females. Similarly, the risk of caries

Table 4. Statistical comparison of dental variables by body mass index.

	DMFT	DT	MT	FT
BMI category				
Underweight	14.0 (3.8)	8.2 (4.6)	0.8 (1.5)	4.9 (4.6)
Normal	13.0 (3.9)	8.4 (4.1)	1.0 (1.5)	3.6 (3.9)
Overweight	13.8 (3.1)	9.0 (4.1)	1.0 (1.4)	3.8 (3.5)
Obese	12.9 (4.4)	8.4 (3.9)	1.0 (1.8)	3.5 (3.9)
P value	.150	.369	.953	.205

Data are mean (standard deviation). DMFT: decayed, missed, filled teeth index; DT: decayed teeth; MT: missing teeth; FT: filled teeth. BMI: body mass index. Statistical analysis by Kruskal-Wallis test.

Table 5. Statistical comparison of dental variables and category of body mass index by age and gender.

	DMFT Female 18-24 y (n=231)	DMFT Female 25-35 y (n=79)	DMFT Male 18-24 y (n=82)	DMFT Male 25-35 y (n=110)
BMI category				
Underweight	13.3 (3.0)	12.7 (3.5)	13.0 (3.7)	20.5 (1.7)
Normal	13.1 (3.8)	13.4 (3.8)	11.9 (4.3)	13.4 (3.6)
Overweight	13.0 (3.2)	14.6 (2.3)	14.4 (3.5)	14.3 (2.9)
Obese	12.7 (4.7)	15.2 (4.0)	11.4 (4.2)	12.1 (3.8)
P value	.966	.181	.110	<.001

Data are mean (standard deviation). DMFT: decayed, missed, filled teeth index; DT: decayed teeth; MT: missing teeth; FT: filled teeth. BMI: body mass index. Statistical analysis by Kruskal-Wallis test.

development is related significantly to age. For every one year increase in age, the risk of caries development is increased by about five times, which is consistent with many previous studies that considered age as a risk factor for caries development.[27]

In conclusion, our study showed that dental caries was not related to BMI whereas age significantly influenced the development of dental caries, and female gender was associated with more missing teeth. However, further longitudinal studies with larger cohorts from several geographic regions are required to validate the exact relationship between BMI and dental caries among adults.

Conflict of interest

The authors declare that they have no conflict of interests, and the work was not supported or funded by any drug company.

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