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The relationship between body mass index and oral health status among Saudi adults: a cross-sectional study

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Objective: *To assess the relationship between body mass index (BMI) and the sum of decayed, missing and filled teeth (DMFT), periodontal pockets, and oral soft tissue variations.* ***Basic Research Design:*** *A systematic sample of 250 people attending King Abdulaziz Medical City was included. The study was conducted using questionnaires and clinical examinations. Questionnaires were prepared to include socio-demographic, smoking, oral hygiene, medical and physical variables. Clinical examination included DMFT, pocket depths and soft tissues changes. BMI was calculated as kg/m^2 using height and weight. Analyses included descriptive statistics, ANOVA, Chi-square and logistic regression.* ***Results:*** *Participants mean age was 35.3 years (18-83 years), and about 60% were females. The mean BMI was 28.24. Two thirds (67%) of participants were overweight (BMI=25.0-29.9kg/m^2) or obese (BMI>30kg/m^2). Mean DMFT correlated with BMI (p=0.005). However, periodontal pocket depths were not associated with increased BMI. In the bivariate analyses, there were associations between BMI and age, education, smoking, tooth brushing, hypertension, diabetes, use of medication and traumatic ulcer. Logistic regression analysis revealed a significant relationship between BMI and DMFT in people educated to less than high school, current smokers, those with any medical problem or with edematous gingiva (P=0.026).* ***Conclusion:*** *Participants higher BMI were more likely to have a higher DMFT score in the presence of low education, presence of edematous gingiva, smoking or a medical condition.*

Keywords: *BMI, Oral, Health, DMFT, Lesion*

Introduction

Body mass index (BMI) is a measurement that relates weight to height, which is commonly used to estimate the level of overweight and obesity. BMI can be considered as an indicator of obesity-related health risks. Obesity was considered a global epidemic problem by the World Health Organization in the 1990s as it has increased internationally over the last decades (WHO, 1998). Overweight and Obesity was considered a major public health problems by the US Surgeon General (U.S. Department of Health and Human Services, 2001).

The effect of increased BMI or obesity on general health is documented to contribute to many systemic diseases such as diabetes and cardiovascular diseases (Agha and Agha, 2017). However, the association between obesity and oral disease is still controversial (Prpić *et al*., 2012). Some studies had identified poor oral health in obese people (Mathus-Vliegen *et al.,* 2007). For example, more missing teeth and periodontal disease were found more commonly in obese compared to healthy individuals (Ostberg *et al.,* 2009; Forslund *et al.,* 2002). The literature provides a rationale for the coexistence of obesity and dental caries, as both exhibit common risk factors including low socioeconomic status and the consumption of free sugars (Shivakumar et al., 2018).

The current dental literature revealed a lack of consensus on whether overweight or obesity higher or lower dental caries prevalence. Studies from USA (Creske *et al*., 2018), Germany (Willerhausen *et al.,* 2007), Iran (Bagherian and Sadeghi, 2013), Turkey (Cantekin *et al.,* 2012) and India (Thippeswamy *et al.,* 2011) have demonstrated significant associations between obesity and dental caries among children. However, others from Denmark (Lempert *et al*., 2014), Netherlands (de Jong-Lenters *et al*., 2015), USA (Pinto *et al*., 2007), India (Elangovan *et al*., 2012), and Brazil (Martins *et al*., 2014) not found an association between the two. Moreover, some studies found negative relationships between caries and obesity (Shailee *et al*., 2013; Parkar *et al*., 2013).

Saudi Arabia ranks 3rd in the Arabic countries and 29th in the world for obesity. Approximately 36% of Saudi university students are obese (Pasha, 2017). However, this figure is less pronounced among adolescents (Alazzeh *et al*., 2018).

Few studies have addressed the association between oral health and obesity in Saudi people. Alsawt and colleagues (2016) reported no difference in BMI among high or low dental caries adult patients attending Taif University. However, Quadri and colleagues (2017) found a significant relationship between untreated dental caries and high BMI among Jizan children. Interestingly, obese children showed healthier teeth, indicating a negative association between dental caries and BMI in one study (Alghamdi and Almahdy, 2017).

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In summary the relationship between BMI and oral health status had been addressed in different countries with variations in the results of the relationship between BMI on periodontal health, missing teeth and dental caries. Furthermore, no studies have investigated the relationship between BMI and the presence of other oral lesions. In addition, there is lack of knowledge regarding the relationship between BMI and oral health status in Saudi Arabia.

The aim of the present study was to assess the relationship between BMI and oral health status including DMFT, periodontal pockets, oral soft tissue variations and oral lesions. It also aimed to investigate the simultaneous impact of several demographic, social, behavioral and health factors on the relationship between BMI and oral health.

Methods

This cross-sectional observational analytical study received ethical approval from the IRB committee of King Abdullah Medical Research Center Saudi Arabia (SP17/330/R).

The study was conducted in King Abdulaziz Medical City's (KAMC) Outpatient Clinics and Departments, Riyadh, Saudi Arabia. The period of recruitment and data collection was between September and December of 2017. All patients and their companions who attended the clinics in that period were eligible to be part of the study. Exclusion criteria included people who were under the age of 18 years, pregnant women, had no natural teeth or who had recently received radiotherapy or chemotherapy.

The study was conducted using questionnaires and clinical examinations. Questionnaires were prepared to include the following sections: A) Sociodemographic data, including: age, gender, nationality, education, occupation, income, and residence. B) Smoking status, including: frequency and duration of smoking. C) Oral hygiene practices, including: brushing, flossing, dental visits. D) Medical conditions and medications used. E) Physical disabilities. F) Physical activity, including: frequency and duration of each activity. The questionnaire was tested using a pilot sample of 40 dental students to answer questions and to provide us with their comments. Rephrasing of some questions was done accordingly.

The interview and dental clinical examination was conducted by first requesting participants to step on a standardized weight and height scale (Detecto 439 Balance Beam Doctor, USA) while wearing no shoes and with light clothes. Height was measured with a ruler touching the head of participants while standing vertically. BMI was then calculated as kg/m^2 and recorded for each participant's examinations sheet. Individuals were classified according to WHO criteria as follows: Underweight (<18.5), normal weight (18.5-24.9), overweight (25.0-29.9), and obese (≥30.0).

The clinical dental examination determined: A) The status of the teeth, in terms of decay, missing, and filled teeth (DMFT), B) periodontal status by measuring pocket depths on the Ramfjord teeth, and C) Oral soft tissue characteristics, including variations from normal, benign and malignant lesions. Dental examinations used the criteria of Oral Health Surveys Basic Methods (WHO, 1997). Clinical dental examinations were conducted by three trained and calibrated dentists. Inter-examiner reliability was checked in the midway and toward the end of participants' examinations. The Kappa statistic was 0.93 for DMFT, 0.89 for periodontal pockets and 0.98 for oral soft tissue abnormalities and oral lesions. Examination took place in a designated area in the waiting areas and participants were examined sitting on an ordinary chair with headrests and head light illumination. Dental mirrors, a cow horn explorer and periodontal probes were used in the examination.

A precision estimate determined a sample of 196 participants would yield a 95% confidence interval for a sampled proportion of 7%. More than one thousand patients were eligible to participate. Every fourth person (patient or companion) waiting for an appointment was asked to participate. Participants were asked to sign consent forms before the interviews and clinical examinations. All waiting areas of the hospital were approached and no attempt was made to select or exclude any participant in these waiting areas. Missing data were prevented as much as possible by proper planning of the study using interviews in which all questions were answered. A number of acceptable missing data was set prior to the study. Missing values were considered as missing at random and no relation to specific missing was observed.

Collected data were entered, cleaned, and analyzed using the IBM SPSS Statistical program version 23 (IBM Inc. NY, USA). Analyses included the following: A) Descriptive statistics including number, means and percentages, B) One-way Analysis of Variance to assess the difference in means of DMFT and periodontal pockets among BMI categories, C) Chi-square analyses to assess the relationship between other categorical parameters of oral health, medical conditions, physical activities, dietary habits with BMI, and D) Ordinal regression analysis to assess the effect of independent variables on the categories of BMI (underweight, normal weight, overweight and obese. The inclusion criterion to enter the model as independent variables was set at 0.06 from the bivariate analyses and the exclusion criterion to be removed was set at 0.10. The level of significance was set at $P< 0.05$.

Results

The final number of participants who agreed to participate and completed questionnaires and clinical dental examination was 250. Of the 18 people who declined participation, 14 preferred not to have an oral examination and 4 were pregnant women. The participation rate was 93%. The mean age of participants was 35.3 years, ranging from 18 to 83 years. Females comprised about 60% of participants and about 48% had high school education or less. Approximately 38% of participants lived below the poverty line (monthly salary ≤Saudi Riyal 12000), 20% were rich and the rest were in the middle category. More than half of the participants were employed, about 82% had never smoked and 18% were current smokers. Most (62%) participants reported brushing their teeth regularly (at least once a day). Eighty-six percent considered themselves not exercising regularly on a weekly basis (Table 1). The mean weight of participants was 75 kg with a range from 39 kg to 138kg. The calculated mean BMI was 28.24 (range 16 - 49. Upon applying the WHO classification, 7% were considered underweight, 26% were normal, and 67% of participants were either overweight or obese (Table 1).

Table 1. Demographic and behavioral characteristics of 250 hospital outpatients

Variable	*Category*	*%*
Gender	Male	40.4
	Female	59.6
Education	Illiterate	4.4
	Primary education	3.2
	Middle education	8.4
	High school	32.0
	Community college	6.8
	Bachelor and above	45.2
Income	SR0-8699*	38.4
	SR8700-11999*	20.0
	SR12000-15299*	13.2
	SR15300-20199*	8.0
	SR>20200*	20.4
Occupation	Unemployed	42.0
	Retired	4.8
	Employed	53.2
Current smoking	Yes	18.4
	No	81.6
Former smoking	Yes	16.5
	No	83.5
Frequency of brushing	Regular	61.6
	Irregular	38.4
Physical activity	Exercise regularly	14.4
	Not exercise regularly	85.6
BMI	Underweight	7.2
	Normal	26.0
	Overweight	31.2
	Obese	35.6

* Saudi Riyal equivalent to $26.7

Table 2 summarises the relationships between BMI and demographic, behavioral and social characteristics. There was a significant relationship between BMI with each of age, education, smoking and brushing status of the participants. More than 69% of male and 65% of female participants were overweight or obese, with no significant difference among the genders. Overweight and obesity was associated with age, with 50% in the younger age group (≤25 years) overweight or obese, 59% in the 26-35 year olds, 77.5% in the 36-45 year olds and 93% in the oldest age group (46-55 years) ($p \leq 0.001$). Highly educated people had significantly lower BMI than less educated people ($p=0.015$). Current smokers tended to have normal BMI compared to non-smokers ($p=0.029$). Participants who brushed their teeth regularly (at least once a day) were less likely to be overweight and obese (60.4%) than those who brushed irregularly (77.1%). BMI was not found to associated with income, employment, previous smoking and social life.

Almost 20% of study participants had either diabetes or hypertension. The prevalence of asthma, hypothyroidism, or joint disease was less than 5% (Table 3). BMI was associated with the presence of hypertension and diabetes. About 68% of participants with hypertension or diabetes were obese. Additionally, the use of daily medication was associated with higher BMI ($p \leq 0.005$). Having any medical problems was also associated with higher BMI, however, there was no association between BMI and asthma, hyperlipidemia, hypothyroidism, joint diseases, migraine, heart disease, psychological illness or physical disabilities.

The mean number of decayed, missing and filled teeth (DMFT) increased from 12 teeth in the underweight and normal weight category, to 14 teeth among the overweight category to 16 in the obese participants ($p=0.005$). Mean pocket depth was slightly higher among overweight and obese participants (PD=2.1-2.2 mm) compared to underweight and normal weight participants (PD=1.87-2.09), but the difference was not statistically significant ($p=0.4$).

Table 2. BMI category in relation to demographic, behavioral and social characteristics.

Variable	*Category*	*Underweight*		*Normal*		*Overweight*		*Obese*		*Total*	*%*	*P (χ2)*
		N.	*%*	*N.*	*%*	*N.*	*%*	*N.*	*%*			
Gender	Males	6	5.9	25	24.8	34	33.7	36	35.6	101	40.4	0.085
	Females	12	8.1	40	26.8	41	29.5	53	35.6	149	59.6	
Age	≤25 yrs.	6	9.4	26	40.6	18	28.1	14	21.9	64	25.6	0.000*
	26-35 yrs.	11	12.9	24	28.2	30	35.3	20	23.5	85	34.0	
	36-45 yrs.	0	0	9	22.5	9	22.5	22	55.0	40	16.0	
	46-55 yrs.	1	2.3	2	4.7	18	41.9	22	51.2	43	17.2	
Years of Education	≤12years	4	3.3	28	23.3	35	29.2	53	44.2	120	48.0	0.015*
	13+ years	14	10.8	37	28.5	43	33.1	36	27.7	130	52.0	
Income	≤SR12000**	8	5.5	35	24.0	41	28.1	62	42.5	146	58.4	0.052*
	> SR12000**	10	9.6	30	28.8	37	35.6	27	26.0	104	41.6	
Employment	Employed	11	8.3	39	29.3	45	33.8	38	28.6	133	53.2	0.101
	Un-employed	7	6.0	26	22.2	33	28.2	51	43.6	117	46.8	
Current Smoking	Yes	3	6.5	20	43.5	11	23.9	12	26.1	46	18.4	0.029*
	No	15	7.4	45	22.1	67	32.8	77	37.7	207	81.6	
Former smoking	Yes	1	2.9	5	14.7	13	38.2	15	44.1	34	16.5	0.341
	No	14	8.1	43	25.0	55	32.0	60	34.9	172	83.5	
Frequency of tooth brushing	Irregular	6	6.3	16	16.7	29	30.2	45	46.9	96	38.4	0.012
	Regular	12	7.8	49	31.8	49	31.8	44	28.6	154	61.6	
Social Life	Excellent	10	8.1	33	26.8	43	35.0	37	30.1	123	49.2	0.318
	Not Excellent	8	6.3	32	25.2	35	44.9	52	58.4	127	50.8	

* $P < 0.05$

** Saudi Riyal equivalent to $26.7

Regarding oral soft tissue variations, traumatic ulcers were found only in those who were overweight and obese (P=0.018). Edematous gingivae were also present in participants who were obese compared to those who were normal or underweight (p=0.068). No associations were found between BMI and other soft tissue lesions (Table 4).

Ordinal regression analysis showed a significant relationship between BMI and DMFT. Higher BMI category was predicted by having DMFT>10, education to less than high school, current smoking, the presence of any medical problem and presence of edematous gingiva (Table 5).

Discussion

This study supported the observation that about two-thirds of Saudi adults are either overweight or obese. Overweight and obesity were associated with higher DMFT scores. In regression analysis, dental caries and treatment experience remained significantly associated with higher BMI when controlling for lower education, smoking and the presence of medical conditions.

The international literature reveals no consensus on the relationship between BMI and dental caries or other oral health parameters. While some studies have failed to find tangible relationships between the two components, others reported significant positive or negative associations (de Jong-Letners *et al.,* 2015; Pinto *et al.,* 2007; Elangovan *et al.,* 2012; Martins *et al.,* 2014; Creske *et al.,* 2018; Willerhausen *et al.,* 2007; Bagherian and Sadeghi, 2013; Cantekin *et al*., 2012; Thippeswamy *et al*., 2011; Shailee *et al.,* 2013; Parkar *et al.,* 2013). This study aimed to evaluate the relationship between BMI and Oral Health Status, in particular with dental caries,

Table 3. BMI in relation to medical, psychological and physical problems and medication use.

Health problem	*Underweight*		*Normal*		*Overweight*		*Obese*		*Total*	*%*	*P (χ2)*
	N.	*%*	*N.*	*%*	*N.*	*%*	*N.*	*%*			
Hypertension	1	3.8	3	11.5	4	15.4	18	69.2	26	10.4	0.002*
Diabetes	1	4.5	1	4.5	5	22.7	15	68.2	22	8.8	0.007*
Asthma	0	0	2	18.2	4	36.4	5	45.5	11	4.4	0.680
Hypothyroidism	1	10.0	0	0	3	30.0	6	60.0	10	4.0	0.206
Joint diseases	0	0	1	12.5	2	25.0	5	62.5	8	3.2	0.398
Migraine	0	0	3	75.0	0	0	1	25.0	4	1.6	0.142
Heart disease	0	0	0	0	1	33.3	2	66.7	3	1.2	0.607
Psychological Illness	0	0	2	25.0	3	37.5	3	37.5	8	3.2	0.870
Physical disability	0	0	1	25.0	1	25.0	2	50.0	4	1.6	0.901
Medication use	4	7.0	6	10.5	17	29.8	30	52.6	57	22.8	0.005*
Any medical condition	3	4.4	8	11.8	19	27.9	38	55.9	68	27.2	0.000*

* P < 0.05

Table 4. BMI in relation to oral soft tissue variations and oral lesions.

Oral Lesions	*Underweight*		*Normal*		*Overweight*		*Obese*		*Total*	*%*	*P (χ2)*
	N.	*%*	*N.*	*%*	*N.*	*%*	*N.*	*%*			
Linea alba	6	33.3	39	60	41	52.6	39	43.8	125	50	0.104
Fissured tongue	4	22.2	22	33.8	27	34.6	29	32.6	82	32.8	0.786
Leukoedema	3	16.7	23	35.4	24	30.8	27	30.3	77	30.8	0.505
Coated tongue	6	33.3	14	21.5	21	26.9	30	33.7	71	28.4	0.386
Fissured lip	7	38.9	16	24.6	17	21.8	27	30.3	67	26.8	0.382
Lip pigmentation	3	16.7	14	21.5	11	14.1	22	24.7	50	20	0.368
Gingival pigmentation	3	16.7	11	16.9	16	20.5	16	18	46	18.4	0.946
Fordyce granules	1	5.6	9	13.8	11	14.1	21	23.6	42	16.8	0.146
Edematous gingiva	1	5.6	2	3.1	10	12.8	14	15.7	27	10.8	0.068
Palatal tori	2	11.1	5	7.7	10	11.2	10	11.2	24	9.6	0.890
Frenal tag	0	0	5	7.7	6	7.7	9	10.1	20	8	0.547
Lingual tori	0	0	3	4.6	7	9.0	5	5.6	15	6.0	0.455
Varix	0	0	5	7.7	3	3.8	7	7.9	15	6.0	0.445
Geographic tongue	0	0	4	6.2	3	3.8	7	7.9	14	5.6	0.489
Labial mucosa	2	11.1	5	7.7	2	2.6	2	2.2	11	4.4	0.157
Petechial lesion	0	0	1	1.5	4	5.1	6	6.7	11	4.4	0.340
Commissural pit	1	5.6	2	3.1	2	2.6	4	4.5	9	3.6	0.874
Traumatic ulcer	0	0	0	0	7	9.0	2	2.2	9	3.6	0.018*
Frictional keratosis	1	5.6	2	3.1	3	3.8	1	1.1	7	2.8	0.625
Buccal pigmentation	1	5.6	1	1.5	1	1.3	2	2.2	5	2.0	0.690
Bony exostosis	1	5.6	1	1.5	3	3.8	0	0	5	2.0	0.221
Melanotic macule	0	0	1	1.5	1	1.3	2	2.2	4	1.6	0.901
Amalgam tatto	0	0	0	0	1	1.3	2	1.2	3	1.2	0.607
Leukoplakia	0	0	0	0	0	0	2	2.2	2	0.8	0.302
Apthous ulcer	0	0	1	1.5	0	0	0	0	1	0.4	0.414
Congenital pit	0	0	0	0	0	0	1	1.1	1	0.4	0.611

* *P < 0.05*

Table 5. Ordinal regression analysis for predictors of categories of BMI.

Variable	*Regression coefficient*	*Standard error*	*P-value*	*Adjusted 95% Confidence Interval*	
				Lower	*Upper*
Education, High school and below	0.614	0.242	.011	0.140	1.089
Smoking, yes	-0.992	0.313	.003	-1.535	-0.308
Any medical problem, yes	1.061	0.294	.000	0.485	1.637
Oedematous gingiva, yes	1.063	0.418	.011	0.242	1.883
DMFT, >10 teeth	-0.57	0.255	0.026	1.07	0.069

periodontal diseases and oral lesions. Of note is that this study is the first in the region to address the issue of the relationship between BMI and components of oral health status in Saudi Arabia.

We observed significant relationships between untreated caries and missing and filled teeth with BMI. Excessive dietary carbohydrates, and specifically sugar in its refined form is causally related to both dental caries and increased BMI. The drinking of sugar-sweetened drinks and soda is major factor that leads to greater weight gain and increases in dental caries (Willerhausen *et al.,* 2007). In addition, dental caries and obesity have other common risk factors, including socioeconomic deprivation and oral and personal hygiene behaviors (Shivakumar *et al*., 2018).

We found no association between periodontal pockets and BMI. These results are similar to those reported by Prpic and colleagues (2013) who found no relationship between BMI and periodontitis. The presence of periodontal pockets was also not associated with obesity by de Castilhos and colleagues (2012). However, other studies have reported contrasting results (Yamashita *et al*., 2015; Saito *et al*., 2005). The variation among these results could be explained by differences in the study populations, setting or assessment criteria.

The sample employed in this study was a systematic sample of Saudi adults attending one of the biggest hospitals in Riyadh city. Since the hospital is also a referral center, the patients and their companions represented all geographic areas in the middle region of Saudi Arabia. Outpatient clinics are considered one of the most convenient places to recruit adults seeking medical care for different medical conditions. The nutrition clinic was avoided as many of their patients are attending for overweight or obesity. There was no attempt to select or exclude any participants based on their weight, height, or oral health. Participants from different geographic areas, educational backgrounds and social standings were invited equally to participate. All possible candidates were invited with only the exclusion of those who couldn't undergo clinical examinations. Pregnant women were excluded because pregnancy might affect their BMI and oral health. Totally edentulous participants were also excluded since the study's objective was to assess the status of remaining teeth and periodontal conditions. The sample size in our study was larger than that of studies from Brazil (Martins *et al.,* 2014) and USA (Pinto *et al.,* 2007; Creske *et al.,* 2018), and comparable to other studies (de Jong-Lenters *et al.,* 2015; Cantekin *et al*., 2012).

Dental examinations were accomplished by two dental examiners using ordinary chairs with headrests. Illumination was obtained using daylight supplemented by headlamps worn by the examiner. Such examinations in the field are an acceptable way to examine dental characteristics and conditions outside of dental clinics. Missing teeth were easily recognized by observing the number of natural remaining teeth. Untreated dental caries was recorded based on examiner's observation of frank caries without radiographic examination, thus, underestimation of caries status might be expected. Utilizing the Ramfjord teeth for periodontal pocket depth examination is an acceptable method of assessing periodontal pockets among community-based research. Oral alterations in the soft tissue, such as changes in color, texture, or volume, were observed and documented using the naked eye of the examiner. Calibration of dental examiners and dental recorders on DMFT, periodontal pocket depth, soft tissue alteration and oral lesions was accomplished two weeks before the dental examinations in the dental clinics of the college by a professor of dentistry.

One of the limitations of the present study is the lack of a random selection of adults were systematically selected from hospital attendees, not randomly selected from adults living in Riyadh city, leading of the possibility of selection bias. Generalization of the results of this study to other settings should be taken with caution. In the present study we attempted to include all cofounders for both BMI and dental caries. Therefore we included variables like demographics, socioeconomic factors and oral hygiene practices. However, many other variables were not included in the study like dietary patterns, utilization of oral health care services and the use of fluoride substance.

Conclusion

There is an observed relationship between Body Mass Index and dental status. Participants with higher BMI were more likely to have higher DMFT scores even when accounting for low education, edematous gingiva, smoking and medical condition. A future study involving a random sample of Saudi adults, which considers independent variables of dietary patterns, utilization of oral health care services and the use of fluoride substance is recommended.

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