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ABSTRACT The prevalence of obesity is increasing in Saudi Arabia and although caries is associated with obesity, this association has not been investigated in Medina. This study aimed to determine the association between dental caries, body mass index (BMI) and dietary habits of 12-year-old boys from four geographically distinct schools in Medina. Mean BMI was 22.17 kg/m² (± 5.15); 41% had normal BMI, 25% were overweight and 30% were obese. The mean Decayed, Missing and Filled Teeth (DMFT) score was 1.46 (± 2.04). Those in the normal BMI range had a significantly higher prevalence of caries (57%) and DMFT score (1.92) compared with the overweight and obese groups (P

Association entre l’indice de masse corporelle, le régime alimentaire et les caries dentaires chez des garçons en dernière année de primaire à Médine (Arabie saoudite)

RÉSUMÉ La prévalence de l'obésité augmente en Arabie saoudite et malgré le lien qui existe entre la carie et l'obésité, cette association n'a pas été étudiée à Médine. La présente étude avait pour objectif de déterminer l'association entre les caries dentaires, l'indice de masse corporelle (IMC) et les habitudes alimentaires de garçons âgés de 12 ans venant de quatre écoles géographiquement distinctes à Médine. L'IMC moyen était de

22,17 kg/m² (± 5,15) ; 41 % avaient un IMC normal, 25 % étaient en surcharge pondérale et 30 % étaient obèses. Le score moyen de l'indice CAO (dent cariée, absente ou obturée) s'élevait à 1,46 (± 2,04). Les garçons dont l'IMC se situait dans les valeurs normales avaient un prévalence de la carie (57 %) et un indice CAO supérieurs (1,92) à ceux du groupe des enfants en surcharge pondérale et souffrant d'obésité (p

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Introduction

There is a strong association between nutritional status and dental caries, and a direct link between caries, sugar consumption and obesity (1,2). Some studies have reported a positive correlation between caries and obesity, whereas others have shown that underweight children tend to have a higher prevalence of caries compared to their overweight counterparts (1,2).

Dental caries is a worldwide epidemic affecting children of all ages (3,4). Its aetiology is multifactorial and includes plaque accumulation, poor oral hygiene and consumption of fermentable carbohydrates (2). Obesity is also multifactorial and its risk factors include poor eating habits, lack of physical activity, genetics and increased consumption of carbohydrates (3).

Children with caries may present with pain and ultimately tooth loss. This could result in a reduction in food intake, which in turn may lead to stunting of growth (3). In contrast, increased

consumption of fermentable carbohydrates can result in increased body weight and prevalence of dental caries (4).

Body mass index (BMI) is currently used as the gold standard to determine anthropometric score and classifies individuals into four groups; underweight, normal weight, overweight and obese (3). Although there have been conflicting results regarding the association between caries and BMI, this association has not been studied in grade 6 children in Medina. Saudi Arabia has one of the highest obesity levels in the world, which could be due to its rapid growth and economic development over the past few years and the widespread introduction and consumption of fast foods and soft drinks (5,6).

This study was carried out in the city of Medina, which is located in North West Saudi Arabia. It is the second holiest site in the Islamic world after Mecca. The aim of the study was to determine the relationship between dental caries, BMI and dietary intake of 12-year-old schoolchildren in Medina.

Methods

Study design

This was a cross-sectional analytical study of Grade 6 schoolboys carried out between February and April 2014. The sample size was calculated by estimating the population of 12 year-old boys in Medina to be 10 000 (7). Assuming the prevalence of obesity to be 23% (8) with a confidence level of 95% and marginal error of ~0.05, a minimum sample size of 370 participants was required. There were 194 male primary schools in Medina and these were divided into 4 geographical areas as follows: North, 40 schools; South, 51 schools; West, 52 schools and East, 51 schools. One school was selected from each cluster using a convenience sampling strategy. All grade 6 students from each of the four schools were invited to participate in the study. A total of 419 participants received consent forms for their parents to sign; this ensured that the minimum sample size would be achieved.

Data collection

The data collection consisted of 3 parts: a clinical oral examination; completion of a dietary questionnaire; and measuring body height and weight.

The oral examinations were performed in classrooms under fluorescent lighting with the participant sitting on a school chair according to the World Health Organization (WHO) criteria (9). The Decayed, Missing and Filled Teeth (DMFT) index was used to record the caries status

of the permanent dentition. The primary dentition was excluded. Only teeth with frank caries were diagnosed as decayed while those with early white spot lesions, unconfirmed caries or fissure sealants were recorded as sound. Teeth that were extracted because of caries were recorded as missing, while teeth removed due to trauma or orthodontic treatment were recorded as healthy according to the WHO criteria (9). Two dentists who had been trained in the diagnosis of dental caries using the DMFT index index completed the oral examinations. Calibration was done using slides and mounted extracted teeth and κ scores of 0.90 and 0.80 were obtained for intra- and inter-examiner reliability, respectively. For simplicity, the DMFT score was divided into 3 categories at the time of data presentation: 0, no caries; 1–3, mild caries; and ≥ 4, severe caries.

A standardized dietary questionnaire (10,11) was used to determine the nutritional intake and physical activity of the participants. A pilot study, to validate the questionnaire, was carried out on 45 boys at the first school. Minor changes were made to the questionnaire and the modified version was used at the remaining schools. Data from the first school was included in the final analysis because there was sufficient overlap between the initial and latter information that was collected. The questionnaire was self-administered and consisted of 12 closed and 1 open-ended questions. The questions were related to the consumption of junk foods such as burgers, pizzas and sweets, soft drinks, milk, water, fruit and vegetables, and the frequency of physical activities.

Trained dental students, using a medical scale to the nearest 100 g and a standardized height measuring tape in meters to the nearest centimetre, recorded the weight and height respectively. The participants removed their shoes and heavy garments before their height and weight were recorded. The BMI was calculated by dividing the weight in kilograms by the square of the height in metres (kg/m2) (12). The recorded height and weight were classified according to the WHO BMI categories using age-related guidelines into underweight, normal, overweight or obese (12).

Oral hygiene

The participants received a 15-minute presentation regarding oral hygiene practices and healthy eating habits. They were shown how to brush and floss their teeth and all participants received a toothbrush, toothpaste and pamphlets containing information on brushing and oral hygiene practices. A referral form was issued to those who were in need of dental treatment and they were advised to visit the Taibah University Dental College & Hospital for further assessment and management.

Statistical analyses

Descriptive statistics including the percentages, means and standard deviations (SDs) were obtained. The χ2 test was used to test the significance of the categorical data in the different BMI and DMFT groups. Analysis of variance (ANOVA) and Kruskal–Wallis tests were used when comparing the continuous data, mean DMFT and mean BMI scores. Linear regression analysis was used to assess whether significance levels remained after controlling for possible confounding variables. BMI was considered the dependent variable and DMFT score was considered the independent variable. Age, school, freque ncy of snacks between meals, consumption of soft drinks, milk, fruit and vegetables, and daily sports activities were all considered as possible confounders and were eventually entered into the model simultaneously to achieve the best model fit. Confounders were entered initially in a stepwise manner to observe the change in the R2 value, which increased from 3% to 11% at most, possibly inferring a poor model fit. However, the standard error of the regression was lowered from 6 to 5, inferring a prediction interval of up to 90%. A probability plot was used for regression model diagnostics to detect any possible nonlinearity or non-normality of the model. The results of the model diagnostics turned out negative. Logistic regression was also done using caries as the binary dependent variable and BMI, age, school, sport activities and dietary intake as independent variables. The crude and adjusted odds ratios (ORs) were calculated to assess the odds of developing caries in the different BMI groups. In all instances, the significance level was set at P **Ethical clearance**

Ethical clearance was obtained from the Taibah Dental Ethics Committee (TUCDREC/20130512/Bhayat) and all information was strictly confidential and anonymous.

Results

The parents of 402 of the 419 participants provided signed consent, yielding a response rate of 96%. Those who were not included either did not have signed consent forms or were absent on the day of the clinical examination. The mean age of the participants was 12.6 years (± 0.62; range 12–14 years) and mean DMFT score was 1.46 (± 2.04; range 0–9) (Table 1). The median DMFT score was 0.0 and the decayed, missing and filled components contributed 86, 3 and 11% of the total DMFT score, respectively.

The mean BMI was 22.17 (± 5.15) kg/m2. Sixteen (4%) of the schoolboys were underweight, 165 (41%) were within the normal range, 100 (25%) were overweight and 121 (30%) were obese (Table 1). Boys in the normal and underweight groups had a significantly higher prevalence of caries (P Table 2). When calculating the unadjusted OR, normal weight children were 1.3 times more likely to develop caries compared to overweight and obese children (P Table 3
). Furthermore, when adjusting for age, school, sport activities and dietary intake variables, the normal weight children were almost 1.8 times more likely to develop caries compared to those who were overweight and obese (P

The participants were also divided into 3 groups based on their DMFT score (13). There were significant differences in the mean BMI scores among the 3 caries severity groups (P Table 4). Those who were caries free (DMFT = 0) had the highest mean BMI (22.69 kg/m2), while those with severe caries (DMFT ≥ 4) had the lowest mean BMI (20.26 kg/m2).

Regarding the dietary intake, less than half of the participants reported eating fruit and vegetables daily (Figure 1). The majority (97%) reported drinking up to 4 glasses of soft drinks per day, while 72% reported drinking

Discussion

The aim of this study was to determine the association between dental caries, BMI and dietary habits of Grade 6 schoolboys in Medina. The mean DMFT score was 1.46, which was within the target set by the WHO and the range (1.31–1.53) reported by previous studies in Medina (13,14). Although the mean DMFT score was low, 49% of the sample were diagnosed with caries, of which, 15% had severe caries. In addition, 86% of the decayed teeth were untreated. This shows the skewed distribution of caries and may be a result of poor utilization of dental services due to fear, geographic location, high costs, lack of oral hygiene practices and poor oral hygiene education (15,16). The heterogeneous distribution of dental caries, with pockets of severe caries, emphasizes the need for regular dental visits and school oral health programmes that could prevent the onset and subsequent progression of dental caries.

More than half of the sample (55%) was either overweight or obese, and many of them could grow into obese adults and possibly suffer from metabolic diseases (17). The high prevalence of overweight and obesity is consistent with previous studies of adolescents in the Middle East (6). Possible reasons for this high prevalence include the increased consumption of fried foods, foods with a high fat content and a lack of physical activity (6). This calls for immediate actions to be taken by school administrations with regards to the type of food products being offered and, more importantly, by the parents at home.

There was a significant inverse association between the DMFT and BMI scores. Normal weight children had a significantly higher mean DMFT score and prevalence of caries compared to the overweight and obese participants. This significant inverse association remained significant even after controlling for possible confounders by means of linear regression. This result confirmed previous studies and highlights an unusual trend in the Middle East (18,19). Sugar is one of the risk factors for the development of caries and obesity. Hence, it can be assumed that if the sugar consumption increases, dental caries and BMI should also increase. However, these studies have shown that as BMI increases, caries prevalence and severity decrease (18,19). The cause of this inverse relationship is not clearly understood, but it may be attributed to the unique dietary patterns found in this region. The common diet comprises fried foods that are loaded with fat but have low amounts of refined carbohydrates. This could increase the BMI

and not necessarily have a direct effect on dental caries.

We used an additional statistical test to confirm the inverse relationship between caries and BMI. Previous studies have shown that if continuous data, like BMI, are categorized into groups, such as normal weight, overweight and obese, insignificant statistical associations could be interpreted as significant, which could result in insignificant associations being interpreted as significant ones (20). To prevent this, we used ANOVA to associate each of the three groups of dental caries with mean BMI. Therefore, mean BMI and BMI categories were associated with DMFT scores to identify any significant associations. Mean BMI scores and categories both yielded significant results when associated with DMFT scores. Those with a higher DMFT tended to have a lower mean BMI. This could be due to their poor diet, or as others have suggested, the increased caries could have resulted in dental pain, which had a negative impact on eating and chewing (18,19). This could have reduced their nutritional intake and resulted in stunting of growth (18,19). In addition, severe caries is associated with iron deficiency anaemia, which could contribute to poor growth and reduced BMI in these children (21).

Children with normal BMI were ~1.8 times more likely to have caries compared to those who were overweight or obese. This contradicts the accepted hypothesis that increased sugar consumption results in obesity and dental caries. It is probable that this sample consumes large volumes of fatty fried foods and unrefined carbohydrates that increase BMI but not necessarily caries. This could not be confirmed in our study as the dietary questionnaire did not specify the type or amount of food that was consumed. Future studies are being planned with a modified dietary questionnaire that addresses these shortfalls in order to identify any confounders that may have influenced the results.

The protective effect of obesity on dental caries could also be explained by an increase in saliva production due to increased food consumption (22). This increase in saliva could act as a mechanical cleanser, buffering the low pH produced by bacteria, and hence reducing the incidence of dental caries.

Although some studies have reported that children with a high DMFT score were more likely to be overweight or obese, these studies compared the BMI categories and not the mean BMI with the DMFT score, which may have affected the results (23,24). In addition, the dietary habits were different from those in the current study. In the previous studies, overweight and obese children consumed more sweetened junk foods compared to children in the normal weight range. This increased both the BMI and DMFT scores (24). Another reason for the contradictory results could be that some studies analysed the caries status of both the primary and permanent dentitions, while the current study was limited to the permanent dentition. The

inclusion of both dentitions at different ages could have skewed the caries prevalence and affected the association between caries and BMI.

There were no significant associations between dietary habits and DMFT scores. This could be due to response acquiescence. The students may have answered the questionnaire based on their knowledge rather than on their actual eating habits. Saudi Arabia has launched many educational campaigns focusing on healthy lifestyle to try and reduce the prevalence of overweight and obesity among school children. This could have improved the students' knowledge on healthy versus unhealthy foods and their effects on health. Therefore, this may have influenced their responses and contributed to the weak correlations between caries and the supposed diet that they were consuming. This was confirmed by the poor responses obtained regarding the diet consumed at schools. Many respondents reported eating junk food regularly while few admitted that they consumed fruit and milk. This has severe implications for oral health, systemic health and intellectual development (10,25). School management should regulate the types of foods being sold in the cafeteria and the types of lunch and snacks being brought from home. This could ensure that children are directed towards eating a healthier diet.

Limitations

The sample comprised only boys because of accessibility limitations. Further studies are required to determine whether these results are common to both genders. Moreover, this study was conducted on a convenience sample, inferring that the results should be interpreted with caution. The dietary questionnaire did not include the volume of food consumed, specific types of food and beverages consumed, oral hygiene practices and socioeconomic status. Future studies should include these variables. It must be noted that students could have answered based on their knowledge and not on their actual dietary intake, which could have skewed the results. Lastly, caries was scored using the DMFT index. This index classifies only frank caries as decayed; early caries and white spot lesions are classified as healthy. This often results in an underestimation of the true disease burden. Future studies should use a more sensitive index that can detect early caries.

Conclusion

Within the limits of the study, we observed a significant inverse relationship between dental caries and BMI among grade 6 students in Medina. Those in the underweight and normal BMI groups had the highest prevalence of caries and were almost 2 times greater at risk of developing caries compared to the overweight and obese groups. Although the prevalence of caries was low, the decayed component contributed most to the DMFT index, which emphasized the unmet dental burden of these participants. In general, they had poor dietary habits and there were no significant associations between any of the dietary variables and caries. We recommend: (1) regulation of the type of food being sold and brought into school; (2) implementation of oral hygiene education in schools; and (3) stressing the importance of regular

dental check-ups, which would identify, treat and subsequently reduce oral health disorders such as dental caries.

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