original article

The prevalence of overweight/obesity in high school adolescents in Jeddah and the association of obesity association with dental caries

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BACKGROUND: The prevalence of overweight/obesity in children in Saudi Arabia is among the highest in the world. The prevalence of dental caries is also high in Saudi children. Studies on the relationship between caries and obesity in Saudi adolescents are lacking.

OBJECTIVES: To study the prevalence of overweight/obesity in adolescents, and determine any association between obesity and caries.

DESIGN: An analytical cross-sectional study.

SETTING: Private and public schools in Jeddah.

PATIENTS AND METHODS: The study sample comprised high school children from public and private schools selected by multistage stratified random sampling. Height, weight, waist circumference (WC), and body mass index (BMI) were measured for all children, who were then classified as underweight/normal, overweight, or obese according to their BMI values, and nonobese or obese according to their WC values. The presence of caries was assessed using the Association of State and Territorial Dental Directors criteria.

MAIN OUTCOME MEASURE(S): The prevalence of overweight/obesity and the association of obesity with the number of decayed permanent teeth.

RESULTS: 801 high school children (48% boys, 49% from public schools) with a mean (SD) age of 16.5 (0.9) years. When the BMI classification was used, 24%, 16%, and 60% adolescents were obese, overweight, and underweight/normal, respectively. When the WC classification was used, 19% and 81% were obese and nonobese, respectively. Obesity was more prevalent in boys and in students attending private schools ($P<.05$). The number of decayed permanent teeth showed a very weak and insignificant correlation with BMI and WC.

CONCLUSION: One in every four adolescents residing in Jeddah was obese, with a high obesity prevalence in boys and in children attending private schools. The prevalence of caries in the permanent dentition was not associated with BMI or WC.

LIMITATIONS: It was difficult to establish temporality in this cross-sectional study. Data on common risk factors were not adjusted for in the analyses.

The World Health Organization (WHO) defines obesity as "abnormal or excessive fat accumulation that may impair health," while overweight is defined as "a body mass index (BMI) of 25 kg/m^2 or more."[1] Overweight and obesity can negatively affect the physiological and psychological well-being of the affected individual,[2-4] and both have become a global issue of concern for researchers, healthcare providers, and education policy makers.[5-7]

Worldwide, the prevalence of obesity is rapidly increasing in all age groups.[5,8] In particular, it is an epidemic in Saudi Arabia.[9] In fact, the prevalence of overweight and obesity in adults and children in Saudi Arabia is among the highest in the world.[9] In 2010, a

study conducted by Al-Dossary et al revealed that the prevalence of overweight/obesity in Saudi children was 37% in preschoolers, 42% in preteens, and 47% in teenagers.[10] Results from a 2010 report on overweight/obesity by El Mouzan et al revealed an alarming prevalence of 32.4% in Saudi children and adolescents, with a 2% prevalence of severe obesity.[11]

Similar to obesity, dental caries is a highly prevalent childhood disease.[12] There is a high prevalence of caries in both boys and girls in Saudi Arabia.[13] There are some common risk factors for obesity and caries, such as high-calorie and cariogenic diets. Therefore, both diseases are often coincidental. The literature is rich with studies investigating the relationship between overweight/obesity and caries; however, the results are diverse. Dental caries is reportedly more prevalent in underweight Saudi preschoolers, which has led the authors to the belief that pain and infection associated with untreated caries can impede growth.[14] Werner et al reported that the number of obese children who presented with dental caries at their initial examination was smaller than of their normal/underweight counterparts.[15] On the other hand, some researchers found a higher caries prevalence in heavier children,[16,17] while some found no relationship between the two conditions, which was attributed to limitations in the study methodologies or sample characteristics.[18-20]

There are a lack of studies on the relationship between dental caries and obesity in Saudi adolescents. The authors of the present study have conducted a series of studies investigating obesity in children of different age groups with different stages of dentition. For the current study, the authors hypothesized that the prevalence of dental caries is high in obese children, because poor dietary habits contribute to the development of both conditions, and that obesity is more prevalent among children attending private schools because of affordability of larger meals and sedentary lifestyles. Accordingly, the study aims were as follows: investigation of the prevalence of overweight/obesity in boys and girls attending public and private high schools in Jeddah, Saudi Arabia; assessment of differences in prevalence according to sex and type of school; and determination of the association between obesity and permanent tooth caries in the same population.

SUBJECTS AND METHODS

Study design and participants

This cross-sectional study was conducted from October 2014 to May 2015 in Jeddah, Saudi Arabia. To ensure that all participants were in the permanent dentition stage, adolescents were selected as the target population. We sampled 98 174 adolescents registered in the Ministry of Education high schools in Jeddah. The mean (SD) prevalence of overweight and obesity in this population was hypothesized to be 23% (3%) on the basis of previous population-based studies;[10] this was used to calculate the sample size using OpenEpi version 2, a free web-based operating-system independent program for use in epidemiology.[21] The power was set at 85% and the confidence level at 95%. On the basis of these calculations, the required sample size was estimated as 751. There were 50 260 boys and 47 914 girls distributed among 320 public and private high schools, which yielded a male-to-female ratio of 1:0.95. Accordingly, our study required 385 boys and 366 girls.

Multistage stratified random sampling was used for the selection of students. First, schools were randomly selected from a previously prepared, numbered list using a random number generator. To achieve necessary sample size, two numbers representing a public and a private school in each of Jeddah's four main districts (North, South, East, and West) were selected for each sex. Then, two 11th grade classrooms were randomly selected from each school. All students in each classroom were included in our study. Eleventh grade was chosen because students in this academic year generally have more free time compared with students in 10th and 12th grades. If the school had only one 11th grade class, randomization was repeated and a different school was selected.

The ethics committee of the Faculty of Dentistry at King Abdulaziz University (KAUFD) approved our study protocol (#02-816, dated January 1, 2013). The Saudi Ministry of Education approved the school visit and data collection procedures. Approval to schedule the school visits was also obtained from all school principals. Information about the study with consent forms were distributed during the first visit. At the second visit, children who returned signed consent forms were examined. The inclusion criteria were as follows: students in the 11th grade who were officially registered in the Ministry of Education, aged between 15 and 19 years, and signed parental consent.

Anthropometric measurements

The weight of all students was measured using an electronic weighing scale after the removal of shoes, jackets, and heavy accessories. The waist circumference (WC) was measured using a nonelastic measuring tape; the reference point was the highest point on the iliac

crest in the standing position. Height was measured using a nonelastic measuring tape. The children were instructed to stand barefoot and look straight ahead. The highest point on the head was marked with a dash on a white cardboard that was previously fixed to the wall. Then, the tape was used to measure the distance from the marked dash to the floor.

All anthropometric measurements were recorded by three coauthors after calibration. For intraexaminer reliability assessment, 10 children attending the clinics at KAUFD were examined twice at one-week intervals (kappa score, 0.85). For interexaminer reliability assessment, 20 patients attending the KAUFD clinics were examined (kappa score, 0.77). In case of any disagreement, a consensus was reached through repeat measurements. For each measurement, two readings were taken and averaged for further analysis.

Oral examination

Caries was considered present in students with a minimum 0.5-mm tooth structure loss from the enamel surface and brown discoloration of the cavity walls. Teeth restored with temporary fillings were marked as decayed. Teeth with pit and fissure sealants and those with only white spot lesion(s) were marked as sound. A sterile, flat-surface mouth mirror, a round-ended community periodontal index-probe (0.5-mm tip ball), and gauze and cotton rolls were used for caries examinations. A confidential report of the child's oral health status and treatment needs was sent to the parents. A referral letter to KAUFD was also enclosed.

Two calibrated coauthors performed the oral examinations. The calibration exercise was conducted using a detailed rubric for caries detection according to the Association of State & Territorial Dental Directors (ASTDD) criteria.[22] For intraexaminer reliability assessment, 10 children attending the clinics at KAUFD were examined twice at one-week intervals (kappa score, 0.85). For interexaminer reliability assessment, 30 patients attending the KAUFD clinics were examined (kappa score, 0.90). In case of disagreement, a consensus was reached through repeat measurements.

Statistical analysis

The BMI of each student was calculated by dividing the weight by the square of the height (kg/m^2). Children were classified as underweight (BMI below the 5th percentile for age and sex), normal weight (BMI between the 5th and 84th percentile for age and sex), overweight (BMI between the 85th and 94th percentiles), and obese (BMI above the 95th percentile) using the Saudi BMI percentiles introduced by Al Herbish et al.[23] The cut-off points used were those suggested by Barlow et al.[24] In addition, the students were classified as obese when WC was above the 90th percentile for age and sex, according to the percentiles estimated by Fernandez et al;[25,26] the remaining students were classified as nonobese. The diseased score (D) was used as an index for permanent tooth caries.

Medians and interquartile ranges (IQRs) were reported for continuous variables and frequencies and percentages for categorical variables. The chi-square test and Fisher exact tests were used to test the association of obesity with sex and school type. The Wilcoxon (Mann-Whitney) test was used to test the association of the number of decayed teeth with sex and school type. The association of BMI and WC as categorical variables with the number of decayed teeth was tested using the Wilcoxon (Mann-Whitney) test and Kruskal-Wallis tests, respectively. The association of BMI and WC as continuous variables with the number of decayed teeth was tested using Spearman's correlation coefficients. A *P* value of <.05 was considered statistically significant. All statistical analyses were performed using STATA version 13.0 (StataCorp, College Station, Texas, USA).

RESULTS

Consent forms were distributed to 950 students. The response rate was 84%. All 801 students who returned signed consent forms were examined. **Table 1** shows the characteristics of the study population. The participants' mean age was 16.5 (0.9) years. Approximately half the students were boys (48%). Fifty-one percent students were enrolled in private schools and 49% in public schools. The median (IQR) BMI and WC values of the participants were 23.4 (20.5, 27.8) kg/m^2 and 84 (77, 94) cm, respectively. According to the BMI classification, 24%, 16%, and 60% students were obese, overweight, and underweight/normal, respectively. According to the WC classification, 19% and 81% students were obese and nonobese, respectively.

The association of obesity with sex and type of school is shown in **Table 2**. The prevalence of obesity based on BMI (*P*<.001) and WC measurements (*P*=.042) was significantly higher in boys than in girls. Approximately 51% boys and 0.5% girls were obese according to BMI measurements, while 22% boys and 16% girls were obese according to WC measurements. With regard to the type of school, the prevalence of obesity was significantly lower in children attending public schools than in those attending private schools. When the BMI classification was used, 41% and 39% children from private and public schools, respectively, were classified as overweight or obese (*P*<.001). When

Table 1. Demographic and anthropometric characteristics of the sample population of adolescents attending high schools in Jeddah (N=801).

Characteristics	N	%
Age [mean (SD), years]	16.5 (0.9)	
Gender		
Male	386	48
Female	415	52
High school type		
Private	406	51
Public	395	49
Height [mean (SD), m]	1.6 (0.1)	
Weight [median (IQR), kg]	63 (51, 78)	
BMI [median (IQR), kg/m^2]	23.4 (20.5, 27.8)	
BMI classification		
Underweight	54	7
Normal	424	53
Overweight	126	16
Obese	197	24
WC [median (IQR), cm]	84 (77, 94)	
WC classification		
Non-obese	650	81
Obese	151	19

BMI: body mass index; WC: waist circumference

the WC classification was used, 24% and 13% children from private and public schools, respectively, were classified as obese (*P*<.001).

The overall prevalence of dental caries was 24.8%. **Table 3** shows the distribution of caries in the permanent dentition by sex and school type. The prevalence of caries was significantly higher in girls than in boys (*P*<.001), while it was significantly lower in children attending private schools than in those attending public schools (*P*<.001).

The distribution of caries in the permanent dentition by obesity status is displayed in **Table 4**. A weak, positive, and insignificant correlation was observed between BMI and the number of decayed teeth (Spearman's rho, 0.01; *P*, 0.737), while a weak, negative, and insignificant correlation was observed between WC and the number of decayed teeth (Spearman's rho, -0.06; *P*, 0.069). The number of decayed permanent teeth was not significantly different between the BMI-(*P*=.433) and WC-classified (*P*=.727) groups.

DISCUSSION

The present cross-sectional study was conducted to investigate the prevalence and distribution of overweight/obesity in high school adolescents in Jeddah, assess differences in the prevalence according to sex (male and female) and type of school (public and private), and determine the association between obesity and dental caries in the permanent dentition. The results revealed that obesity was more prevalent in boys and in children attending private schools, while dental caries was more prevalent in girls and in children attending public schools. There was no significant cor-

Table 2. Prevalence of obesity (based on BMI and WC classifications) by gender and high school type among adolescents attending high schools in Jeddah (N=801).

Variable	Gender		*P*	High school type		*P*
	Male n (%)	Female n (%)		Private n (%)	Public n (%)	
BMI classification						
Underweight	0 (0)	54 (13)	<.001	5 (1.2)	49 (12)	<.001
Normal	122 (32)	302 (73)		242 (60)	182 (46)	
Overweight	69 (18)	57 (14)		65 (16)	61 (15)	
Obese	195 (51)	2 (0.5)		94 (23)	103 (26)	
WC classification						
Non-obese	302 (78)	348 (84)	.042	307 (76)	343 (87)	<.001
Obese	84 (22)	67 (16)		99 (24)	52 (13)	

BMI: body mass index; WC: waist circumference. Statistical analysis by chi-square test and Fisher exact test. Chi-square test statistic: Gender by BMI classification, 0.000 (Fisher exact); Gender by WC classification, 4.1248; High school type by BMI classification, 44.7379; High school type by WC classification, 16.4750.

Table 3. Distribution of dental caries by gender and high school type among adolescents attending high schools in Jeddah (N=801)

Variables	Number of decayed teeth		*P*
	Mean (SD)	Median (IQR)	
Gender			
Male	3.9 (3.5)	3 (1, 6)	<.001
Female	4.9 (3.7)	5 (2, 7)	
High school type			
Private	3.8 (3.6)	3 (1, 6)	<.001
Public	5.1 (3.6)	5 (2, 7)	

Statistical analysis by Wilcoxon (Mann-Whitney) test. Gender vs number of decayed teeth, z=-4.089, High school type vs number of decayed teeth, z=-5.776.

Table 4. Distribution of dental caries by obesity status (based on BMI and WC) among adolescents attending high schools in Jeddah (N=801).

Variables	Number of decayed teeth		*P*
	Mean (SD)	Median (IQR)	
BMI (Spearman's ρ)	0.01		.737[a]
BMI classification			
Underweight	4.9 (3.0)	5 (2, 7)	.433[b]
Normal	4.5 (3.9)	4 (1, 7)	
Overweight	4.5 (3.3)	4 (2, 7)	
Obese	4.3 (3.5)	4 (2, 6)	
WC (Spearman's ρ)	-0.06		.069[a]
WC classification			
Non-obese	4.5 (3.6)	4 (2, 7)	.727[c]
Obese	4.5 (3.8)	4 (1, 7)	

Statistical analysis by [a]Spearman's correlation, [b]Kruskal-Wallis test (Chi-squared, 2.717 with 3 df) and [c]Wilcoxon (Mann-Whitney) test. BMI: body mass index; WC: waist circumference.

relation between obesity and dental caries.

Adolescence, roughly defined as the age between 10 and 18 years, is a critical growth phase characterized by unique physiological changes and social and psychological needs.[27] The Arab population is considered relatively young, with more than half the population below the age of 25 years.[28] It is estimated that approximately 51% of the Saudi population are adolescents.[29]

Obesity is a dangerous epidemic with a rapidly increasing incidence worldwide.[5] Currently, Saudi Arabia ranks among countries with the highest rates of obesity in children.[9] This oil-rich country with a relatively young population has witnessed massive development in recent years, with a marked rise in the standard of living. These changes have led to a shift in the general lifestyle of the Saudi population, which has begun to prefer a more slow-paced, sedentary life. Physical activity has been marginalized and the time spent watching television and on electronic/video games has increased.[30,31] Dietary habits have also been altered, with children consuming more than their daily calorie requirement and less home-prepared meals compared with earlier times.[30,32]

Obesity is often measured by BMI, which is an easy measure. Despite its popularity, BMI has some limitations. It does not factor in the composition of the body mass and can wrongly classify a muscular individual as obese or an individual with a high percentage of body fat with normal weight as healthy. To overcome these limitations, we used both BMI and WC measurements to classify obesity in the present study.

The results of the present study revealed that obesity was quite prevalent among the study population, with 24% and 19% adolescents classified as obese according to BMI and WC measurements, respectfully. According to both measurements, the prevalence was significantly higher in boys and children attending private schools. Sex-related differences in the rates of adolescent obesity are inconsistently reported in the literature.[33] Our findings are consistent with those of Al-Dossary et al, who noticed a steady increase in obesity with age in Saudi children, with a prevalence of 36% and 19% in adolescent boys and girls, respectively.[10] In a report by Abalkhail, a marked increase in obesity was observed among Saudi children from 1994 to 2000, with the most dramatic increase observed in boys between 10 and 16 years of age.[34] Our results also coincide with internationally documented higher obesity rates in adolescent boys.[35,36] The sex-related differences in the present study can be attributed to the conservative Saudi culture. Boys are more likely to spend time outside home and are allowed to drive, thus having easy access to unhealthy food.[10,37] Girls in this age group, on the other hand, are more self-conscious and more concerned with their body image, so they follow healthier dietary habits.[10,38] In addition, parental feeding practices have been reported to be associated with the weight of children.[39] Parental food restrictions may apply more to girls, who are more likely to stay at home, than to boys. However, some Saudi surveys have found that obesity is more prevalent in girls.[40,41] Adolescent Saudi girls are less engaged in physical activity, which is a significant risk factor for adolescent obesity.[42] In a report by Al-Hazzaa et al, Saudi girls aged 14-19 years consumed more French fries, cakes, potato chips, and chocolate compared with their male

counterparts.[30]

In the present study, we found that obesity was more prevalent in girls and boys attending private schools than in those attending public schools. Generally, children attending private schools belong to more affluent families that are more likely to provide larger and more frequent meals with fewer restrictions on snacks. Children attending private schools are also more likely to be driven around in vehicles and consequently walk less. In addition, they have easy access to electronic/video games. Our findings are consistent with those of regional and international surveys. The findings of a study by Al-Hazzaa et al indicated that adolescents attending private schools showed a higher odds of being overweight or obese.[30] Similarly, Patanik et al found a higher prevalence of obesity in Indian adolescents attending private schools.[43] A 2015 report from Tanzania found that obesity was more prevalent in children aged 7-14 years who attended private schools.[44]

Obesity and caries share common risk factors. The role of a poor diet, for example, a diet high in calories and sugar, is significant in the development of the two conditions. Children with a high BMI and those with a high prevalence of dental caries share similar lifestyle habits.[45] Moreover, low family income has been linked to the occurrence of both conditions in children.[46]

In the present study, the relationship between obesity and dental caries was tested in high school adolescents, and the results revealed no significant correlation. A plausible reason for this finding is the lack of assessment of dietary habits, socioeconomic status, oral hygiene practices, and other factors that could act as confounders. For example, children on high-fat diets would likely develop obesity, but not caries, while children with meticulous oral hygiene habits and a high sugar intake may be obese and caries-free. The results of a study by Mojarrad et al also did not support an association between obesity and dental caries.[19] The authors attributed their findings to the low number of obese children in their study.[19] Another American study found no correlation between BMI and dental caries in children with severe early childhood caries, probably because of the high number of malnourished (underweight) children in their study.[20] Tripathi et al found no association between dental caries and obesity and suggested that caries was underestimated because of the lack of assessment on dental radiographs.[18] They also attributed their findings to the absence of data on the dietary habits of the enrolled children. In contrast, in a study by Alkarimi et al, dental caries was inversely associated with anthropometric measurements in Saudi children, and it was suggested that untreated caries was associated with poorer growth.[14] This inverse relationship was also documented in an America in which more children with a normal weight presented with dental caries at the first examination compared with obese children.[15] This was probably because caries causes dental pain that can limit the child's ability to eat, leading to malnourishment and growth impairment. Furthermore, infection associated with caries can indirectly affect the child's weight through endocrine, immune, and metabolic responses, ultimately leading to malnutrition and growth retardation.[47] In another American study, there was a positive association between a high BMI and caries in permanent molars,[17] while Willershausen et al reported that significantly more children with a normal weight were caries-free compared with obese children.[48] In Saudi children, an association between a poor diet and overweight/obesity has been reported.[28] Although dental caries was not explored in that study, it was found that heavier children consumed more carbohydrates and fats than recommended.

There are a number of limitations inherent to this study. First, caries data was gathered on the sole basis of clinical examinations, with no use of radiographs. Second, several common risk factors such as diet and socioeconomic status could have modified the relationship between obesity and dental caries. However, information on these common risk factors was not collected; therefore, we could not adjust for them in our analyses. Third, we could not establish temporality because of the cross-sectional study design. The strength of the study was that children from both sexes, public and private schools, and all four districts of Jeddah were included. Moreover, the limitations of BMI were overcome by the concomitant use of WC measurements to assess obesity.

In conclusion, the present study found that the prevalence of obesity in high school adolescents in Jeddah was higher when BMI measurements were used than when WC measurements were used, although the rates were high with both measurements. More boys than girls were obese, and children attending private schools showed a higher prevalence compared with those attending public schools. Dental caries was not associated with obesity according to both BMI and WC measurements.

Our results show that approximately one in every four adolescents residing in Jeddah is obese. Adolescence obesity has been described as the foundation for adulthood obesity.[49] Therefore, diagnostic, interventional, and prevention strategies should be implemented at an early age to improve current and

future health. Healthcare providers and education policy makers should be encouraged to set strategies for preventing, identifying, and managing childhood obesity. The role of pediatric dentists in obesity control is vital and includes diet counseling and medical referrals as needed.

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Conflict of interest

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