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Original article

Prevalence of obesity and overweight among school-aged children in saudi arabia and its association with vitamin D status

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Summary. *Background:* Childhood obesity is a significant global public health problem. Worldwide data showed an increasing trend over the years. We aimed to explore the prevalence of obesity, and its association with vitamin D status. *Methods:* This cross-sectional study was conducted during the period from 2016 to 2017. The study included 3613 school children aged 6-19 years in the western, central, and eastern regions in Saudi Arabia. Anthropometric data including age, sex and body mass index (BMI) was collected and the serum 25OH- vitamin D (25OHD) was measured. Age-sex standardized BMI Z-scores using the 2007 World Health Organization growth standards were applied. *Results:* Data from 3613 school-aged children (females = 51.8%), with equal percentage of participants from each region were analyzed. Prevalence of obesity and overweight was estimated at 7.1% and 14.4% respectively. An increasing trend was detected with age (p: 0.006). Obesity started to increase at the age of 10 years and continued to increase until 19 years. Most of the obese children (64.2%) had deficient vitamin D levels, compared to 33.7% of them with suboptimal levels and only 2.0% with optimal levels (p: <0.001). *Conclusions:* This large cohort study revealed a high prevalence (21.5%) of obesity and overweight in school children aged between 6-19 years with increasing trend with age. Children with high BMI showed extremely high prevalence of vitamin D deficiency and insufficiency. These findings are alarming and point to the need for effective national interventions that include improving and encouraging access to physical activity and exposure to sunlight, educational activities for students, parents, and schoolteachers and possible enrichment of staple food with vitamin D. (www.actabiomedica.it)

Keywords: Obesity, Overweight, School-Aged Children, Vitamin D

Introduction

Childhood obesity represents a significant public health concern due to its rising trend (1-3). The prevalence of obesity among children worldwide has doubled in 70 countries and continue to increase since 1980 reaching 107.7 million in 2015 (4-6). Almost one-quarter (23%) of both male and female children, in developed countries, are overweight or obese (4). However, in developing countries, overweight and obesity, among children, has been estimated to be 13% (7,8).

The high rates of increased body weight and obesity observed worldwide, and vitamin D insufficiency are closely interrelated problems and both have deleterious health effects in all age groups.

The prevalence of vitamin D insufficiency (VDI) among children and adolescents with obesity is extremely high in many countries: 96.0% in Germany, 78.4% in the United States, and up to 92.0% in the Russian Federation (9-13). The prevalence of vitamin D insufficiency in these countries are high when the cut-off level is set at 75 nmol/L (30 ng/mL), as recommended by the United States National Endocrine Society in 2011 (14).

Obesity among children is more likely to continue during adulthood leading to long term associated disease burden (15-19), including: higher risk for type 2 diabetes mellitus, dyslipidemia, cardiovascular disorders, osteoarthritis, and psychological disorders (20-22). Several modifiable risk factors contribute to overweight and obesity among children. The most significant among these factors are dietary intake and physical activity (18,19).

A systematic review of 18 articles from the Saudi population (6-21 years old), between 1998 and 2010, including 88.265 children and adolescents, showed an average prevalence of overweight and obesity of 26.7% (range: 16-42.3%) (23). These studies used different references for measuring overweight and obesity (i.e., World Health Organization 1995, 2005 and 2007, International Obesity Task Force and Center for Disease Control 1995 and 2000) (23). Furthermore, inconsistency of the type of reference and the applied cut-off values adds difficulty to compare results between studies (23). Current national data, in Saudi Arabia, with a reasonably large sample size is still lacking.

The main objective of this study was to determine the prevalence of overweight and obesity among school-aged children, in different regions in Saudi Arabia, and to measure their vitamin D status.

Methods

Study design

This cross-sectional study included 3.613 school children, aged 6-19 years, in Saudi Arabia. The study was conducted during the period from 2015 to 2016.

Study sampling

We included apparently healthy school children and adolescents living in three geographical regions of Saudi Arabia (Central, Western and Eastern regions). The study subjects were recruited from secondary, intermediate, and primary schools in major cities in these three regions of Saudi Arabia. Blood samples for vitamin D levels were collected from different cities throughout the academic year periods. Vitamin D serum samples from different sites were sent to the central lab at Jeddah city (King Abdulaziz Medical City), and analyzed by chemiluminescence immunoassay within two weeks of sample collection.

Study variables

After getting permission from the school authority, anthropometric data including age, sex, weight, and height were collected from all the schools in the study regions. Children were weighed using a standard beam balance. Weight was recorded in kg and height in cm. Height was measured using a stadiometer (Harpenden Holtain, UK). The body mass index (BMI) was calculated (weight in kilograms) divided by the square of height (in meters).

Other studied variables (exercise and intake of milk) were obtained through a self-reported simple questionnaire. Enclosed with the questionnaire was a cover letter explaining the objectives of the study and the investigators' contacts for inquires.

Age and sex standardized BMI Z-scores using the 2007 World Health Organization (WHO) growth standards were applied (24). This reference has been applied by several national studies and provided a better standard for comparison within and between countries (25-28). BMI was calculated as weight in kilograms divided by the square of height in meters. Z-scores were calculated for each individual using the formula, z= (calculated BMI - WHO median BMI reference of the same age group and sex) / standard deviation.

BMI Z scores were used to categorize children as thin (<-2SD), normal (-2SD to +1SD), overweight (>+1SD to +2SD) or obese (>+2SD) among boys and girls (27,28).

For the interpretation of vitamin D levels the following cu-off were used: ≤25 nmol/L for vitamin D deficiency (VDD) , >25-50 nmol/L for VDI , and >50 nmol/L for vitamin D sufficiency (29,30).

Ethical Approval

The research has complied with all the relevant national regulations, institutional policies, was in accordance with the Helsinki Declaration, and was approved by the IRB office (reference # RC08/121/J) at King Abdullah International Medical Research Center (KAIMRC). Consent of participants was obtained at the time of the study that covered ethical issues related to the questionnaire and the study.

Statistical Analysis

Descriptive statistics were used to describe categorical variables as frequency and percentages, and continuous variables as mean, standard deviation, or median. A Chi-square test was used to determine the distribution of independent categorical variables (gender, region, and school) according to BMI categories. The 95% Confidence interval for the BMI categories proportions was estimated. Multivariate regression analysis was performed to determine factors associated with overweight or obesity. An odds ratio with a 95% confidence interval (CI) was used. Level of significance was determined at p-value <0.05. All analyses were performed using IBM SPSS version 25.

Results

Data from 3.613 school-aged children (51.8% were females) in the western, central, and eastern regions of Saudi Arabia were analyzed. An equal percentage of the participating children was taken from each of the 3 regions. Most of the children were in high school (41.8%), followed by the intermediate and primary schools.

The overall mean (SD) age of the studied children was 14.70 (2.56) years (Table 1).

Regarding the prevalence of overweight and obesity, 7.1% of the children were obese (95% CI: 6.2% - 7.9%), 14.4% were overweight (95% CI: 13.3- 15.6%) and the majority (78.5%) were normal weight (95% CI: 77.1-79.8%). None of the students was found to be underweight. Overweight and obesity showed rising trend with increasing age of the students (p=0.006) (Table 1 and Figure 1).

The prevalence of obesity began to increase at the age of 10 years and continued to rise over the years, until the age of 19 years.

Table 2 shows the distribution of the level of serum vitamin D according to different BMI categories. Most children had either deficient or suboptimal levels of serum vitamin D (95.6%). 64.2% of the obese children had VDD and 33.7% had VDI. Only 2.0% had optimal vitamin D level.

The association between different variables and overweight or obesity has been documented using the multivariate analysis. Serum level of vitamin D level was significantly associated with obesity (OR=2.96, 95% CI: 1.18- 7.43; p: 0.02). Overweight and obesity were not significantly associated with gender, region, school age, type of housing, exercise or drinking milk (Tables 2 and 3).

Discussion

The overall prevalence of overweight or obesity in a large cohort of Saudi school children is 21.5%. A similar prevalence of overweight and obesity has been reported in the United Arab Emirates (UAE), among the same age group (5-17 years old) (31). The current prevalence was higher than that reported in other countries including children aged 8-11 years old in Ghana (16.4%; 9.2% were overweight and 7.2% were obese) (32) , and children 12-16 years old in India (17%; 10.8% were overweight and 6.2% were obese) (33).

However, other countries reported higher prevalence compared to our study. A study from South Africa reported a prevalence of overweight and obesity

Table 1. Demographic characteristics and distribution of overweight and obesity

Characteristics	**Total N (%)**	**Normal weight* n=2.836 (78.5%) 95% CI** (77.1%-79.8%)**	**Overweight n=522 (14.4%) 95% CI (13.3%-15.6%)**	**Obese n=255 (7.1%) 95% CI (6.2%-7.9%)**	**P value**
Gender					
Male	1746 (48.3)	1377 (78.9)	246 (14.1)	123 (7.0)	0.84
Female	1867 (51.8)	1459 (78.1)	276 (14.8)	132 (7.1)	
Region					
Western	1245 (34.5)	970 (77.9)	192 (15.4)	83 (6.7)	0.10
Eastern	1063 (29.4)	859 (80.0)	140 (13.2)	64 (6.0)	
Central	1305 (36.1	1007 (77.2)	190 (14.6)	108 (8.3)	
School age					
Primary (6-12 Ys)	751 (20.8)	618 (82.3)	98 (13.0)	35 (4.7%)	0.006
Intermediate (13-15 Ys)	1352 (37.4)	1064 (78.7)	197 (14.6)	91 (6.7)	
High (16-18 Ys)	1510 (41.8)	1154 (76.4)	227 (15.0)	129 (8.5)	
Type of housing					
Rented	1729 (48.3)	1349 (78.0)	259 (15.0)	121 (7.0)	0.62
Owned	1848 (51.7)	1458 (78.9)	256 (13.9)	134 (7.3)	

*Legend:*Normal refer to normal BMI (-2SD to +1SD); **95% Confidence Interval*

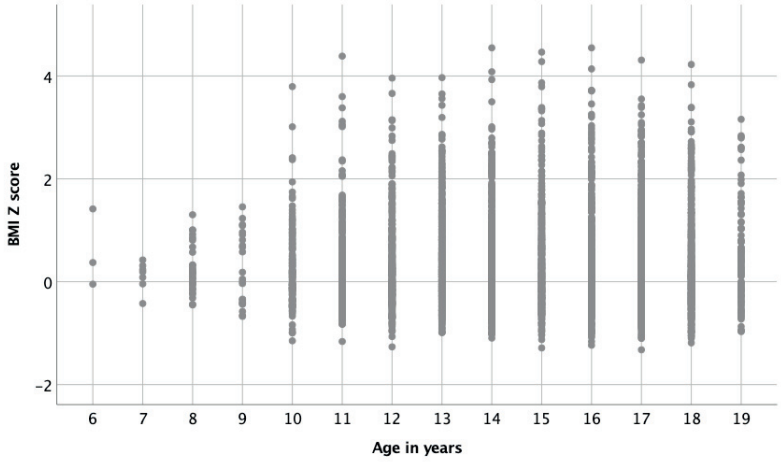

Figure 1. Body Mass Index Z score distributed by age of students

Table 2. Association between obesity and serum vitamin D, exercise and drinking milk

Vitamin D level	**Normal weight*** **n=2.836 (78.5%)** **95% CI**** **(77.1%-79.8%)**	**Overweight** **n=522 (14.4%)** **95% CI** **(13.3%-15.6%)**	**Obese** **n=255 (7.1%)** **95% CI** **(6.2%- 7.9%)**	**P value**
Vitamin D level,				
Deficient (n=1687, 49.0%)	1279 (75.8)	250 (14.8)	158 (9.4)	0.001
Suboptimal (n=1602, 46.6%)	1300 (81.1)	219 (13.7)	83 (5.2)	
Optimal (n=151, 4.4%)	125 (82.8)	21 (13.9)	5 (3.3)	
Performing exercise,				
Yes (n=1400, 50.2%)	1098 (78.4)	200 (14.3)	102 (7.3)	0.34
No (n=1388, 49.8%)	1056 (76.1)	220 (15.9)	112 (8.1)	
Drinking milk,				
Two or less days/week (n=1706, 61.7%)	1323 (77.5)	260 (15.2)	123 (7.2)	0.53
Three days or more (n=1061, 38.3%)	813 (76.6)	159 (15.0)	89 (8.4)	

*Legend:*Normal refer to normal BMI (-2SD to +1SD); **95% Confidence Interval*

of 22.9% among students (7-18 years) (34). In Nepal, 25.7% of primary school children (6-13 years old) were overweight or obese (95% confidence interval: 22.1-29.2) (35).

Previous studies in Saudi Arabia showed variable prevalence of obesity in children and adolescents based on the age and geographic region selected as well as the measurement reference (23). A study on 7931 students (6-16 years old) living in Riyadh, in the central region of Saudi Arabia, performed in 2015 showed a lower total prevalence of 13.4% overweight and obesity compared to our study (36). However, the authors reported similar prevalence of overweight and obesity among adolescent age group (>11 years) (20.2%) compared to 15.7% among younger age children (36). using the 2007 WHO growth standard reference.

Another study by Al-Hussaini et al. (37) in the same age groups showed a prevalence of obesity and overweight equal to 23.5% in high school students, 21.3% in intermediate school and 17.7% in primary school children).

With this high prevalence and rising trend of obesity and overweight, our study and others pointed out to the importance of providing more attention for the prevention of obesity and overweight in students at the intermediate and high school age. In addition, further studies should focus on a quantitative measurement of the risk factors and assessing the impact on health consequences.

In contrast to our study, previous reports identified that boys were almost twice as obese as girls (32,35). While, other studies showed similar proportions of increased BMI among boys and girls without significant differences (33), other reports documented a significantly higher prevalence of overweight among girls compared to boys (23,37).

An increased socioeconomic status of the children and a sedentary life significantly contributed to a

Table 3. Multivariate regression analysis of factors associated with overweight and obesity

Characteristics	Overweight or Obesity vs. Normal			Obesity vs. Normal or overweight		
	OR	95%CI	P	OR	95%CI	P
Gender						
Male (n=1746, 48.3%)	1			1		
Female (n=1867, 51.75)	0.86	0.71, 1.05	**0.14**	0.74	0.55, 1.0	**0.054**
Region						
Western (n=1245, 34.5%)	0.89	0.73, 1.09	**0.27**	0.76	0.56,1.04	**0.08**
Eastern (n=1063, 29.4%)	0.95	0.69, 1.38	**0.75**	0.94	0.60,1.49	**0.80**
Central (n=1305, 36.1%)	1			1		
School age						
Primary (6-12 Ys) (n=751, 20.8%)	1			1		
Intermediate (13-15 Ys) (1352, 37.4%)	1.14	0.82, 1.59	**0.44**	1.22	0.68,2.20	**0.50**
High (16-18 Ys) (1510, 41.8%)	1.14	0.82, 1.60	**0.43**	1.45	0.81,2.58	**0.21**
Type of housing						
Rented (n=1729, 48.3%)	1.12	0.93, 1.35	**0.24**	1.01	0.75,1.37	**0.94**
Owned (n=1848, 51.7%)	1			1		
Performing exercise						
Yes (n=1400, 50.2%)	1			1		
No (n= 1388, 49.8%)	0.91	0.75, 1.12	**0.23**	0.98	0.72,1.35	**0.92**
Drinking milk						
Two or less days/week (n=1706, 61.7%)	0.98	0.81, 1.19	**0.83**	0.94	0.70,1.26	**0.68**
Three days or more (n=1061, 38.3%)	1			1		
Serum vitamin D						
Deficient (n=1687, 49.0%)	1.64	0.99, 2.69	**0.053**	2.96	1.18,7.43	**0.02**
Suboptimal (n=1602, 46.6%)	1.25	0.76, 2.07	**0.38**	1.35	0.53,3.42	**0.53**
Optimal (n=151, 4.4%)	1			1		

Legend: OR= Odds ratio, CI= Confidence Interval

higher prevalence of overweight or obesity (32,38).The association of higher overweight or obesity with an increased socioeconomic status in developing countries has been attributed to the consumption of high energy foods, snacks, and drinks, and the use of motorized transportation to and from schools (32,33).

In developed countries, increased BMI was similarly associated with reduced physical activity (39), low consumption of healthy foods (40), and low socioeconomic groups (41,42).

Hu et al. (43) found that combined lifestyle risk factors, low physical activity, and non- healthy diet contributed to more than one-third of obesity (35%) among children 9-12 years old, and 28% was attributed to decreased physical activity (43). These findings highlights the burden associated with increased sedentary lifestyle among school children related to increased videogame playing, computer use, and television viewing (43).

Drinking milk was not associated with overweight or obesity in the current study, however, other studies reported a significant association among high school students (43). The authors attributed such association to the high levels of saturated fat especially in whole milk (43). Accordingly, the American Academy of Pediatrics recommended that children aged 2 years or older should consume skim or low-fat milk (44).

In our study, obese children had significantly lower values of 25(OH) D than those of the normal weight participants (p: < .001). Many clinical and epidemiological studies reported that obese patients have lower serum concentrations of 25(OH) D (45,46). The link between VDD and obesity can be explained by sequestration of vitamin D within adipose tissue (47) , in addition to lack of sun exposure due to sedentary lifestyle and to very hot weather not encouraging outdoor activities (48).

There is evidence that weight loss is associated with increased serum 25 (OH) D concentration in overweight or obese people. McGill et al. (49) conducted a weight-loss study on 243 adults and found a decrease of 0.75 nmol/L in serum 25(OH) D per 1 kg/m^2 increase in BMI. Based on our data and others, we suggest doing screening of obese children for vitamin D concentration for early detection and management. However, although a relationship between obesity and vitamin D deficiency is clearly demonstrated through numerous studies, there is still a need for a controlled study to assess the proper amount of vitamin D required by obese children and adolescents and whether supplementation with vitamin D has any beneficial therapeutic effect in the management of obesity.

The main strength of this study is the large sample size; hence, the findings can be generalized to represent the status of overweight and obesity among school children in Saudi Arabia. The limitations are related to the self-reporting of data as well as the recall bias, and the lack of detailed information on physical activity and diet. However, previous studies that collected information on physical activity and diet suffered from subjective measurements and potential inaccuracy. Therefore, future studies should focus on quantitative assessment of food consumption and objectively measure physical activity among students at school and home. Longitudinal cohort studies would help to establish a causal association between independent risk factors (including socioeconomic status and activity-related behaviors) and occurrence of overweight or obesity among school-aged children.

Conclusions and Recommendations

The current study reported strong evidence of increased burden of overweight and obesity in a large representative sample of school-aged children in Saudi Arabia. One in every five school children aged between 6-19 years old was overweight or obese. The prevalence of overweight and obesity increased with the age of the students. The very high prevalence of VDD and VDI among our obese children and adolescents emphasize the critical need for appropriate interventions to address both problems of obesity and poor vitamin D status in this age group. There is a bad need for a national comprehensive obesity prevention programs among school-aged children, focusing on effective educational activities targeting families, school, teachers, and children. Encouraging physical activity and providing facilities with adequate sunlight exposure in schools are considered necessary. The availability of healthy foods at schools are required to reduce both obesity and VDD. Consequentially, this may then lead

to lowering the negative burden on health as a whole. Education of schoolchildren will impact their families' health where educational messages can be transferred through the children to their families.

Conflict of Interest

Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

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