doi: 10.1002/osp4.37

ORIGINAL ARTICLE

Increasing obesity rates in school children in United Arab Emirates

A. AlBlooshi[1], S. Shaban[2], M. AlTunaiji[3], N. Fares[3], L. AlShehhi[3], H. AlShehhi[3], A. AlMazrouei[3] and A. -K. Souid[1]

[1]Department of Pediatrics, United Arab Emirates University, Al-Ain, UAE;
[2]Department of Medical Education, United Arab Emirates University, Al-Ain, UAE;
[3]School Health Clinic, Ministry of Health, Ras Al-Khaimah, UAE

Received 21 December 2015; revised 22 February 2016; accepted 23 February 2016

Address for correspondence: Afaf AlBlooshi, UAE University, P.O. Box 17666, Al-Ain, United Arab Emirates. E-mail: afaf.alblooshi@uaeu.ac.ae

Summary

Background

The remarkable socioeconomic changes in United Arab Emirates (UAE) necessitate regular monitoring of obesity in our population. This study explored the epidemiology of obesity in a large cohort of UAE students.

Methods

This population-based study investigated the prevalence of obesity in 44,942 students attending governmental schools in Ras Al-Khaimah. Body-mass-index (BMI) was calculated in 15,532 children (4–12 y) in 2013–2014, and in 29,410 children (3–18 y) in 2014–2015. The International Obesity Task Force, World Health Organization, and Centers for Disease Control (CDC) reference methods were used to identify overweight, obesity, and extremely-obesity.

Results

Using CDC interpretation of BMI, from 11 to 14 y, the prevalence of BMI ≥85th percentile was 41.2%, BMI ≥95th percentile 24.3% and BMI ≥99th percentile 5.7%. Obesity increased linearly from 3 to 12 y ($R^2 \geq 0.979$); each year an additional 2.36% of the students became obese and 0.28% became extremely obese. The rate of extreme-obesity was 9.6-fold higher in boys than girls (0.58% vs. 0.06%). From 15 to 18 y, 10.3% of boys were extremely obese and 3.0% of girls were extremely obese.

Conclusions

These results confirm a steady rise in obesity in children 3–18 y. The rising rate of extreme obesity is also alarming, especially among boys.

Keywords: Adolescents, extreme obesity, obesity, overweight, school children.

Introduction

Childhood obesity is a growing epidemic problem, especially in economically developed countries. It has been estimated that each year an additional 0.5 to 1% of children gain excess body fat, and up to 32% of these individuals become overweight and 8% become obese (1). According to the International Obesity Task Force (IOTF), 10% of children 5–17 y have excess body fat because of consumption of high in sugar and energy dense food and inadequate physical activity (1). This global estimate is even higher in the Western Hemisphere (2). Children with obesity are prone to numerous medical problems, such as cardiovascular disease, hypertension, stroke, diabetes, metabolic syndrome, respiratory complaints (sleep apnea and asthma), gastrointestinal problems (e.g. gallbladder disease) and certain cancers (3).

Obesity was previously investigated in UAE using different methods for BMI interpretation; Centers for Disease Control (CDC) (4,5), IOTF (6,7) or World Health Organization (WHO) (8,9). Using the CDC method in children 6–16 y, prevalences of overweight and obesity were 17% and 8%, respectively (4). Using the IOTF method in children 5–17 y, prevalences of overweight and obesity were 22% and 14%, respectively (7). Using the WHO method in children 6–18 y, prevalences of overweight and obesity were 17% and 16%, respectively

(9). Similar rates were observed in other Gulf countries (10).

The trend of obesity in UAE school children is not clear, because this could not be estimated using the previous regional studies as they have used different BMI interpretation. BMI interpretations using CDC, WHO and IOTF give different outcome in the same population (11,12). Monitoring the prevalence and trends of obesity offers better assessment and management of childhood obesity. For example, preventing obesity in dependent children requires parental and school controls of their food choices and physical activities. Obesity control in adolescents, on the other hand, requires effective health education that advocates for good nutritional choices and regular exercise.

Childhood obesity prevention necessitates early intervention. This study explored the rate of obesity in a large cohort of children from 3 to 18 y of age, using the CDC, WHO and IOTF methods.

Methods

This population-based study utilized student anthropometric measurements, gained by nurses as part of governmental school annual health assessments in Ras Al Khaimah. In these schools, student health is under the authority of School Health Clinic and measurement accuracy is consistently checked by head nurses and physicians. Over 90% of students attending these 91 kindergarten to secondary education schools are UAE citizens. Some of these schools, however, have no assigned nurses or the measurements are not directly supervised; these schools, thus, were not included in this study. In addition, student health in the 34 private schools is conducted by private clinics, and these schools were not included in this study. All remaining governmental schools were included.

This study was conducted in two phases; the first phase was in 2013–2014 (68 schools) and the second phase was in 2014–2015 (83 schools); most of the students in the first phase were included in the second phase of the study. Standing height was measured using rigid stadiometers, with students standing erect and without shoes. Weight was measured using calibrated balance scales, with students wearing school uniforms and no shoes. Both measurements were done by qualified school nurses (certified and registered under the Ministry of Health). Body mass index (BMI) was calculated using the standard formula: weight (kg)/height $(m)^2$.

Gender-specific BMI-for-age US Growth charts were used to identify overweight (BMI $\geq 85^{th}$ percentile and $< 95^{th}$ percentile), obese (BMI $\geq 95^{th}$ percentile and $< 99^{th}$ percentile) and extremely obese (BMI $\geq 99^{th}$ percentile) children (13). In addition, the IOTF and WHO cut-off values were also used to identify overweight, obese and extremely obese children (14). A website (http://cmhsweb.uaeu.ac.ae/childbmicalculator) was developed to process BMI values according to the IOTF, WHO and CDC cut-off criteria. This process involved requirement analysis, relational database design, algorithm programming and process flow design. For this purpose, Microsoft Active Server Pages (ASP) was used as the programming language for data processing. JavaScript was used for data entry checking. Microsoft SQL Server and relational database management system were used for storing and retrieving data pertaining to the website. The ASP program contained the algorithms, and the database contained the tables needed for calculating BMI values and percentiles for the three reference methods.

Statistical analysis was carried out using the Statistical Package for Social Sciences (SPSS 21.0.0.0; Chicago, IL, USA). The data were presented as mean ± standard deviation (median). Comparisons were performed by Chi-square with Yates' correction (two-tailed) or Fisher's exact test as appropriate; p-value < 0.05 was considered significant. Comparison of the current study with previous studies was conducted using age- and gender-matched data and the same BMI interpretation to define overweight and obesity.

Results

In 2013–2014, 15,532 students (49% females; 94% UAE citizens) from kindergarten to 7th grade (3.8–12.0 y) participated in this phase of the study. In 2014–2015, 29,410 students (51% females) from kindergarten to the 12th grade (3 to 18 y) participated in the second phase of the study; 27,078 (92%) students were citizens and 2,332 (8%) were residents from over 30 countries (Table 1).

Rates of overweight, obesity and extreme-obesity based on IOTF, WHO and CDC cutoff criteria are shown in Table 2. IOTF underestimated and WHO overestimated obesity and extreme-obesity in all age groups. CDC values were between those of IOTF and WHO, and thus, the results below were based on CDC interpretation of BMI.

BMI for age $\geq 95^{th}$ percentile (obesity and extreme-obesity)

The prevalence of obesity and extreme-obesity increased linearly with age in children 3–12 y (2.36% per year, $R^2 \geq 0.979$, Figure 1A, 2014–2015). A similar rate was

Table 1 Sample size of the studied children by gender, age and nationality

	2013–2014 (68 government schools)			2014–2015 (83 government schools)		
	All	Citizens	Residents*	All	Citizens	Residents*
No.	15,532	14,640 (94%)[#]	892 (6%)[#]	29,410	27,078 (92%)[#]	2,332 (8%)[#]
Girls	7,584 (49%)[$]	7,198 (49%)[$]	386 (43%)[$]	14,849 (51%)[$]	13,905 (51%)[$]	944 (41%)[$]
Age (Y)	8.4 ± 2.0	8.4 ± 2.0	8.8 ± 1.9	10.4 ± 3.9	10.3 ± 3.8	12.2 ± 3.7
	(3.8–12.0)	(3.8–12.0)	(5.0–12.0)	(3.0–18.9)	(3.0–18.9)	(3.2–18.9)
Grade	Kindergarten to 7th grade			Kindergarten to 12th grade		

[#]This is the percentage from all the population in each academic year.
[$]This is the percentage of girls to boys.
Age is mean ± SD; (range).
*Resident students were from over 30 countries.

Table 2 Prevalence of overweight, obesity and extreme obesity for age and gender (2014–2015, $n = 27{,}113$ citizens) using the IOTF, WHO and CDC methods

	IOTF								
	Overweight, obesity and extreme obesity (BMI ≥25 kg/m^2 equivalent)			Obesity and extreme obesity (BMI ≥30 kg/m^2 equivalent)			Extreme obesity (BMI ≥35 kg/m^2 equivalent)		
Age, Y	All	Girls	Boys	All	Girls	Boys	All	Girls	Boys
3–6 ($n = 6{,}731$)	11.5	12.7	10.4	5.2	5.8	4.7	2.9	3.4	2.5
7–10 ($n = 9{,}058$)	27.6	28.9	26.2	12.4	12.7	12.1	4.1	4.4	3.9
11–14[(‡)] ($n = 7{,}437$)	41.2	38.3	43.1	18.9	17.3	20.7	6.4	5.6	7.1
15–18[(‡)] ($n = 3{,}852$)	38.0	35.6	42.4	19.3	17.2	22.6	8.1	7.2	9.6
	WHO								
	Overweight, obesity and extreme obesity (BMI for age ≥85th percentile)			Obesity and extreme obesity (BMI for age ≥95th percentile)			Extreme obesity (BMI for age ≥99th percentile)		
Age, Y	All	Girls	Boys	All	Girls	Boys	All	Girls	Boys
3–6 ($n = 6{,}731$)	14.0	15.1	13.0	11.2	11.9	10.6	—	—	—
7–10 ($n = 9{,}058$)	31.2	32.3	30.2	27.0	28.2	25.9	—	—	—
11–14[(‡)] ($n = 7{,}437$)	43.1	42.6	43.8	37.5	37.0	38.2	—	—	—
15–18[(‡)] ($n = 3{,}852$)	38.4	36.0	41.6	33.8	31.2	37.4	—	—	—
	CDC								
	Overweight, obesity and extreme obesity (BMI for age ≥85th percentile)			Obesity and extreme obesity (BMI for age ≥95th percentile)			Extreme obesity (BMI for age ≥99th percentile)		
Age, Y	All	Girls	Boys	All	Girls	Boys	All	Girls	Boys
3–6 ($n = 6{,}731$)	14.2	15.2[(¶)]	13.3	7.4	7.7[(#)]	7.1	3.3	3.1[(#)]	3.5
7–10 ($n = 9{,}058$)	29.0	28.6[(#)]	29.3	16.7	15.7[(¶)]	17.6	3.8	3.6[(#)]	4.0
11–14[(‡)] ($n = 7{,}437$)	41.2	38.7	39.5	24.3	21.6	27.5	5.7	4.4	7.1
15–18[(‡)] ($n = 3{,}852$)	37.2	33.8	41.3	22.2	18.3	27.2	8.8	3.0	10.3

Prevalence values are percent.
[#]*P*-value between girls and boys is >0.05.
[¶]*P*-value between girls and boys is <0.01.
[‡]*P*-value between girls and boys is <0.001 in all BMI categories.

observed in 2013–2014 in children 4–11 y (2.25% per year, $R^2 \geq 0.948$, Figure 1D). The rate was 30% higher in boys than in girls (2.70% per year vs. 2.066% per year, Figure 1B–C). Obesity and extreme-obesity peaked in children 11–14 y, reaching 24.3% (21.6% in girls and 27.5% in boys); it slightly declined thereafter to 22.2% (18.3% in girls and 27.2% in boys), Table 2. A significantly lower value was observed in 11–14 y UAE residents (21.6%, $p < 0.05$), Table 3.

Prevalence of extreme-obesity also increased linearly with age in children 3–17 y (0.28% per year, $R^2 \geq 0.740$, Figure 1A, 2014–2015). A slightly lower rate was observed

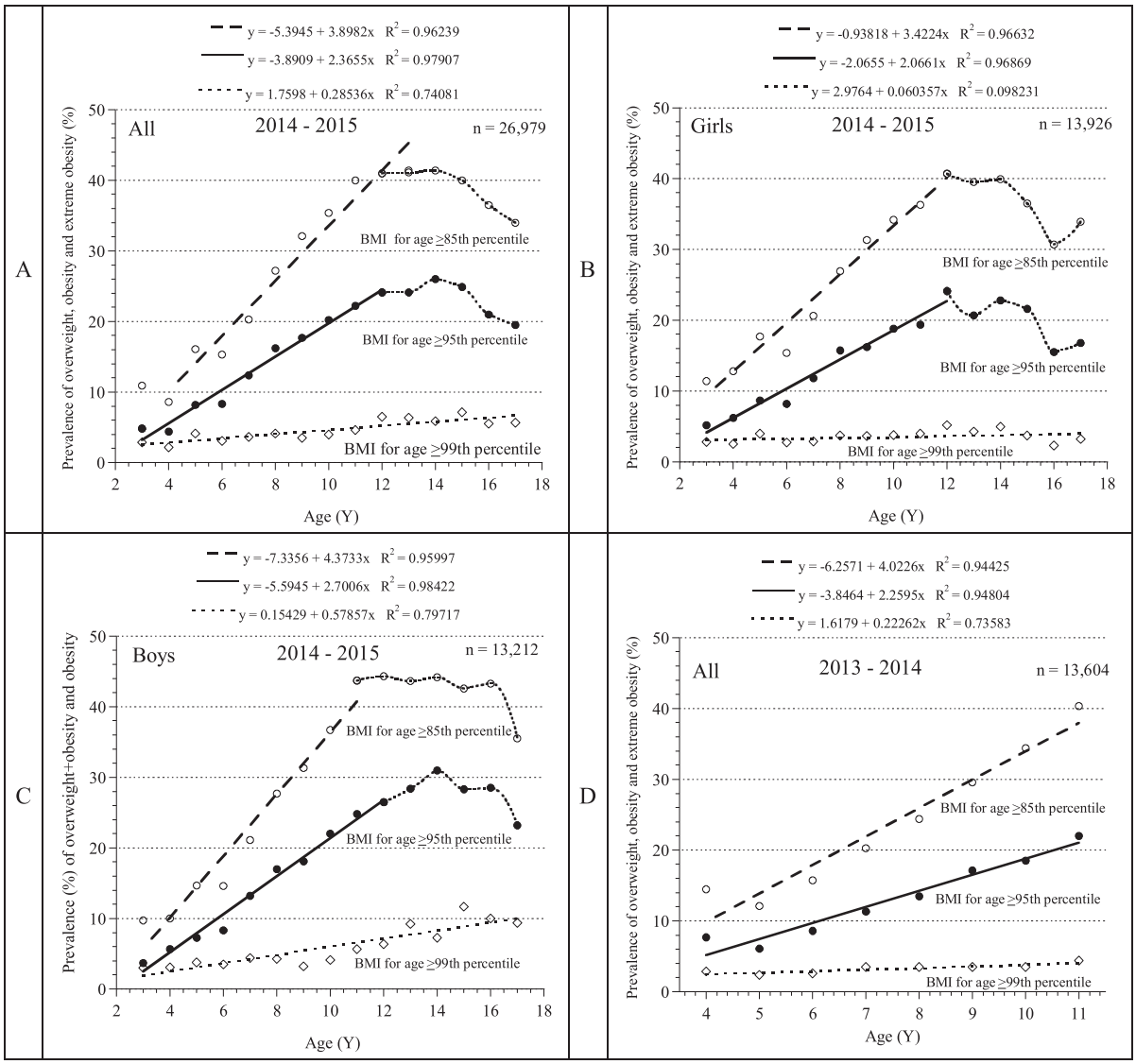

Figure 1 Prevalence of overweight, obesity and extreme-obesity for age and gender. *Panels A–C*: 2014–2015; *Panel D*: 2013–2014. The straight lines are best linear fits.

Table 3 Prevalence of overweight, obesity and extreme obesity for age (2014–2015, $n = 2{,}332$ residents) using the CDC method

Age, Y	Overweight, obesity and extreme obesity (BMI for age ≥85th percentile)	Obesity and extreme obesity (BMI for age ≥95th percentile)	Extreme obesity (BMI for age ≥99th percentile)
3–6 ($n = 289$)	$n = 37$ (12.8%)	$n = 19$ (6.6%)	$n = 7$ (2.4%)
7–10 ($n = 516$)	$n = 146$ (28.3%)	$n = 74$ (14.3%)	$n = 11$ (2.1%)
11–14 ($n = 867$)	$n = 323$ (37.3%)	$n = 187$ (21.6%)	$n = 41$ (4.7%)
15–18 ($n = 660$)	$n = 242$ (36.7%)	$n = 138$ (20.1%)	$n = 25$ 3.8%

Prevalence values are percent. (*) Significantly lower than the prevalence in UAE citizens ($p < 0.05$).

in children 4–11 y in 2013–2014 (0.22% per year, $R^2 \geq 0.735$, Figure 1D). The rate was 9.7-fold higher in boys than in girls (0.57% per year vs. 0.06% per year), Figure 1B–C. Prevalence of extreme-obesity in 15–18 y boys was 10.5% and girls 3.0% (Table 2). A significantly lower prevalence was observed in 15–18 y UAE residents

(4.0%) when compared to UAE citizens (8.8%), $p < 0.05$, Table 3.

BMI for age ≥85th percentile (overweight, obesity, and extreme-obesity)

Prevalence of overweight, obesity and extreme-obesity increased linearly with age in children 3–12 y (3.89% per year, $R^2 \geq 0.962$, Figure 1A, 2014–2015). A similar rate was observed in children 4–11 y in 2013–2014 (4.02% per year, $R^2 \geq 0.944$, Figure 1D). The rate was 28% higher in boys than in girls (3.42% per year vs. 4.37% per year), Figure 1B–C. The prevalence peaked in children 11–14 y, reaching 41.3% (39.1% in girls and 44.0% in boys); it slightly declined thereafter to 37.2% (33.6% in girls and 41.0% in boys), Table 2. A significantly lower value was observed in 11–14 y UAE residents (37.2%, $p < 0.05$), Table 3.

Height, weight and BMI for age and gender

Median height increased linearly with age in children 3–14 y (5.3 cm per year, $R^2 \geq 0.996$), Fig 1S-Panel A and Table 1S (Supporting Information). Thereafter, it changed a little in girls and continued to increase in boys for at least three years (reflecting puberty). Median weight increased exponentially with age in children 3–14 y ($R^2 \geq 0.992$), Fig. 1S-Panel B (Supporting Information). Median height-for-median weight was similar in both genders in children 3–14 y, with a logarithmic fit ($R^2 \geq 0.992$), Fig. 1S-Panel C (Supporting Information). Thereafter, the curves became horizontal, earlier in girls than in boys (Fig. 1S-Panel C, arrows). Median BMI increased linearly with age in children 6–14 y (~1.0 kg/m^{-2} per year, $R^2 \geq 0.985$, Fig. 1S-Panel D and Table 1S).

Discussion

Important findings in this study include: (1) the rising rate of obesity in children 3–18 y compared to previous reports (Table 4); (2) the fact that obesity starts in toddlers and progresses linearly with age (Figure 1) and (3) the high prevalence of extreme obesity, especially among boys (Table 2). These trends mandate early intervention (e.g. increasing parental control of food choices and physical activity for young children), improved school health policy and practice (offering better nutrition and exercise) and enhanced public awareness of obesity and its adverse consequences (ability to ameliorate risks of attaining obesity by proper exercise and nutritional choices). These needs are especially relevant to UAE because health illiteracy is very common (15).

A previous study (year 2000) in Ras Al Khaimah showed that 8% of children 6–16 y were obese (4); this

Table 4 Comparing the prevalence of overweight and obesity between current and previous studies.Table 1S**.** Children's height, weight and BMI for age and gender (2014–2015, $n = 27{,}113$ citizens)

Studies	Study Yr	UAE City	Age (Yr)	Student number*	Prevalence of overweight	Prevalence of obesity
CDC						
AlHaddad et al. (4)	2000	Ras Al-Khaimah	6–16	4,075	17% (¶)	8% (ǂ)
Current study	2014–2015			21,641	14% (¶)	19% (ǂ)
Alhourani et al. (5)	2003	Five cities	11–18	898 Females	14% (¶)	10% (ǂ)
Current study	2014–2015	Ras Al-Khaimah		6,257 Females	17% (¶)	20% (ǂ)
IOTF						
AlHaddad et al. (6)	1998–1999	Seven cities	4–18	16 391	19% (Δ)	7% (η)
Current study	2014–2015	Al-Khaimah		26,569	16% (Δ)	14% (η)
Malik et al. (7)	2007	Abu Dhabi	5–17	4,381	22% (Δ)	14% (Δ)
Current study	2014–2015	Ras Al-Khaimah		24,741	16% (Δ)	14% (Δ)
WHO						
Bin Zaal, et al. (8)	2009	Dubai	12–17	661	16% (¶, §)	21% (¶, §)
Current study	2014–2015	Ras Al-Khaimah		9,139	5.2%	36%
SW Ng et al. (9)	2009–2010	Seven cities	6–18	529	17% (¶, ∩)	16% (¶, ∩)
Current study	2014–2015	Ras Al-Khaimah		22,585	4.5%	30.3%

*Student number includes both gender unless specified.
¶BMI for age ≥85th percentile and <95th percentile.
ǂBMI for age ≥95th percentile.
ΔBMI ≥25 kg/m^2 equivalent and <30 kg/m^2 equivalent.
ηBMI ≥30 kg/m^2 equivalent.
§Used WHO 1995 cutoff levels.
∩Used WHO 2000 cutoff levels.

prevalence is more than doubled since then (19%, Table 4). The increase is presumably related to our rapid urbanization that substituted healthy foods with less desirable diets (consuming energy-rich products high in fat and sugar and low in necessary nutrients) and sedentary lifestyle (spending too much time watching television and playing computer games) (8).

UAE residents, on the other hand, come from diverse backgrounds (citizens of over 30 countries) and assessing their trends in obesity requires more extensive (longitudinal) studies. Thus, the data in Table 3 are a rough estimation of the prevalence of obesity in this ethnically mixed population. Nevertheless, the prevalence of childhood obesity has increased several fold in the last three decades worldwide (16).

The current study shows linear increases in the rate of obesity throughout childhood (3–12 y) in 2013–2014 and 2014–2015 (Figure 1). Each year over 2% (the slopes of the curves of BMI-for-age ≥95% in Figure 1, Panels A and D) of children become obese; these rates are higher than that previously reported by the IOTF Childhood Obesity Working Group in 2004 (0.5 to 1%) (1). In addition, each year over 0.2% (the slopes of the curves of BMI-for-age ≥99% in Figure 1, Panels A and D) of children become extremely obese. The prevalence of extreme obesity is increasing more rapidly in boys than in girls (0.57% per year in boys vs. 0.06% per year in girls).

Previous regional studies included sample sizes that ranged from 500 to 16,000 students (4–9). Three studies were conducted in a single emirate (Ras al Khaimah (4), Abu Dhabi (7) and Dubai (8)), one in five emirates (5), and two in seven emirates (6,9). Our study included a much larger number of students (15,532 students in 2013–2014 and 29,410 in 2014–2015, Table 1), which included over 70% (29,410 of about 41,400) of the children in Ras Al Khaimah governmental schools. Doing this study in a single emirate, however, is a limitation. Nevertheless, Ras Al Khaimah is highly populated by UAE citizens, and the large sample size used here represents children of the entire UAE (17). Moreover, UAE population is tribal in nature and people residing in different emirates descend from the same tribes and share the same characteristics. It is also worth noting that UAE is a relatively small country with an area of 83,600 km^2, 2/3 of which is unpopulated areas (desert) (18). All cities are within ~200 km radius.

The high prevalence of obesity in school children necessitates regular screening and monitoring for hypertension, dyslipidemia and diabetes, especially because these disorders are exceptionally common in UAE (19–21). Early intervention (e.g. 5-7% decrease in weight) has been shown to produce measurable health benefits(22). Comprehensive campaigns, counselling services and outpatient health-promoting clinics are, thus, highly needed. Overcoming our cultural barriers to healthy lifestyles (e.g. using parks, gym facilities, in-school sport activities and walking tracks in streets) is also important.

Previous studies have shown BMI interpretations using CDC, WHO and IOTF give different outcome in the same population (11,12). Our findings support these previous results. IOTF underestimated and WHO overestimated obesity and extreme-obesity in all age groups, and CDC values were between those of IOTF and WHO (Table 2).

The previous reports in UAE used single method to define obesity; CDC (4,5), WHO (8,9) or IOTF (6,7), which could overestimate or underestimate the prevalence of obesity. This study applied the three methods of BMI interpretations (Tables 2, 3), allowing reasonable comparisons between our data and those of previous studies. This comparison shows the trends in overweight and obesity are increasing in school children (Table 4).

Conclusion

This study revealed an alarming rise in the rate of childhood obesity in UAE. Obesity rate increases linearly from 3 to 12 y. About one-fourth of children 11–14 y are either obese or extremely obese. From 15 to 18 y, 10% of boys are extremely obese and 3% of girls are extremely obese. Improved public awareness and preemptive measures are required to tackle this emerging problem in the country.

Conflicts of interest statement

All authors have no conflicts of interest.

Acknowledgments

We thank the school staff and students for their support and participation in this study. AA designed the study and analysed the result. MAT, NF, LAS, HAS and AAM, collected the data. SS and A-KS contributed to data analysis and manuscript writing. All authors read and approved the final manuscript.

References

1. Baur L, Lobstein T, Uauy R. Obesity in children and young people: a crisis in public health. Report of the International Obesity Taskforce Childhood Obesity Working Group. *Obes Rev* 2004; **5**(S1): 4–85.
2. Hedley AA, Ogden C, Johnson C, et al. Prevalence of obesity among school children in the United Arab Emirates. *Am J Hum Biol* 2000; **12**: 498–502.
3. Must A, Strauss RS. Risks and consequences of childhood and adolescent obesity. *Int J Obes Relat Metab Disord* 1999; **23**: 2–11.

4. Al-Haddad F, Al-Nuaimi Y, Little B, Thabit M. Prevalence of obesity among school children in the United Arab Emirates. *Am J Hum Biol* 2000; **12**: 498–502.
5. Al-Hourani HM, Henry CJK, Lightowler HJ. Prevalence of overweight among adolescent females in the United Arab Emirates. *Am J Hum Biol* 2003; **15**: 758–764.
6. Al-haddad FH, Little BB, Abdul Ghafoor AGM. Childhood obesity in United Arab Emirates schoolchildren: a national study. *Ann Hum Biol* 2005; **32**: 72–79.
7. Malik M, Bakir A. Prevalence of overweight and obesity among children in the United Arab Emirates. *Obes Rev* 2007; **8**: 15–20.
8. Bin Zaal AA, Musaiger AO, D'Souza R. Dietary habits associated with obesity among adolescents in Dubai, United Arab Emirates. *Nutr Hosp* 2009; **24**: 437–444.
9. Ng S, Zaghloul S, Ali H, et al. Nutrition transition in the United Arab Emirates (UAE). *Eur J Clin Nutr* 2011; **65**: 1328–1337.
10. Alnohair S. Obesity in Gulf Countries. *Int J Health Sci* 2014; **8**: 79–83.
11. Kain J, Uauy R, Vio F, et al. Original communications—trends in overweight and obesity prevalence in Chilean children: comparison of three definitions. *Eur J Clin Nutr* 2002; **56**: 200–204.
12. Zimmermann MB, Gübeli C, Püntener C, Molinari L. Detection of overweight and obesity in a national sample of 6–12-y-old Swiss children: accuracy and validity of reference values for body mass index from the US Centers for Disease Control and Prevention and the International Obesity Task Force. *Am J Clin Nutr* 2004; **79**: 838–843.
13. Kuczmarski RJ, Ogden C, Guo S, et al. CDC Growth Charts for the United States: methods and development. *Vital health Stat*Series 11, Data from the national health survey 2000; **2002**: 1–190.
14. Onis M, Onyango A, Borghi E, et al. Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ* 2007; **85**: 660–667.
15. Al-Kaabi JM, Al Maskari F, Cragg PI, Afandi B, Souid A. Illiteracy and diabetic foot complications. *Prim Care Diabetes* 2015; **9**: 465–472.
16. Ebbeling CB, Pawlak DB, Ludwig DS. Childhood obesity: public-health crisis, common sense cure. *The Lancet* 2002; **360**: 473–482.
17. http://opendata.nbs.gov.ae/search?query=UAE%20population%20density. 2013 (accessed 15 December 2015).
18. http://opendata.nbs.gov.ae/iznkglf/united-arab-emirates-regional-statistics-2013 (accessed 14 December 2015).
19. Sinaiko AR, Donahue R, Jacobs D, Prineas R. Relation of weight and rate of increase in weight during childhood and adolescence to body size, blood pressure, fasting insulin, and lipids in young adults: the Minneapolis Children's Blood Pressure Study. *Circulation* 1999; **99**: 1471–1476.
20. Neumark-Sztainer D, Story M, Hannan P, Rex J. New moves: a school-based obesity prevention program for adolescent girls. *Prev Med* 2003; **37**: 41–51.
21. Veugelers PJ, Fitzgerald AL. Effectiveness of school programs in preventing childhood obesity: a multilevel comparison. *Am J Public Health* 2005; **95**: 432–435.
22. Heideman WH, Middelkoop B, Nierkens V, et al. Changing the odds. What do we learn from prevention studies targeted at people with a positive family history of type 2 diabetes? *Prim Care Diabetes* 2011; **5**: 215–221.

Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's web site.

Fig. 1S. Median height, weight, height-for-weight and BMI for age and gender. The straight lines are best linear fit.