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Prevalence and determinants of overweight/obesity among school-aged adolescents in the United Arab Emirates: A comparative study of private and public schools

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ABSTRACT

Objectives The United Arab Emirates (UAE) identified child and adolescent obesity rates as a target for action. We clarified the prevalence of obesity among adolescents attending UAE private and public schools and identified contributing factors.

Design This study used a cross-sectional design using cluster sampling technique.

Settings Private and public secondary schools across the UAE, 2018-2019.

Participants A total of 1224 adolescents both males and females, aged 13–19 years, recruited in the current study of which 932 completed the surveys and measurements.

Outcome measures We used self-report questionnaires to collect sociodemographic data and assess fruit/vegetable consumption and physical activity. Participants' anthropometric indices were measured.

Results In total, 34.7% of participants were overweight/obese; 20.2% in public and 14.5% in private schools. We found significantly higher anthropometric indices among public school participants compared with private school participants. Overweight/obese participants had significantly lower fruit/vegetable consumption and were less active than their underweight or normal weight peers.

Conclusion This study highlights an urgent need for focused nutritional and physical activity interventions targeting adolescents in secondary schools.

Keywords: Adolescents, obesity, public schools, private schools, anthropometric indices, fruit and vegetable consumption, physical activity.

Word count: 3489

Strengths and limitations of this study

- This study was the first in the Arabian region to assess obesity and its determinants utilizing a representative sample of adolescents from private and public schools across the United Arab Emirates.
- The study included multiple variables related to obesity, including abdominal obesity indicators, blood pressure measurement, physical activities and lifestyle factors.
- This study used a cross-sectional design and causality cannot be assumed.
- The data collection process was lengthy as it involved many parameters and measurements that impacted the number of students who agreed to participate.

Introduction

Adolescence is a transitional developmental period characterized by changes in physical, intellectual, social, and emotional health. Optimal growth during adolescence is important for maintaining good health throughout the life course. Obesity among adolescents is a serious health problem and public health issue that demands urgent attention. [1] Globally, the prevalence of overweight/obesity has increased among children and adolescents. For example, the global prevalence was 4% in 1975, whereas the 2016 estimate was over 18%; this increase was similar among boys and girls (19% and 18%, respectively). [2] Increasing overweight and obesity are also issues for Middle Eastern and North African countries, especially as rapid increases in obesity have been observed among children and adolescents[3]. A large-scale epidemiological study (n=44,942) conducted in Ras Al Khaimah confirmed obesity was steadily increasing in those aged 3–18 years; each year an additional 2.36% were classified as obese and 0.28% as extremely obese. [4] In 2014, a global action plan that aimed to prevent and control noncommunicable diseases was adopted by the World Health Assembly. [1] This action plan highlighted the importance of measures to address obesity rates globally, including among children and adolescents. Many countries have reflected the need to focus on reducing and preventing obesity among young people in national policies and strategies; for example, the United Arab Emirates (UAE) has included obesity among children as an indicator in the Vision 2021 National Agenda. [5]

In addition to causing health problems in childhood and adolescence, overweight and obesity among young people can have long-term health impacts into adulthood (e.g., cardiovascular disease, insulin resistance, type 2 diabetes mellitus, psychosocial complications). [6] Childhood obesity can also predict obesity in adulthood . A long-term follow-up study indicated efforts to influence body mass index (BMI) over the life course should begin early (e.g., before 6 years), and noted the progression toward a high BMI begins in adolescence for boys and young adulthood for girls.[8] These studies highlight that early intervention is important to prevent increased BMI and associated health risks, which also contribute to increased healthcare expenditure.[8]

Various external factors that influence obesity have changed in recent years, such as rapid changes in dietary practices (e.g., fast food, processed foods), extensive use of technology (e.g., the Internet and mobile devices), and increasingly sedentary lifestyles. Such developments have been associated with high obesity rates among adolescents, especially in developing countries.[9] In particular, the rapid socioeconomic transition in Middle Eastern and North African countries has resulted in increased urbanization and drastic changes in lifestyles, manifested in low physical activity and unhealthy dietary practices. [3] These factors combined with the growing fast food industry have led to various nutritional-related chronic conditions among adolescents, including obesity.[9]

The UAE has also witnessed rapid economic development and corresponding changes in lifestyles, leading to a marked increase in obesity in children/adolescents. Recently, the Global School-based Student Health Survey reported the obesity prevalence in the UAE youth population (aged 13–15 years) was 16.2%.[10] Previous cross-sectional studies from different cities across the UAE have also shown increased rates of obesity in adolescents, with the reported prevalence ranging from 18.9% in Abu Dhabi [11] to 35% in Dubai.[12]

Given the increased prevalence of obesity, it is important to clarify factors that contribute to obesity. School type (e.g., public, private) may be a key determinant of obesity, as students spend much of their day in school. Previous studies investigated differences in obesity rates between public and private schools. For example, one study found that many students attending public schools were obese and had low physical activity, low fruit/vegetable consumption, and low intakes of water, fiber, vitamins, and minerals.[13] Another study found that children attending public schools had a high BMI and a greater likelihood of being overweight compared with children attending private schools.[14] However, other studies have reported opposite trends. Studies conducted in different countries like Pakistan, Kenya, and India, all reported private school students had higher rates of obesity compared with those attending public schools.[15-17] Another study conducted in Shanghai also reported more students at private schools were overweight compared with those at public schools.[18] That study also noted that this difference may be explained by diet, socioeconomic status, school environment, and factors related to infancy.

Most previous studies conducted in the UAE focused on the prevalence of obesity and did not consider the type of school and how this related to obesity or its determinants. This study sought to understand the prevalence of obesity in school-aged adolescents in the UAE and clarify factors contributing to obesity in this population. By mapping and rigorously assessing adolescents' obesity-related health status, healthcare providers, policy makers, schools, and families will be able to collaborate to develop appropriate evidence-based approaches to promote adolescent health.

In this study, we explored the epidemiology of overweight and obesity and identify determinants of factors contributing to obesity in adolescents in the UAE using a representative sample of adolescents from private and public schools.

METHODS

Study Design and Setting

We adopted a quantitative correlational design. The sample was drawn from intermediate and high schools that were randomly selected from lists obtained from the Ministry of Education and other private/public school governing bodies in the UAE's seven emirates (Sharjah, Dubai, Abu Dhabi, Ajman, Ras Al Khaimah, Fujairah, and Umm Al Quwain). This study was reported according to the STROBE checklist for reports of cross-sectional studies (see supplementary File 1).

Participants

Based on an overweight/obesity prevalence of 40% among UAE adolescents, [11] a 3% margin of error, 95% confidence interval (CI), and significance level of 0.05, a sample size of 1124 adolescents was needed. An additional 100 participants were included to allow for non-response, meaning we aimed to recruit 1224 participants for this study. The sample included male and female students in grades 9–12 (aged 13–19 years) of any nationality whose parents provided consent for them to participate. We excluded students with chronic diseases such as type 2 diabetes, cancer, and mental health conditions, based on information from students' school records. The principals of each school provided access to students depending on participating schools' class schedules and students' availability. Convenience sampling was then used to select students from the identified classrooms until the required sample size was reached.

Data Collection

Figure 1 presents a flowchart of the data collection process. Participating students completed a self-report questionnaire covering demographic information, fruit/vegetable consumption, and physical activity. Trained research assistants administered the questionnaire in participating students' classrooms. Participating students were then directed to the on-site school clinic where anthropometric measurements, SBP, DBP, and random capillary blood glucose were collected by trained research assistants. Data collected over 10 months from 2018-2019.

General demographic information. Information on participants' general characteristics was collected using self-report tools. Data collected included age, sex, nationality, country of origin, current medical conditions, and type of school (private vs. public). We also collected information on parents' level of education, employment (employed/unemployed), and income (below average/average/above average) as reported by students.

Physical activity. We collected information concerning participants' physical activity using the Physical Activity Questionnaire for Adolescents (PAQ-A). This tool is a 7-day recall self-report questionnaire with nine-items.[19] The PAQ-A was originally developed to evaluate physical activity levels among high school students (aged 14–19 years). Responses are on a 5-point Likert-scale, and the nine items are summed to give a total physical activity score. A high mean score indicates a high level of physical activity. The English version of the PAQ-A has high reliability (Cronbach's alpha: 0.77–0.88) and high concurrent validity.[20] The Arabic version of the scale demonstrated good reliability and validity parameters when used in Arabic children and adolescents.[21] The estimated completion time for the PAQ-A is 20 minutes.[20]

Fruit and vegetable consumption. We based assessment of fruit/vegetable consumption on participants' self-report using the National Cancer Institute (NCI) Fruit and Vegetable Screener.[22] This instrument covers the frequency/amount consumed of specific items. These include: 100% fruit juice, fruit (e.g., fresh, canned, frozen), fried potatoes (e.g., French fries), other potatoes, dried beans, other vegetables, and tomato-based sauces (e.g., pasta, pizza). The instrument also evaluates the frequency of consumption of vegetable combinations (e.g., sandwiches, salads, casseroles/stews, stir-fries). We calculated servings per day using NCI standard scoring algorithms. [23] The English version of the scale has been reported to have excellent reliability and validity in both adults and adolescents.[24] The scale also had acceptable reliability (Cronbach's alpha: 0.82) and predictive validity among Saudi young adults.[24]

Anthropometric measurements. Anthropometric indices measured included waist and hip circumference (WC and HC, respectively), waist to hip ratio (WHR), waist to height ratio

(WHtR), and percentage of body fat (%BF). For these measurements, students removed their shoes and wore minimal light-weight clothing as per World Health Organization (WHO) guidelines. [25] We measured participants' height (to the nearest 0.1 cm) and weight (to the nearest 0.1 kg) using a telescopic measuring rod (Seca 220) for column scales. Two measurements for WC and HC were recorded for each participant using an inextensible anthropometric tape (Seca 201). These measurements were taken while participants stood erect with their arms by their sides and feet close together.

We calculated participants' WHtR by dividing WC by height. We used 0.5 as the cut-off point to define abdominal obesity (26-27). We calculated WHR by dividing participants' WC by their HC.[26] We calculated and classified BMI (weight [kg] divided by height [m^2]) according to WHO criteria:[27] underweight (BMI <3rd percentile); normal weight (BMI between the 3rd and 85th percentiles); overweight (BMI between the 85th and 97th percentiles); and obese (BMI >97th percentile).[25]

Participants' %BF was measured using the Body Composition Analyzer (TANITA MC 780 multi-frequency segmental body composition analyzer). This device measured participants' body composition parameters by evaluating differences in impedance of body components (e.g., muscle and lean tissue). Various body composition parameters are automatically calculated, including total body muscle and fat mass, total body water, total body fat and water ratios, muscle mass of the arms/legs, BMI, and basal metabolic rate. This technology has been shown to be valid and reliable.[28]

Capillary random blood sugar was measured by an ACCU Check Blood Glucose Meter, with values of 126 mg/dl or higher indicative of diabetes.[29] An Omron digital basic BP machine was used to measure BP; 120/80 mmHg in the 95th percentile or greater was considered a determinant of hypertension.[30]

Data Analysis

We calculated descriptive statistics for the study variables. Next, we compared differences in categorical sociodemographic variables by school type (private vs. public) using chi-square, and performed independent sample t-tests to identify statistically significant differences between continuous independent variables (anthropometric measurements, physical activity, fruit/vegetable consumption) and school type.

We combined overweight and obesity in a single category and considered BMI-by-age ≥85% as indicator of overweight and obesity. We then analyzed variables to find determinants of overweight/obesity using logistic regression analysis. This model calculated odds ratios (OR) and 95% CIs. Significance was set at $p<0.05$. We used SAS version 9.4 for all statistical analyses.

Ethical Considerations

Ethical approval to conduct this study was obtained from the Research Ethics Committee at the principal investigator's institution (REC/15/12/10), the UAE Ministry of Health and Prevention (MOHAP REC-11). Parental consent was obtained for each student that agreed to participate in this study.

RESULTS

Sample Characteristics and Anthropometric Results

Table 1 presents participants' characteristics. Of the 1224 adolescents who participated in this study, complete data were available for 932 participants (76.1% response rate). Major reasons for not participating is lacking of interest in the study. Of these, 434 (46.6%) attended private schools and 498 (53.4%) attended public schools. Participants' average age was 15.8±1.43 years; 311 (33.4%) were male and 621 (66.6%) were female. The majority of participants were UAE nationals (61.1%). More than two-thirds of participants' mothers were not employed (n=682, 73.2%) and the majority (58%) had an average family income (based on participant's self-report). Participants' mean fruit and vegetable consumption score was 3.1±1.83 and mean PAQ-A score was 2.3±0.71.

Table 1

Characteristics of Participating Adolescents (N = 932)

Characteristics	Frequency (%) or mean±SD
Gender	
Male	311 (33.4)
Female	621 (66.6)
Age (years)	15.8±1.43
Nationality	
UAE National	569 (61.1)
Non-UAE National	363 (38.9)
Type of school	
Public	498 (53.4)
Private	434 (46.6)
Mother's employment	
Employed	250 (26.8)
Unemployed	682 (73.2)
Economic status	
Below average	32 (3.4)
Average	541 (58.1)
Above average	359 (38.5)
Fruits and vegetables score[a]	3.1±1.83
Physical Activity Questionnaire for Adolescents[b]	2.3±0.71
BMI-age percentile	61.8±33.0
Underweight	79 (8.4)
Normal	530 (56.9)
Overweight	158 (17.0)
Obese	165 (17.7)
Waist circumference[c]	76.8±13.3
Normal	491 (52.6)
Above normal	441 (47.4)
Waist-hip ratio (cm)	0.83±0.07
Normal	720 (77.3)
Abnormal	212 (22.7)
Waist-height ratio (cm)	0.47±0.08
Normal	679 (72.9)
Abnormal	253 (27.1)
Percent body fat	27.6 (12.0)
Glucose (random)	93.3±23.7
Blood pressure (mmHg)	

Systolic	119.2±43.3
Diastolic	74.6±9.9

[a] score reflects the number of servings of fruits and vegetables per day; [b] score of 2.75 or lower considered inactive; [c] threshold based on age and gender. SD, standard deviation.

Epidemiology of Obesity for all Participants

BMI-by-age percentiles indicated the majority of participants had normal weight (56.9%). In total, 323 participants (34.7%) were overweight (17.0%) or obese (17.7%). Abdominal obesity was prevalent among 47.4% of participants estimated by WC, 22.7% estimated by WHR, and 27.1% estimated by WHtR. The mean %BF was 27.6% (SD 12.0%) (Table 1).

Private Versus Public Schools

Table 2 below shows the associations between sociodemographic factors, lifestyle variables, and anthropometric indices by school type. The majority of participants attending public schools were of Emirati nationality with an average family income ($p<0.001$). Participants attending public schools had significantly higher BMI (overweight or obese) compared with those from private schools ($p=0.001$). Moreover, public school participants had significantly larger WC ($p=0.028$), higher mean WHtR ($p<0.000$), higher mean %BF ($p=0.001$), and higher SBP and DBP ($p=0.001$ and $p=0.002$, respectively) than those attending private schools (Table 2).

Table 2

Comparisons Between Private And Public Schools (N = 932)

	Public schools n (%), mean±SD (n=498)	Private schools n (%), mean±SD (n=434)	p-value
Gender			0.694
Male	169 (18.2)	142 (15.2)	
Female	329 (35.3)	292 (31.3)	
Nationality			<0.000†
UAE National	407 (43.6)	162 (17.4)	
Non-UAE National	91 (9.8)	272 (29.2)	
Mother's employment			0.123
Employed	144 (15.4)	106 (11.4)	
Unemployed	354 (38.0)	328 (35.2)	
Economic status			<0.000†
Below average	30 (3.2)	2 (0.2)	
Average	374 (40.1)	167 (17.9)	
Above average	94 (10.1)	265 (28.5)	
Fruits and vegetables score[a]	3.0±1.7	3.1±1.9	0.232
Physical Activity Questionnaire for Adolescents[b]	2.2±0.70	2.2±0.62	0.543
BMI			0.001†
Underweight	44 (4.7)	35 (3.8)	
Normal	266 (28.5)	264 (28.3)	
Overweight	77 (8.3)	81 (8.7)	
Obese	111 (11.9)	54 (5.8)	
Waist circumference[c]			0.028†
Normal	247 (26.5)	246 (26.4)	
Above normal	251 (27.0)	187 (20.1)	
Waist-hip ratio (cm)	0.83±0.07	0.83±0.06	0.283
Waist-height ratio (cm)	0.48±0.08	0.46±0.06	<0.000†
Percent body fat	27.6±10.4	25.3±8.9	0.000†
Glucose (random)	92.9±26.6	93.5±17.7	0.700
Blood pressure (mmHg)			
Systolic	119.4±12.3	116.5±12.4	0.001†
Diastolic	75.6±10.1	73.7±9.1	0.002†

[a]score reflects the number of servings of fruits and vegetables per day; [b] score of 2.75 or lower considered inactive; [c] threshold based on age and gender. SD, standard deviation.

Determinants of Overweight and Obesity

The logistic regression analysis showed that school type, fruit/vegetable consumption score, PAQ-A score, SBP, and DBP were significantly associated with BMI (Table 3 below). Participants from public schools were more likely to be overweight or obese than private school participants (OR 1.34, 95% CI: 1.02–1.76). Overweight/obese participants were significantly less likely to consume fruits and vegetables or engage in physical activity compared with their peers who were underweight (OR 0.79, 95% CI: 0.72–0.86) or normal weight (OR 0.54, 95% CI: 0.38–0.78). In addition, overweight/obese participants had significantly higher odds of having high SBP and DBP compared with participants that were underweight (OR 1.03, 95% CI: 1.02–1.04) and of normal weight (OR 1.02 95% CI: 1.00–1.03). Finally, participants that were overweight/obese had higher odds of having larger anthropometric indices (WC, WHR, WHtR, and %BF).

Table 3

Simple Logistic Regression Analysis For Associations Of Sample Characteristics With Overweight/Obesity (N = 932)

Sample characteristics	OR (95% CI)	p-value
Gender		0.231
Male	Ref	
Female	0.84 (0.63–1.12)	
Nationality		0.052
UAE national	Ref	
Non-UAE national	0.76 (0.57–1.00)	
Mother's employment		0.800
Unemployed	Ref	
Employed	0.96 (0.71–1.30)	
Economic status		0.154
Below average	0.83 (0.62–1.11)	
Average	Ref	
Above average	1.60 (0.77–3.23)	
Type of school		0.034†
Private	Ref	
Public	1.34 (1.02–1.76)	
Fruits and vegetables score[a]	0.79 (0.72–0.86)	<0.000†
Physical Activity Questionnaire for Adolescents[b]		0.001†
Low intensity	Ref	
Moderate high intensity	0.54 (0.38–0.78)	
Waist circumference[c]		<0.000†
Normal	Ref	
Abnormal	9.49 (6.83–13.03)	
Waist-hip ratio (cm)		0.001†
Normal	Ref	
Abnormal	1.71 (1.25–2.33)	
Glucose		0.217
Normal	Ref	
Abnormal	1.44 (0.81–2.58)	
Waist-height ratio (cm)		<0.000†
Normal	Ref	
Abnormal	20.3 (14.0–29.5)	
Percent body fat	1.19 (1.16–1.22)	<0.000†
Blood pressure (mmHg)		

Systolic	1.03 (1.02–1.04)	<0.000†
Diastolic	1.02 (1.00–1.03)	0.009†

[a] score reflects the number of servings of fruits and vegetables a day; [b] score of 2.75 or lower considered inactive; [c] threshold based on age and gender. OR, odds ratio; CI, confidence interval.

DISCUSSION

This study contributed new information regarding the epidemiology and determinants of overweight/obesity among UAE school-aged adolescents. We found a high prevalence of overweight/obesity among participants (34.7%), which supports previous UAE-based epidemiological studies.[4 11 12] The high prevalence of overweight/obesity observed in our study was also consistent with studies from other Arab countries, including Saudi Arabia (39%),[31] Kuwait (44.3%),[32] Lebanon (32.2%),[33] and Egypt (35%).[34] Conversely, studies conducted in Western countries reported lower obesity rates compared with our study. For example, the obesity rate among adolescents in European countries was 22%–25%, although higher rates were reported among American adolescents (30%).[35] Lower obesity rates were also reported in Italy (23.3%) [36] and Greece (overweight 19.1%, obesity 3.2%).[37] However, these variations may be attributable to geographical locations and differing lifestyles, along with different cut-off values for interpreting BMI results.

A concerning finding in our study was that abdominal obesity indicators were high (WC 47.4%, WHR 22.8%, and WHtR 27.2%). However, the literature indicates some inconsistency in indices used to determine abdominal obesity. For example, El Kassas and Ziade [33] reported central obesity rates evaluated by WC (41.8%) and WHtR (38.3%). Similarly, Al Hazza et al. [31] reported abdominal obesity using WHtR (35.9% for adolescent males and 30.3% for females). Abolfotouh et al. [34] reported abdominal obesity among Egyptian adolescents using WHR (16.1%), WC (4.5%), and WHtR (16.7%). However, our results are of concern regardless of variations in indices used to determine abdominal obesity. Visceral adiposity (as measured by WC, WHR, and WHtR) is associated with an increased risk for obesity-related morbidity and mortality. Excess weight gain in childhood and adolescence may lead to lifelong overweight/obesity, which is associated with greater risks for and earlier onset of metabolic disorders.[3, 8]

We found that participating adolescents showed low physical activity levels and low fruits/vegetables consumption. A recent UAE study reported that around 28% of Emirati adolescents had the recommended daily intake of fruits/vegetables. [38] Our participants also showed low levels of physical activity. This was consistent with a global estimate from the WHO that 81% of those aged 11−17 years did not meet daily physical activity recommendations. [39] Physical inactivity and low fruit and vegetable consumption in adolescence may persist throughout adulthood, increasing the risk for chronic lifelong diseases.[39]

Obesity in Public Versus Private Schools

Interestingly, we found a higher prevalence of obesity in adolescents from public schools than among adolescents from private schools. Differences in obesity rates between private and public schools have been reported in different countries. A study examining obesity rates among students in Palermo reported more public school students were overweight/obese compared with private school students (age 13 years: 40.8% vs. 34.5%; age 15 years: 36.7% vs. 30.2%). [13] Other studies have reported contrasting findings. A Kenyan study found that overweight/obesity rates were significantly higher (29.0%) among private school children than those from public schools (11.5%) (16). Similar trends of higher obesity rates in private schools compared with public schools were observed in studies from India, [17] Pakistan, [1]5 and Saudi Arabia. [31]

In our study, public school students had significantly higher abdominal obesity indicators (WC, WHtR, and %BF) than private school students. Most previous studies in the UAE reported BMI rates and did not examine these obesity indicators. Similarly, other studies that compared private and public schools in various countries did not compare abdominal obesity indicator. [13 15 16 18] Our results highlighted the importance of measuring anthropometric indices as obesity indicators (e.g., WC, WHC, WhtR, and %BF) when screening adolescents. We also noted that private school participants had higher SBP and DBP compared with public school participants, which may indicate an increased risk for developing cardiovascular disease in adulthood. [40] Primary prevention measures may be necessary to prevent the long-term negative impact of obesity on cardiovascular and metabolic health in adulthood.

Determinants of obesity

Our investigation highlighted the importance of evaluating WC, WHR, WHtR, and %BF. Overweight/obese participants with high WC and WHtR had significantly higher odds of having high BMI. A previous study reported WHtR was associated with visceral fat mass and cardiovascular risk factor clustering. [4]1 There are also significant correlations between determinants of obesity, including abdominal obesity indices (WHR and WC) and BMI, with abdominal obesity being the most frequent indicator of metabolic syndrome. [41] The close association between abdominal obesity and BMI suggests abdominal obesity should be closely monitored.

We found significant associations between high SBP/DBP and overweight/obesity in our participants. This was consistent with previous studies that demonstrated significant associations between obesity and hypertension or high BP (≥90th percentile) in children and adolescents.[40] Compared with adolescents with normal BMI, we found 7- and 2-fold increased risks for high SBP in obese girls and boys, respectively. The association between BMI and BP may be explained by various interacting complex systems.[40] Therefore, children with high BP may need intensive lifestyle management including daily physical activity and high fruit/vegetable diets.

In terms of lifestyle factors, we found that obese participants reported low physical activity and less consumption of fruits/vegetables compared with those with low/normal BMI. Other studies have also shown that low levels of physical activity and unhealthy dietary practices predicted obesity among adolescents. [5] Rapid urbanization and lifestyle changes in the UAE have increased exposure to fast/processed foods, along with reduced fruit/vegetable consumption and physical activity. [3, 13, 17] Therefore, promoting healthy lifestyles (e.g., increased fruit/vegetable consumption and physical activity) among adolescents is a public health priority that may have significant impacts on health in adulthood. Addressing this issue should involve multiple approaches targeting behavior change (e.g., food labeling, planning "exercise friendly" cities).

Conclusion

Our study showed a high prevalence of overweight and obesity among school-aged adolescents in the UAE, which confirms that obesity remains a widespread problem in our schools. This study highlights that early screening of WHtR, WC, and BP are important in the routine assessment of adolescents, because abdominal obesity and high BP are important indicators of metabolic syndrome and cardiometabolic risk. It may also be necessary to promote healthier lifestyles (e.g., healthy eating and increased physical activity) among children and adolescents to help curb obesity trends and prevent development of chronic diseases. Additional studies are needed to observe the changes in obesity rates necessary to achieve the UAE Vision 2021 National Agenda of a world class healthcare system by reducing the prevalence of obesity among children to support a healthy population in our schools.

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Contributors

All authors wrote the proposal for the study. WBI, HR, AA, SE, conducted statistical analysis. WBI, HR, RF, ML wrote the initial draft of the manuscript. All authors contributed to writing the initial results and provided critical review of the manuscript.

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Disclaimer

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Competing interests

None declared.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research

Patient consent for publication

Not required.

Ethical Considerations

Ethical approval to conduct this study was obtained from the Research Ethics Committee at the principal investigator's institution, the UAE Ministry of Health and Prevention, and the UAE Ministry of Education. Parental consent was obtained for each student that agreed to participate in this study

Data availability statement

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

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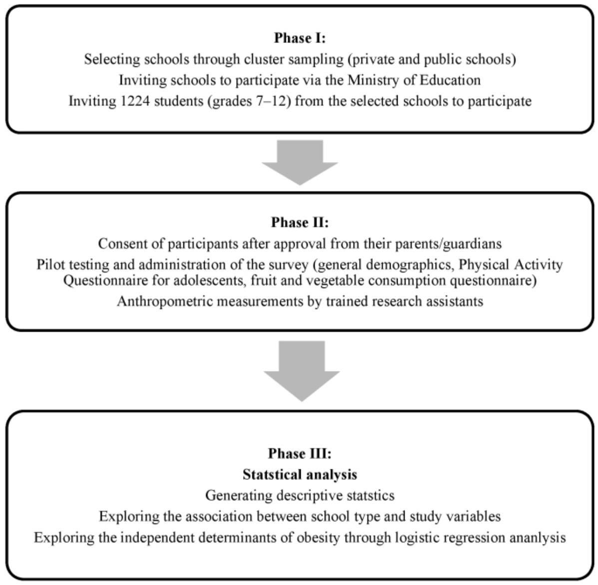

Figure 1: Flow diagram of data collection and analysis

279x215mm (300 x 300 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

Prevalence and determinants of overweight/obesity among school-aged adolescents in the United Arab Emirates

	Item No	Recommendation		Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract		1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found		1
		Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported		2-5
Objectives	3	State specific objectives, including any prespecified hypotheses		4
		Methods		
Study design	4	Present key elements of study design early in the paper		5-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection		5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants		5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable		8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group		*6-7*
Bias	9	Describe any efforts to address potential sources of bias		13 under limitation
Study size	10	Explain how the study size was arrived at		5 Under participants
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why		5-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding		8
		(*b*) Describe any methods used to examine subgroups and interactions		
		(*c*) Explain how missing data were addressed		
		(*d*) If applicable, describe analytical methods taking account of sampling strategy		8
		(*e*) Describe any sensitivity analyses		

		Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed		8
		(b) Give reasons for non-participation at each stage		8
		(c) Consider use of a flow diagram		Attached as a separate file
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders		8-9
		(b) Indicate number of participants with missing data for each variable of interest		
Outcome data	15*	Report numbers of outcome events or summary measures		9-10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included		9-10
		(*b*) Report category boundaries when continuous variables were categorized		9-10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		9-10
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses		
		Discussion		
Key results	18	Summarise key results with reference to study objectives		10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias		13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence		13
Generalisability	21	Discuss the generalisability (external validity) of the study results		
		Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based		In the title page

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Prevalence and determinants of overweight/obesity among school-aged adolescents in the United Arab Emirates: A cross-sectional study of private and public schools

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Prevalence and determinants of overweight/obesity among school-aged adolescents in the United Arab Emirates: A cross sectional study of private and public schools

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ABSTRACT

Objectives The United Arab Emirates (UAE) identified childhood obesity as a target for public health action. This study investigated the prevalence of obesity and factors influencing obesity among adolescents in the UAE.

Design Cross-sectional study.

Settings Private and public secondary schools.

Participants Adolescents aged 13–19 years (N = 932) selected though cluster sampling; 434 (46.6%) from private schools and 498 (53.4%) from public schools.

Measures Self-report questionnaires wereused to collect data on adolescents' sociodemographic factors, fruit/vegetable (F/V) intake, and physical activity. Participants' weight, height, waist circumference (WC), hip circumference (HC), and body fat percentage (%BF) were measured, and waist to height ratio (WHtR), waist to hip ratio (WHR), and body mass index (BMI) were calculated. Overweight/obesity was determined by BMI (BMI ≥85th percentile for age), abdominal obesity (AO) (measured by WC, WHtR, and WHR) and %BF. Multiple logistic regression analyses were conducted to determine the predictors of obesity.

Results In total, 34.7% of participants were overweight/obese (BMI ≥85th percentile) and 378 (40.6%) had high %BF. AO was noted in 47.3%, 22.7%, and 27.1% of participants as evaluated by WC, WHR, and WHtR, respectively. Significantly more participants from public schools were overweight/obese (BMI ≥85th percentile) compared with their private school counterparts (37.8% vs. 31.1%). Similarly, significantly more participants from public schools had AO (WC, WHR, WwHtR) than those from private schools. F/V intake and physical activity were the strongest predictors of obesity in participants: BMI (odds ratios [ORs] = 1.88 and 2.21, respectively), AO (WC: ORs = 1.54 and 1.78, respectively; WHtR: ORs = 1.35 and 1.64, respectively), and %BF (ORs = 2.43 and 1.46, respectively).

Conclusions This study highlights the need for nutritional and physical activity interventions, with sustained strategies to fight obesity in adolescents. In addition to BMI, AO must be considered when estimating obesity in adolescents.

Keywords: Adolescents, obesity, body mass index, abdominal obesity, body fat percentage, public schools, private schools, fruit and vegetable intake, physical activity.

Strengths and limitations of this study

- This study was among the first in UAE to assess obesity using different obesity indices (BMI, abdominal obesity, and body fat percentage) and examine its determinants using a representative sample of adolescents from private and public schools.
- This study identified two important factors impacting obesity in adolescents including fruit and vegetable consumption and physical activities that can inform the direction of public health policy.
- This study used a cross-sectional design and causality cannot be assumed.
- Future studies should include more male participants and more participants from private schools to provide a better estimate of obesity in the UAE adolescent population.
- Future research should investigate ethnic-specific cutoff values and criteria to define obesity in adolescent populations.

INTRODUCTION

Adolescence is a transitional developmental period characterized by changes in physical, intellectual, social, and emotional health. Optimal growth during adolescence is important for maintaining good health throughout the life course. Obesity among adolescents is a serious health problem and public health issue that demands urgent attention.[1] Globally, the prevalence of overweight/obesity has increased among children and adolescents. For example, the global prevalence was 4% in 1975, whereas the 2016 estimate was over 18%; this increase was similar among boys and girls (19% and 18%, respectively).[2] Increasing overweight and obesity rates are important public health issues for Middle Eastern and North African countries, especially as rapid increases in obesity have been observed among children and adolescents.[3] A large-scale epidemiological study (n=44,942) conducted in Ras Al Khaimah, United Arab Emirates (UAE), confirmed obesity was steadily increasing in those aged 3–18 years; each year an additional 2.36% were classified as obese and 0.28% as extremely obese.[4] In 2014, a global action plan that aimed to prevent and control noncommunicable diseases was adopted by the World Health Assembly.[1] This action plan highlighted the importance of measures to address obesity rates globally, including among children and adolescents. Many countries have reflected the need to focus on reducing and preventing obesity among young people in national policies and strategies; for example, the UAE included obesity among children as an indicator in the Vision 2021 National Agenda.[5]

In addition to causing health problems in childhood and adolescence, overweight and obesity among young people can have long-term health impacts into adulthood (e.g., cardiovascular disease, insulin resistance, type 2 diabetes mellitus, psychosocial complications).[6] Childhood obesity can also predict obesity in adulthood. A long-term follow-up study indicated efforts to influence body mass index (BMI) over the life course should begin early (e.g., before age 6 years), and noted the progression toward a high BMI begins in adolescence for boys and young adulthood for girls.[7 8] These studies highlighted that early intervention is important to prevent increased BMI and associated health risks, which also contribute to increased healthcare expenditure.[7 8]

Various external factors that influence obesity have changed in recent years, such as rapid changes in dietary practices (e.g., fast food, processed foods), extensive use of technology (e.g., the

Internet and mobile devices), and increasingly sedentary lifestyles. Such developments have been associated with high obesity rates among adolescents, especially in developing countries.[9] In particular, the rapid socioeconomic transition in Middle Eastern and North African countries has resulted in increased urbanization and drastic lifestyle changes, manifested in low physical activity and unhealthy dietary practices.[3] These factors combined with the growing fast food industry have led to various nutritional-related chronic conditions among adolescents, including obesity.[9]

The UAE has also witnessed rapid economic development and corresponding changes in lifestyles, leading to a marked increase in obesity in children/adolescents. Recently, the Global School-based Student Health Survey reported the obesity prevalence in the UAE youth population (aged 13–15 years) was 16.2%.[10] Previous cross-sectional studies from different cities across the UAE have also shown increased rates of obesity in adolescents, with the reported prevalence ranging from 18.9% in Abu Dhabi[11] to 35% in Dubai.[12]

Given the increased prevalence of obesity, it is important to clarify factors that contribute to obesity. School type (e.g., public, private) may be a key determinant of obesity, as students spend much of their day in school. Previous studies investigated differences in obesity rates between public and private schools. For example, one study found that many students attending public schools were obese and had low physical activity, low fruits and vegetables (F/V) consumption, and low intakes of water, fiber, vitamins, and minerals.[13] Another study found that children attending public schools had a high BMI and a greater likelihood of being overweight compared with children attending private schools.[14] However, other studies have reported opposite trends. Studies conducted in different countries such as Pakistan, Kenya, and India, all reported private school students had higher rates of obesity compared with those attending public schools.[15-17] Another study conducted in Shanghai also reported more students at private schools were overweight compared with those at public schools.[18] That study noted that this difference may be explained by diet, socioeconomic status, school environment, and factors related to infancy.

Most previous studies that investigated the prevalence of obesity in the UAE did not consider school type and other potentially associated factors. The majority of available studies[4 11 12] only used BMI as indicator of obesity in school-aged adolescents and did not include other parameters such as abdominal obesity (AO) indicators and body fat percentage (%BF). Relying on BMI only does not provide a realistic and comprehensive picture of obesity in adolescents.[1 2] By mapping and rigorously assessing adolescents' obesity-related health status, healthcare providers, policymakers, schools, and families will be able to collaborate to develop appropriate evidence-based approaches to promote adolescent health.

This study explored the epidemiology of overweight and obesity in the adolescent population and compared obesity figures between private and public schools. We also aimed to determine factors that contributed to overweight and obesity in participants, using BMI, AO, and %BF indicators. Factors measured included sociodemographic data for age, gender, nationality, parents' level of education, employment (employed/unemployed), self-reported income (below average/average/above average), school type (public vs. private), and lifestyle factors (F/V intake, physical activity levels).

SUBJECTS AND METHODS

Study design and setting

We adopted a quantitative correlational design. The sample was drawn from intermediate and high schools (secondary education) that were randomly selected from lists obtained from the Ministry of Education and other private/public school governing bodies in the UAE's seven emirates (Sharjah, Dubai, Abu Dhabi, Ajman, Ras Al Khaimah, Fujairah, and Umm Al Quwain). Recent statistics from the Ministry of Education (2018)[19] showed the UAE has fewer public schools than private schools (619 public vs. 643 private schools). Similarly, in terms of secondary schools (study population), the UAE has more private (N = 257) than public schools (128).[19] This study was reported according to the STROBE checklist for reports of cross-sectional studies (see Supplementary File 1).

Participants and sampling

This study used one-stage cluster sampling of private and public schools. To obtain a representative sample, a simple random sampling technique was used to select 10 schools from the public cluster and 15 schools from the private cluster. Cluster sampling is cost effective and recommended when it is difficult to compile a sampling frame that includes all elements of the study population.[20]

A convenience sample of classes from grades 9–12 was chosen by the principals of the selected schools based on students' availability. All students in those classes were invited to participate in this study. Convenience sampling was justifiable in our situation as it increased the cooperation of school principals and staff in data collection. The principal of each school provided access to classes depending on the class schedules, students' availability, and willingness of school personnel to facilitate data collection. Furthermore, selected schools requested that data collection procedures did not interrupt the planned educational activities which were set at the beginning of the academic year (e.g., exams' schedules, physical activity classes, and other extra-curricular activities).

The sample included male and female students from grades 9–12 in private and public schools (aged 13–19 years) of any nationality whose parents provided consent for them to participate. We excluded students with chronic diseases (e.g., type 2 diabetes, cancer, and mental health conditions) based on information from students' school records. This was because management of chronic diseases requires following special lifestyles and dietary practices that may affect the study's anthropometric measurements (Figure 1: Flow diagram of data collection process and analysis).

We used a standard sample size estimation method to obtain the sample size for a proportion data.[21] Based on an overweight/obesity prevalence of 40% among UAE adolescents,[4] a 3% margin of error, 95% confidence interval (CI), and a significance level of 0.05 (two tailed),[21] a total of 1024 participants was needed. The 40% obesity prevalence rate used for this calculation was based on recent evidence of an increased prevalence of obesity in adolescents and rates reported in similar studies that included large populations of UAE school-aged adolescents from all nationalities, which was similar to our population.[4 11 12] An additional 100 participants were included to allow for non-responses and control for the design effect associated with cluster sampling, where less precise information is anticipated because people in a cluster tend to be more alike.[20] The larger sample size also increased precision during multiple comparisons in the statistical analyses and aided in controlling for possible confounding variables.[21]

Data collection

Figure 1 presents a flowchart of the data collection process. Participating students completed a self-report questionnaire that included questions about sociodemographic characteristics, F/V intake, and physical activity. This was followed by collection of anthropometric measurements. Trained research assistants administered the questionnaire in the selected classrooms. Participating students were then directed to the on-site school clinic where anthropometric measurements were taken by the research team using standardized techniques. The same research team administered the questionnaire and took the anthropometric measurements to maintain consistency and uniformity in the data collection process across different sites. Data were collected from September 2018 to May 2019, which was a regular school period excluding the summer holiday. In the UAE, there are no large seasonal variations during this part of the year and the temperature falls within an acceptable range; therefore, we anticipated no seasonal differences in anthropometric measurements.

Measurements

The self-reported questionnaire included sociodemographic data (age, gender, nationality, and type of school (private vs. public), parents' level of education, employment (employed/unemployed), and self-reported income (below average/average/above average).

Physical activity

Participants' physical activity was recorded using the Physical Activity Questionnaire for Adolescents (PAQ-A). This tool is a 7-day recall self-report questionnaire with nine-items.[22] The PAQ-A was originally developed to evaluate physical activity levels among high school students (aged 14–19 years). Responses are on a 5-point Likert-scale, and the nine items are summed to give a total physical activity score. A high mean score indicates a high level of physical activity, and a cutoff score <2.75 is considered inactive. The English version of the PAQ-A has high reliability (Cronbach's alpha: 0.77–0.88) and high concurrent validity.[23] The Arabic version of the scale demonstrated good reliability and validity parameters when used in Arabic children and adolescents.[24] The estimated completion time for the PAQ-A is 20 minutes.[23]

F/V intake

F/V intake was assessed using the National Cancer Institute (NCI) Fruit and Vegetable Screener.[25] This instrument covers the frequency/amount consumed of specific items. These include: 100% fruit juice, fruit (e.g., fresh, canned, frozen), fried potatoes (e.g., French fries), other potatoes, dried beans, other vegetables, and tomato-based sauces (e.g., pasta, pizza). The instrument also evaluates the frequency of consumption of vegetable combinations (e.g., sandwiches, salads, casseroles/stews, stir-fries). We calculated servings per day using NCI standard scoring algorithms.[26] The English version of the NCI has been reported to have excellent reliability and validity in both adults and adolescents.[27] The scale also had acceptable reliability (Cronbach's alpha: 0.82) and predictive validity among Saudi young adults.[27] A F/V intake of <5 servings was considered a low intake.

Obesity-related anthropometric measurements and indices

Anthropometric indices included height (cm), weight (kg), waist and hip circumferences (WC and HC, respectively), waist to hip ratio (WHR), waist to height ratio (WHtR), and %BF. For these measurements, students removed their shoes and wore minimal light-weight clothing as per World Health Organization (WHO) guidelines.[28] Participants' height (to the nearest 0.1 cm) and weight (to the nearest 0.1 kg) were measured using a telescopic measuring rod (Seca 220) for column scales. Two measurements for WC and HC were recorded for each participant using an inextensible anthropometric tape (Seca 201). These measurements were taken while participants stood erect with their arms by their sides and feet close together.

Abdominal obesity (AO) indices included: WC, WHtR, and WHR. For WC, a cutoff of above the 90th percentile for age indicated AO. [28] Participants' WHtR was calculated by dividing their WC by height, and a cutoff value of 0.5 was used to define AO.[28 29] WHR was calculated by dividing the WC by HC (WHO, 2008), with a cutoff of value of 0.85 used to define AO.[28] BMI (weight in kg divided by height in m^2) was calculated and classified according to WHO criteria: underweight = BMI <3rd percentile; normal weight = BMI between the 3rd and 85th percentiles; overweight = BMI between the 85th and 97th percentiles; and obesity = BMI >97th percentile.[30]

A BMI at or above the 85th percentile for adolescents was adopted to classify participants as either overweight/obese or underweight/normal, as this was widely used in similar epidemiological studies [4 11 12] and recommended by international organizations (e.g., WHO, Centers for Disease Control, and International Obesity Taskforce) to define obesity.[30 31 32] However, because there are clinical limitations in using BMI to estimate obesity in adolescent populations and the lack of a gold standard to define obesity, [33] we also reported other obesity indices including AO indicators (WC, WHtR, WHR) and %BF. This combination was critical to provide valid and reliable obesity estimates in our adolescent population.

Participants' %BF was measured using the Body Composition Analyzer (TANITA MC 780 multi-frequency segmental body composition analyzer). This device measured participants' body composition parameters by evaluating differences in impedance of body components (e.g., muscle and lean tissue).[34] Various body composition parameters are automatically calculated, including total body muscle and fat mass, total body water, total body fat and water ratios, muscle mass of the arms/legs, BMI, and basal metabolic rate. This technology has been shown to be valid and reliable.[34 35] Standardized %BF cutoff ratios were used with 25% for boys and 30% for girls.[36]

Data analysis

Data were analyzed using SAS version 9.4. Descriptive characteristics were presented using frequency, percentage, mean, and standard deviation. Next, we compared differences in categorical sociodemographic variables by school type (private vs. public) using chi-square tests.

Simple and multiple logistic regression analyses were conducted to assess the associations between sociodemographic variables, school type, physical activity, and F/V intake, and all obesity indicators (BMI, AO, and %BF). Variables with a p-value ≤0.20 in the simple regression analysis were included in the multivariate regression model (gender, nationality, school type, F/V intake, and physical activity). Results of the logistic regression models were expressed as odds ratios (ORs) with 95% CIs. P-values less than 0.05 were considered statistically significant.

Ethics

Ethical approval to conduct this study was obtained from the University of Sharjah/Research Ethics Committee (REC/15/12/10) and the UAE Ministry of Health and Prevention (MOHAP REC-11). Parental consent was obtained for each student that agreed to participate.

RESULTS

Participants' characteristics and obesity-related indices

Table 1 presents participants' characteristics. Of the 1124 adolescents who were recruited and met the inclusion criteria, complete data were available for 932 participants (82.9% response rate). Missing and incomplete data were eliminated from the analyses.

The most common reason for not participating was lack of interest in this study. Of the participating adolescents, 434 (46.6%) attended private schools and 498 (53.4%) attended public schools. Participants' average age was 15.8±1.43 years; 311 (33.4%) were males and 621 (66.6%) were females. The majority of the participants were UAE nationals (61.1%). More than two-thirds of participants' mothers were not employed (n=682, 73.2%) and the majority (60%) had an average family income (based on participants' self-report). Participants' mean F/V intake score was 3.1±1.83, with 87.4% having <5 F/V servings. The mean physical activity score was 2.3±0.71; 79.7% of participants were classified as inactive.

The prevalence rate of overweight/obesity was 34.7% (n=323) (BMI ≥85th percentile), and rates for AO were 47.4%, 22.7%, and 27.1% as evaluated by WC, WHR, and WHtR, respectively. Moreover, 378 (40.6%) participants had excess body fat as estimated by %BF using TANITA (M=27.6%, 12.0%) (Table 1).

Table 1. Characteristics of participating adolescents (N = 932)

Characteristics	Frequency (%) or mean±SD
Gender	
Male	311 (33.4)
Female	621 (66.6)
Age (years)	15.8±1.4
Nationality	
UAE National	569 (61.1)
Non-UAE National	363 (38.9)
Type of school	
Public	498 (53.4)
Private	434 (46.6)
Mother's employment	
Employed	250 (26.8)
Unemployed	682 (73.2)
Economic status	
Below average	32 (3.4)
Average	559 (60)

Above average	341 (36.6)
F/V score	3.1±1.8
≥5 servings	117 (12.6)
<5 servings	815 (87.4)
PAQ-A	2.3±0.7
Active (mean score ≥2.75)	189 (20.3)
Inactive (mean score <2.75)	743 (79.7)
BMI (kg/m^2)	61.8±33.0
Underweight	79 (8. 4)
Normal	530 (56.9)
Overweight	158 (17.0)
Obese	165 (17.7)
WC (cm)	76.8±13.3
Normal	491 (52.7)
Abdominal obesity	441 (47. 3)
WHR (cm)	0.83±0.07
Normal	720 (77.3)
Abdominal obesity	212 (22.7)
WHtR (cm)	0.47±0.08
Normal	679 (72.9)
Abdominal obesity	253 (27.1)
%BF	27.6 ±12.0
Normal	554 (59.4)
Above normal (excess body fat)	378 (40.6)

Abbreviations: SD, standard deviation; F/V, fruits and vegetables intake score; PAQ-A, Physical Activity Questionnaire-Adolescents; BMI, body mass index; WC, waist circumference; WHR, waist to hip ratio; WHtR, waist to height ratio; %BF, body fat percentage.

Private versus public schools

Table 2 shows the associations between sociodemographic factors, lifestyle variables, and obesity-related indices by school type. Public schools had significantly more Emirati students compared with private schools that had more expatriate students (p=0.001). In addition, significantly more participants from public schools (75.1%) had an average family income compared with their counterparts from private schools, where 61% stated they had an above average income (p=0.001).

Significantly more participants from public schools consumed <5 F/V servings compared with their private school counterparts (p=0.007).

With regards to differences in obesity indicators, significantly more participants attending public schools were overweight/obese (BMI ≥85th percentile) compared with those from private schools (37.8% vs. 31.1%) (p=0.001). Moreover, significantly more participants from public schools had AO than their counterparts from private schools, as estimated by WHtR (p=0.001), WC (p=0.028), and WHR (p=0.04) (Table 2).

Table 2. Comparisons between private and public schools (N = 932)

	Public schools n (%), mean±SD (n=498, 53.4%)	Private schools n (%), mean±SD (n=434, 46.6%)	p-value[a]
Gender			0.694
Male	169 (33.9)	142 (32.7)	
Female	329 (66.1)	292 (67.3)	
Nationality			<0.001
UAE National	407 (81.7)	162 (37.3)	
Non-UAE National	91 (18.3)	272 (62.7)	
Mother's employment			0.123
Employed	144 (28.9)	106 (24.4)	
Unemployed	354 (71.1)	328 (75.6)	
Economic status			<0.001
Below average	30 (6.0)	2 (0.5)	
Average	374 (75.1)	167 (38.5)	
Above average	94 (18.9)	265 (61.0)	
F/V score	3.0±1.7	3.1±1.9	
≥5 servings	49 (9.8)	68 (15.7)	0.007
<5 servings	449 (90.2)	366 (84.3)	
PAQ-A score	2.2±0.70	2.2±0.6	
Active	403 (81)	340 (78.3)	0.320

Inactive	95 (19)	94 (21.7)	
BMI (kg/m2)			0.001
Underweight	44 (8.8)	35 (8.1)	
Normal	266 (53.4)	264 (60.8)	
Overweight	77 (15.5)	81 (18.7)	
Obese	111 (22.3)	54 (12.4)	
WC (cm)	78.5 ±15.0	74.80 ± 11.0	0.028
Normal	247 (49.6)	247 (57.0)	
Abdominal obesity	251 (50.4)	187 (43.0)	
WHR (cm)	0.83±0.07	0.83±0.06	
Normal	372 (74.7)	348 (80.2)	0.04
Abdominal obesity	126 (25.3)	86 (19.8)	
WHtR (cm)	0.48±0.08	0.46±0.06	
Normal	333 (66.9)	346 (79.7)	0.001
Abdominal obesity	165 (33.1)	88 (20.3)	
%BF	27.6±10.4	25.3±8.9	0.510
Normal	301 (60.4)	253(58.3)	
Above normal (excess fat)	197 (39.6)	181 (41.7)	

[a]P-values significant at <0.05 based on chi-square tests
Abbreviations: F/V, fruits and vegetables intake score; PAQ-A, Physical Activity Questionnaire-Adolescents; BMI, body mass index; WC, waist circumference; WHR, waist to hip ratio; WHtR, waist to height ratio; %BF, body fat percentage

Predictors of overweight/obesity: body mass index, AO, and %BF

After adjustment, predictors of being overweight/obese (based on BMI) were: consuming <5 servings of F/V (adj OR 1.88, CI: 1.41, 2.49) and being inactive (adj OR 2.21, CI: 1.51, 3.22). Similarly, consuming <5 servings of F/V and being inactive significantly predicted AO based on WC, WHtR, and %BF (p-values for ORs <0.05) (Table 3).

An examination of participants' characteristics showed that attending a public school contributed to AO (based on WC, WHtR, and WHR) (p-values for ORs <0.05). In addition, being Emirati was independently associated with AO as measured by WC and WHR (p-values for ORs <0.05). Compared with female participants, males had greater odds of having AO (based on WHtR) and were less likely to have high %BF (p-values for ORs <0.05) (Table 3).

Table 3. Determinants of overweight/obesity based on body mass index, abdominal obesity indicators and total body fat percentage (N = 932)

Variables	BMI-Overweight/Obese		Elevated WC		Elevated WHtR		Elevated WHR		High %BF	
	adj OR	[a]95% CI	adj OR	95% CI	adj OR	95% CI	adj OR	95% CI	adj OR	95% CI
Gender										
Male[a] / Female	1.27	[0.95, 1.71]	0.99	[0.75, 1.31]	**1.51**	**[1.11, 2.06]**	1.11	[0.80, 1.54]	**0.33**	**[0.24, 0.43]**
Type of school										
Private[a] / Public	0.81	[0.59, 1.11]	**0.62**	**[0.46, 0.83]**	**0.47**	**[0.33, 0.66]**	**0.59**	**[0.41, 0.84]**	1.16	[0.85, 1.57]
Nationality										
Expatriate[a] / Emirati	1.20	[0.87, 1.65]	**0.65**	**[0.47, 0.88]**	0.81	[0.58, 1.15]	**0.63**	**[0.44, 0.90]**	1.18	[0.87, 1.62]
F/V score										
<5servings[a] / ≥5 servings	**1.88**	**[1.41, 2.49]**	**1.54**	**[1.18, 2.01]**	**1.35**	**[1.10, 1.82]**	1.10	[0.80, 1.50]	**2.43**	**[1.58, 3.73]**
PAQ-A										
Inactive[a] / Active	**2.21**	**[1.51, 3.22]**	**1.78**	**[1.26, 2.50]**	**1.64**	**[1.10, 2.43]**	1.03	[0.70, 1.52]	**1.46**	**[1.04, 2.07]**

Abbreviations: adj OR, adjusted odds ratio; CI, confidence interval; F/V, fruits and vegetables intake score, PAQ-A, Physical Activity Questionnaire-Adolescents; WC, waist circumference; WHR, waist to hip ratio; WHTR, waist to height ratio; %BF, body fat percentage.
[a]Reference category.
Numbers in bold are statistically significant (p-value <0.05).

DISCUSSION

This study presents new information regarding the epidemiology and determinants of overweight/obesity among UAE school-aged adolescents. We found a considerably high prevalence of overweight/obesity among participants (34.7%), which supported previous UAE-based epidemiological studies that used BMI to define obesity.[4 11 12] The prevalence rates of overweight/obesity observed in our study was also consistent with studies from other Arab countries that used BMI to classify obesity, including Saudi Arabia (39%),[37] Kuwait (44.3%),[38] Lebanon (32.2%),[39] and Egypt (35%).[40] Conversely, studies conducted in Western countries reported lower obesity rates compared with our study. For example, the obesity rate among adolescents in European countries was between 22%–25%, with the rate for Italy[41] being 23.3% (either overweight or obese) and rates for Greece being 19.1% (overweight) and 3.2% (obesity).[42] In the US, 30% of adolescents were overweight/obese.[43]

In the present study, we also investigated other obesity indicators using AO indices. A concerning finding in our study was that AO indicators were high (WC 47.4%, WHR 22.8%, and WHtR 27.2%). Visceral adiposity (as measured by WC, WHR, and WHtR) is associated with an increased risk for earlier onset of metabolic disorders, and obesity-related morbidity and mortality.[3 8] There are variations in the literature on indices and values used to define AO in adolescents. For example, El-Kassas and Ziade[39] reported central obesity rates as evaluated by WC (41.8%) and WHtR (38.3%), whereas Al Hazza et al.[37] reported abdominal obesity using WHtR (35.9% for adolescent males and 30.3% for females). Abolfotouh et al.[40] reported lower AO rates among Egyptian adolescents using WHR (16.1%), WC (4.5%), and WHtR (16.7%). These variations may be attributable to geographical location, genetic compositions, and differing lifestyles, along with different cut-off values for interpreting AO results.

We found that the majority of the participating adolescents showed low physical activity levels (79.7%) and low F/V consumption (87.4%). A recent study in UAE reported that only around 28% of Emirati adolescents had the recommended daily F/V intake.[44] As for the low levels of physical activity, our finding was consistent with a global estimate from the WHO that 81% of those aged 11−17 years did not meet daily physical activity recommendations.[45] It is noteworthy that physical inactivity and low F/V consumption in adolescence may persist throughout adulthood, which will increase the risk for chronic lifelong diseases later in life.[45]

Obesity in public versus private schools

Interestingly, we found a higher prevalence of obesity in adolescents from public schools than among adolescents from private schools (as measured by BMI). Differences in obesity rates between private and public schools have been reported in different countries in studies that used BMI. Similar to our findings, a study examining obesity rates among students in Palermo reported more public school students were overweight/obese compared with private school students (age 13 years: 40.8% vs. 34.5%; age 15 years: 36.7% vs. 30.2%).[13] However, other studies have reported contrasting findings. For example, a study in Kenya found that overweight/obesity rates were significantly higher (29.0%) among private school children than those from public schools (11.5%).[16] Similar trends of higher obesity rates in private schools compared with public schools were also observed in studies from India,[17] Pakistan,[15] and Saudi Arabia.[37] A possible explanation for the inconsistent findings related to obesity rates between private and public schools could be differences in sociodemographic and cultural factors of attending students. For example, in the UAE, public schools are mostly attended by Emirati/national students whereas private schools are mainly attended by expatriates.[19] Therefore, different eating habits among cultures could contribute to these findings. Furthermore, offering unhealthy items in vending machines, poor communication between food suppliers and school personnel, and limited physical activity facilities at schools may be correlated with body weight in adolescents.[46]

Similarly, in our study, public school students had significantly higher AO indicators (WC, WHR, WHtR) than private school students, which were consistent with our results for BMI values. Most previous UAE-based studies reported BMI rates and did not examine these obesity indicators. Similarly, many other studies that compared private and public schools in various countries did not compare AO indicators.[13 16 17 18] Accordingly, our results align with the recommendation from several previous research suggesting that in addition to BMI, other anthropometric measurements should be included as indicators of obesity when screening adolescents in schools (e.g., WC, WHC, and WHtR).[28 33]

Furthermore, we found that participants from public schools consumed significantly less F/V than those in private schools. Similar findings were reported in previous studies. A comparative study of Brazilian school children aged 10–12 years (151 from public schools and 55 from private schools) found that public school participants reported less F/V consumption compared with those from private schools.[47] Similarly, a study from Petrolina-Brazil found that only 28.3% of adolescents in public schools (n=210, aged 15–17 years) consumed adequate F/V.[48] A recent mixed method study from the UAE in which the majority of the sample was from public schools (24 public, 10 private) reported that only 28% of participants (n=620) met the WHO recommended daily F/V intake.[44] The low consumption of F/V in participants from public schools compared with their private school counterparts may partially explain the higher obesity indices (BMI and AO) found in public schools.

In our study, variations were noted in sociodemographic factors, nationality, and economic status between participants from private and public schools. These personal factors could play an important role in determining obesity rates in adolescents, [41 44 49] and therefore warrant further attention. Understanding the differences between private and public schools and the sociodemographic structure among adolescents is essential to build focused interventions that overcome barriers to healthy choices, especially in public schools.

Determinants of obesity in participants

Physical activity and F/V intake were strong determinants of overweight/obesity, and showed independent correlations with different obesity indicators including BMI, AO (WC, WHtR), and %BF. Other studies have also shown that low levels of physical activity and unhealthy dietary practices predicted obesity among adolescents.[5] Rapid urbanization and lifestyle changes in the UAE have increased exposure to fast/processed foods, sedentary lifestyle along with reduced F/V consumption and less physical activity.[3 13 17] Adolescents tend to spend most of their time playing computer games, doing homework and similar activities instead of spending time on exercise and sports.[44] Therefore, promoting healthy lifestyles for adolescents is a public health priority as the WHO recommends at least 60 minutes of moderate-to-vigorous physical activity each day, and a dietary intake of at least 400 grams of F/V each day (roughly equivalent to five servings of F/V per day).[50] Therefore, there is a need to enforce school policies that motivate adolescents to consume the recommended intake of F/V and engage in physical activities for better health outcomes. In the school environment, guidelines for food consumption inside schools, canteen food menus, and diet and exercise self-efficacy must be explored in future studies. [5 44]

As noted earlier, special attention must be given to adolescents in public schools because we found that more participants from public schools had higher AO, consistent with previous studies.[14] AO has been associated with visceral fat mass, higher blood pressure, and cardiovascular risk factor clustering, and should be measured along with BMI.[51 52] In adolescents in Poland (141 boys and 168 girls, aged 16–18 years), AO (WC, WHR, WHTR) was associated with family environment and modifiable lifestyle factors.[52] In the UAE, adolescents come from diverse backgrounds, meaning it is essential to investigate lifestyle, cultural practices, and genetic factors contributing to AO. Considering gender differences is critical, as male participants in our study were more likely to have AO (above normal WHtR) and less likely to have increased %BF compared to girl participants, which was consistent with previous studies. For example, significantly higher AO (measured by WHR, WC) was reported in boy adolescents compared to girl adolescents from Poland. [52] Similarly, in another study from Brazil, higher AO (measured by WC) was reported in male adolescents (n=258) compared to female adolescents (n=443). [53] Focused nutritional and physical activity programs that assess the differences in lifestyles and perceptions of overweight and obesity in male adolescents to are needed to promote better health outcomes. Addressing this issue should involve multiple approaches targeting behavior change (e.g., food labeling, planning "exercise-friendly" cities).

The results from the present study concerning the high obesity prevalence and its determinants confirm the need for a strong and unified policy that considers students' diverse sociodemographic characteristics, school type and environment, and educational polices when initiating campaigns to combat obesity. Government health campaign interventions and strategies must be established at the federal level to support schools to identify overweight and obese adolescents and increase their awareness about the negative impact of obesity on health outcomes in adolescents.[5 44] A unified and collaborative health promotion model is needed where UAE health officials, teachers, parents, students, and social media are involved as early as possible.[5 50 45] Furthermore, it is recommended that a surveillance system for obesity indicators for UAE adolescents is implemented to monitor the effectiveness of policies aiming to counteract obesity in this population.

Strengths and limitations

Our study is among the first in the UAE to provide valid estimates of obesity by considering BMI, AO indicators, and %BF. This study highlights the urgent need to screen for obesity in our schools and emphasizes the importance of health promotion campaigns and practices, especially in public schools. Further, the present findings focus on the importance of considering F/V intake and physical activity among adolescents as important predictors of obesity, which can be used to inform the direction of public health policy geared toward improving lifestyle of adolescents.

Many males in higher secondary education move to vocational and technical schools to build their skills, meaning fewer males stay in secondary schools.[19] This trend was reflected in this study where there were fewer male participants than female participants. This limits the generalizability of the study findings. Furthermore, we expected to recruit more adolescents from private schools we as invited more private schools to participate; however, fewer private school participants were recruited for this study. This might be attributable to limited access given by school administration to classes in the private schools cluster. Additional genetic, family, dietary pattern, stress, and social factors should be examined in future studies to provide a comprehensive picture of the determinants of obesity in adolescents.

Despite the use of multiple obesity indices in this study to provide a valid picture of obesity among the UAE adolescent population, we used international cutoff points to classify participants into overweight/obese and normal/underweight groups. Given the overwhelming health risks associated with obesity in adolescents, there is an urgent need for a standardized definition of obesity in adolescents so that trends can be monitored and comparisons made between adolescents of different ethnic groups. Subsequently, established gold standards can be used to determine obese adolescents in clinical practice as well as in relevant epidemiological studies.

CONCLUSIONS

Our study showed a high prevalence rate of overweight/obesity among school-aged adolescents in the UAE (as measured by BMI), which confirms that obesity remains a widespread problem in UAE schools. This study underscores the importance of early screening of AO indicators (WHtR, WC, and %BF) in the routine assessment of adolescents in addition to BMI, because AO is associated with high blood pressure, metabolic syndrome, and cardiometabolic risks. It is also necessary to promote healthier lifestyles (e.g., healthy eating by increasing F/V intake and increased physical activity) among children and adolescents to help curb obesity trends and prevent the development of chronic diseases. Additional studies are needed to observe the changes in obesity rates necessary to achieve the UAE Vision 2021 National Agenda of a world-class healthcare system by reducing the prevalence of obesity among children to support a healthy population in our schools.

Finally, obesity in adolescents is multifactorial; therefore, further research is needed to examine the contributions of modifiable and non-modifiable risk factors to obesity among adolescents in different cultures. Future research should establish cutoff values for different obesity indicators to yield better screening and diagnosis of obesity among adolescents.

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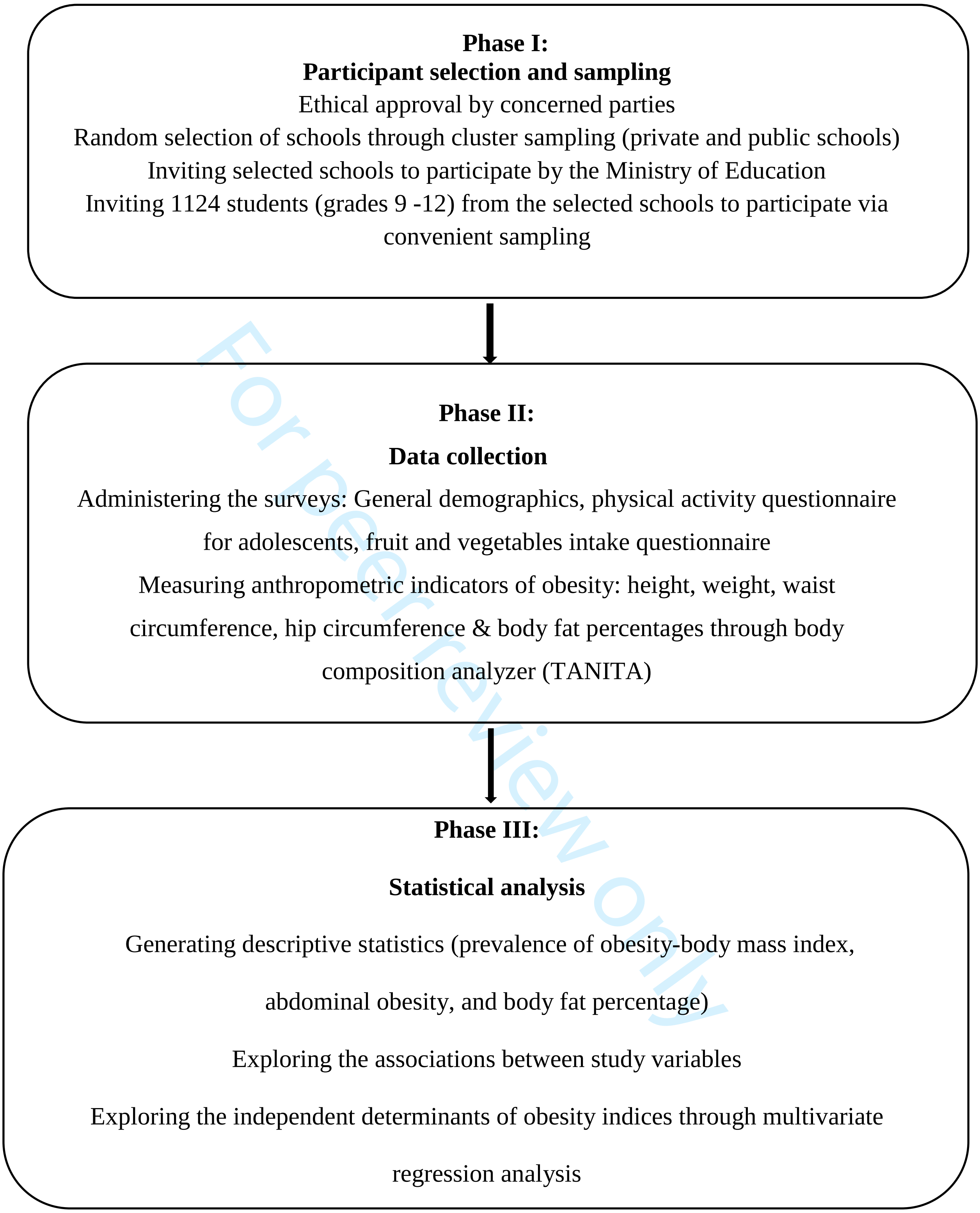

Figure 1 Flow diagram of data collection process and analysis

STROBE Statement—checklist of items that should be included in reports of observational studies

Prevalence and determinants of overweight/obesity among school-aged adolescents in the United Arab Emirates: A cross sectional study of private and public schools

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1	See title page and abstract Prevalence and determinants of overweight/obesity among school-aged adolescents in the United Arab Emirates: A cross sectional study of private and public schools
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3	See abstract section
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-7	See background section
Objectives	3	State specific objectives, including any prespecified hypotheses	7	In this study, we explored the epidemiology of overweight and obesity in the total population and compared obesity figures between private and public schools. We also aimed to determine factors that contributed to overweight and obesity in participants including sociodemographic factors (sex, age, nationality, parents' employment and socioeconomic status); school type (public vs. private); and lifestyle factors (F/V consumption, physical activity levels).
Methods				
Study design	4	Present key elements of study design early in the paper	7	We adopted a quantitative correlational design
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-8	See subjects and methods
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up		

		Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	8	
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	Not relevant	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9-11	See measurement section (page 9-10), also data analysis section (page 11)
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*9-10*	Full descriptions of all variables measured provided –under measurement section
Bias	9	Describe any efforts to address potential sources of bias	8-9, 11	We used trained research assistants The same research team collected the data Random selection of school through cluster sampling Multivariate logistic regression (page 11)
Study size	10	Explain how the study size was arrived at	8	See last paragraph of participants and samples

Continued on next page

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11	Data analysis section
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11	Data analysis section
		(*b*) Describe any methods used to examine subgroups and interactions		
		(*c*) Explain how missing data were addressed	11	Results section, paragraph 1 Missing and incomplete data were eliminated from the analyses.
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	11	
		(*e*) Describe any sensitivity analyses	NA	
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11	Results section, paragraph 1
		(b) Give reasons for non-participation at each stage	11	Results section, paragraph 1
		(c) Consider use of a flow diagram	Included as separate file (available online)	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11-12	Participants' characteristics and obesity-related indices Table 1
		(b) Indicate number of participants with missing data for each variable of interest	*NA*	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	*NA*	

Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	*NA*	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	*NA*	
		Cross-sectional study—Report numbers of outcome events or summary measures	11-17	Results section
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-17	Results section
		(*b*) Report category boundaries when continuous variables were categorized	11-17	Results section
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA	

Continued on next page

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA	
Discussion				
Key results	18	Summarise key results with reference to study objectives	16-20	Discussion section
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	21	See strengths limitation section
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	21	See strengths limitation section
Generalisability	21	Discuss the generalisability (external validity) of the study results	21	See strengths limitation section
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	21	This research was funded by the University of Sharjah/Research Institute for Medical and Health Sciences\ Health Promotion Research Group (Grant number 150310)

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Prevalence and determinants of overweight/obesity among school-aged adolescents in the United Arab Emirates: A cross sectional study of private and public schools

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ABSTRACT

Objectives To estimate the prevalence and predictors of obesity among adolescents in the United Arab Emirates.

Design Cross-sectional study.

Setting Private and public secondary schools.

Participants Adolescents aged 13–19 years; 434 (46.6%) from private schools and 498 (53.4%) from public schools.

Measures A Self-report questionnaires were used to assess adolescents' sociodemographic factors, fruit/vegetable (F/V) intake, and physical activity. Participants' weight, height, waist circumference (WC), hip circumference (HC), and body fat percentage (%BF) were measured, and waist to height ratio (WHtR), waist to hip ratio (WHR), and body mass index (BMI) were calculated. Overweight/obesity was determined by BMI ≥85th percentile for age), abdominal obesity (AO) (WC, WHtR, and WHR) and %BF.

Results A total of 34.7% of participants were overweight/obese (BMI ≥85th percentile) and 378 (40.6%) had high %BF. AO was noted in 47.3%, 22.7%, and 27.1% of participants, based on WC, WHR, and WHtR respectively. Significantly more participants from public schools were overweight/obese (37.8% vs. 31.1%) and had greater AO (based on WC, WHR, WHtR) compared with those from private schools. Predictors of obesity based on BMI were: consuming <5 servings of F/V (adjusted odds ratio [AOR] 2.41, 95% confidence interval [CI]: 1.73, 3.36), being physically inactive (AOR 2.09, CI: 1.36, 3.22), and being male (AOR 3.35, 95% CI: 2.20, 5.10). Predictors of AO were being male (WC: AOR 1.42, 95% CI: 1.01, 2.00; WHtR: AOR 2.72, 95% CI: 1.81, 4.08); studying at public school (WHR: AOR 1.67, 95% CI: 1.06, 2.66); being Emirati (WHR: AOR 0.62, 95% CI: 0.43, 0.90); consuming <5 servings of F/V (WC: AOR 1.71, 95% CI: 1.27, 2.30; WHtR: AOR 1.46, 95% CI: 1.05, 2.03), and being physically inactive (WC: AOR 1.63; 95% CI: 1.13, 2.35).

Conclusions Focused interventions are needed to combat obesity while considering AO indicators and BMI to diagnose obesity in adolescents.

Keywords: Adolescents, obesity, body mass index, abdominal obesity, body fat percentage, public schools, private schools, fruit and vegetable intake, physical activity.

Strengths and limitations of this study

- This study examined prevalence and determinants of obesity using different obesity indices (body mass index, abdominal obesity, and body fat percentage) in a representative sample of adolescents from private and public schools.
- This study used a cross-sectional design; therefore, causality cannot be assumed.
- In addition, we cannot rule out the potential effect of confounding factors that may influence obesity outcomes, such as participants' genetic composition, school dietary practices/polices, social factors, and participants' full dietary intake.

INTRODUCTION

Adolescence is a transitional developmental period characterized by changes in physical, intellectual, social, and emotional health. Optimal growth during adolescence is important for maintaining good health throughout the life course. Obesity among adolescents is a serious health problem and public health issue that demands urgent attention.[1] Globally, the prevalence of overweight/obesity has increased among children and adolescents. For example, the global prevalence was 4% in 1975, whereas the 2016 estimate was over 18%; this increase was similar among boys and girls (19% and 18%, respectively).[2] Increasing overweight and obesity rates are important public health issues for Middle Eastern and North African countries, especially as rapid increases in obesity have been observed among children and adolescents.[3] A large-scale epidemiological study (n=44,942) conducted in Ras Al Khaimah, United Arab Emirates (UAE), confirmed obesity was steadily increasing in those aged 3–18 years; each year an additional 2.36% were classified as obese and 0.28% as extremely obese.[4] In 2014, a global action plan that aimed to prevent and control noncommunicable diseases was adopted by the World Health Assembly.[1] This action plan highlighted the importance of measures to address obesity rates globally, including among children and adolescents. Many countries have reflected the need to focus on reducing and preventing obesity among young people in national policies and strategies; for example, the UAE included obesity among children as an indicator in the Vision 2021 National Agenda.[5]

In addition to causing health problems in childhood and adolescence, overweight and obesity among young people can have long-term health impacts into adulthood (e.g., cardiovascular disease, insulin resistance, type 2 diabetes mellitus, psychosocial complications).[6] Childhood obesity can also predict obesity in adulthood. A long-term follow-up study indicated efforts to influence body mass index (BMI) over the life course should begin early (e.g., before age 6 years), and noted the progression toward a high BMI begins in adolescence for boys and young adulthood for girls.[7 8] These studies highlighted that early intervention is important to prevent increased BMI and associated health risks, which also contribute to increased healthcare expenditure.[7 8]

Various external factors that influence obesity have changed in recent years, such as rapid changes in dietary practices (e.g., fast food, processed foods), extensive use of technology (e.g., the

Internet and mobile devices), and increasingly sedentary lifestyles. Such developments have been associated with high obesity rates among adolescents, especially in developing countries.[9] In particular, the rapid socioeconomic transition in Middle Eastern and North African countries has resulted in increased urbanization and drastic lifestyle changes, manifested in low physical activity and unhealthy dietary practices.[3] These factors combined with the growing fast food industry have led to various nutritional-related chronic conditions among adolescents, including obesity.[9]

The UAE has also witnessed rapid economic development and corresponding changes in lifestyles, leading to a marked increase in obesity in children/adolescents. Recently, the Global School-based Student Health Survey reported the obesity prevalence in the UAE youth population (aged 13–15 years) was 16.2%.[10] Previous cross-sectional studies from different cities across the UAE have also shown increased rates of obesity in adolescents, with the reported prevalence ranging from 18.9% in Abu Dhabi[11] to 35% in Dubai.[12]

Given the increased prevalence of obesity, it is important to clarify factors that contribute to obesity. School type (e.g., public, private) may be a key determinant of obesity, as students spend much of their day in school. Previous studies investigated differences in obesity rates between public and private schools. For example, one study found that many students attending public schools were obese and had low physical activity, low fruits and vegetables (F/V) consumption, and low intakes of water, fiber, vitamins, and minerals.[13] Another study found that children attending public schools had a high BMI and a greater likelihood of being overweight compared with children attending private schools.[14] However, other studies have reported opposite trends. Studies conducted in different countries such as Pakistan, Kenya, and India, all reported private school students had higher rates of obesity compared with those attending public schools.[15-17] Another study conducted in Shanghai also reported more students at private schools were overweight compared with those at public schools.[18] That study noted that this difference may be explained by diet, socioeconomic status, school environment, and factors related to infancy.

Most previous studies that investigated the prevalence of obesity in the UAE did not consider school type and other potentially associated factors. The majority of available studies [4 11 12] only used BMI as indicator of obesity in school-aged adolescents and did not include other parameters such as abdominal obesity (AO) indicators and body fat percentage (%BF). Relying on BMI only does not provide a realistic and comprehensive picture of obesity in adolescents.[1 2] By mapping and rigorously assessing adolescents' obesity-related health status, healthcare providers, policymakers, schools, and families will be able to collaborate to develop appropriate evidence-based approaches to promote adolescent health.

This study explored the epidemiology of overweight and obesity in the adolescent population and compared obesity figures between private and public schools. We also aimed to determine factors that contributed to overweight and obesity in participants, using BMI, AO, and %BF indicators. Factors measured included sociodemographic data for age, gender, nationality, parents' level of education, employment (employed/unemployed), self-reported income (below average/average/above average), school type (public vs. private), and lifestyle factors (F/V intake, physical activity levels).

SUBJECTS AND METHODS

Study design and setting

We adopted a quantitative correlational design. The sample was drawn from intermediate and high schools (secondary education) that were randomly selected from lists obtained from the Ministry of Education and other private/public school governing bodies in the UAE's seven emirates (Sharjah, Dubai, Abu Dhabi, Ajman, Ras Al Khaimah, Fujairah, and Umm Al Quwain). Recent statistics from the Ministry of Education (2018)[19] showed the UAE has fewer public schools than private schools (619 public vs. 643 private schools). Similarly, in terms of secondary schools (study population), the UAE has more private (*n*=257) than public schools (128).[19] This study was reported according to the STROBE checklist for reports of cross-sectional studies (see Supplementary File 1).

Participants and sampling

This study used one-stage cluster sampling of private and public schools. To obtain a representative sample, a simple random sampling technique was used to select 10 schools from the public cluster and 15 schools from the private cluster. Cluster sampling is cost effective and recommended when it is difficult to compile a sampling frame that includes all elements of the study population.[20]

A convenience sample of classes from grades 9–12 was chosen by the principals of the selected schools based on students' availability. All students in those classes were invited to participate in this study. Convenience sampling was justifiable in our situation as it increased the cooperation of school principals and staff in data collection. The principal of each school provided access to classes depending on the class schedules, students' availability, and willingness of school personnel to facilitate data collection. Furthermore, selected schools requested that data collection procedures did not interrupt the planned educational activities which were set at the beginning of the academic year (e.g., exams' schedules, physical activity classes, and other extra-curricular activities).

The sample included male and female students from grades 9–12 in private and public schools (aged 13–19 years) of any nationality whose parents provided consent for them to participate. We excluded students with chronic diseases (e.g., type 2 diabetes, cancer, and mental health conditions) based on information from students' school records. This was because management of chronic diseases requires following special lifestyles and dietary practices that may affect the study's anthropometric measurements (Figure 1: Flow diagram of data collection process and analysis).

We used a standard sample size estimation method to obtain the sample size for a proportion data.[21] Based on an overweight/obesity prevalence of 40% among UAE adolescents,[4] a 3% margin of error, 95% confidence interval (CI), and a significance level of 0.05 (two tailed),[21] a total of 1024 participants was needed. The 40% obesity prevalence rate used for this calculation was based on recent evidence of an increased prevalence of obesity in adolescents and rates reported in similar studies that included large populations of UAE school-aged adolescents from all nationalities, which was similar to our population.[4 11 12] An additional 100 participants were included to allow for non-responses and control for the design effect associated with cluster sampling, where less precise information is anticipated because people in a cluster tend to be more alike.[20] The larger sample size also increased precision during multiple comparisons in the statistical analyses and aided in controlling for possible confounding variables.[21]

Data collection

Figure 1 presents a flowchart of the data collection process. Participating students completed a self-report questionnaire that included questions about sociodemographic characteristics, F/V intake, and physical activity. This was followed by collection of anthropometric measurements. Trained research assistants administered the questionnaire in the selected classrooms. Participating students were then directed to the on-site school clinic where anthropometric measurements were taken by the research team using standardized techniques. The same research team administered the questionnaire and took the anthropometric measurements to maintain consistency and uniformity in the data collection process across different sites. Data were collected from September 2018 to May 2019, which was a regular school period excluding the summer holiday. In the UAE, there are no large seasonal variations during this part of the year and the temperature falls within an acceptable range; therefore, we anticipated no seasonal differences in anthropometric measurements.

Measurements

The self-reported questionnaire included sociodemographic data (age, gender, nationality, and type of school (private vs. public), parents' level of education, employment (employed/unemployed), and self-reported income (below average/average/above average).

Physical activity

Participants' physical activity was recorded using the Physical Activity Questionnaire for Adolescents (PAQ-A). This tool is a 7-day recall self-report questionnaire with nine-items.[22] The PAQ-A was originally developed to evaluate physical activity levels among high school students (aged 14 to 19 years). Responses are on a 5-point Likert-scale, and the nine items are summed to give a total physical activity score. A high mean score indicates a high level of physical activity, and a cutoff score <2.75 is considered inactive. The English version of the PAQ-A has high reliability (Cronbach's alpha: 0.77 to 0.88) and high concurrent validity.[23] The Arabic version of the scale demonstrated good reliability and validity parameters when used in Arabic children and adolescents.[24] The estimated completion time for the PAQ-A is 20 minutes.[23]

F/V intake

F/V intake was assessed using the National Cancer Institute (NCI) Fruit and Vegetable Screener.[25] This instrument covers the frequency/amount consumed of specific items. These include: 100% fruit juice, fruit (e.g., fresh, canned, frozen), fried potatoes (e.g., French fries), other potatoes, dried beans, other vegetables, and tomato-based sauces (e.g., pasta, pizza). The instrument also evaluates the frequency of consumption of vegetable combinations (e.g., sandwiches, salads, casseroles/stews, stir-fries). We calculated servings per day using NCI standard scoring algorithms.[26] The English version of the NCI has been reported to have excellent reliability and validity in both adults and adolescents.[27] The scale also had acceptable reliability (Cronbach's alpha: 0.82) and predictive validity among Saudi young adults.[27] A F/V intake of <5 servings was considered a low intake.

Obesity-related anthropometric measurements and indices

Anthropometric indices included height (cm), weight (kg), waist and hip circumferences (WC and HC, respectively), waist to hip ratio (WHR), waist to height ratio (WHtR), and %BF. For these measurements, students removed their shoes and wore minimal light-weight clothing as per World Health Organization (WHO) guidelines.[28] Participants' height (to the nearest 0.1 cm) and weight (to the nearest 0.1 kg) were measured using a telescopic measuring rod (Seca 220) for column scales. Two measurements for WC and HC were recorded for each participant using an inextensible anthropometric tape (Seca 201). These measurements were taken while participants stood erect with their arms by their sides and feet close together.

Abdominal obesity (AO) indices included: WC, WHtR, and WHR. For WC, a cutoff of above the 90th percentile for age indicated AO. [28] Participants' WHtR was calculated by dividing their WC by height, and a cutoff value of 0.5 was used to define AO.[28 29] WHR was calculated by dividing the WC by HC (WHO, 2008), with a cutoff of value of 0.85 used to define AO.[28] BMI (weight in kg divided by height in m^2) was calculated and classified according to WHO criteria: underweight = BMI <3rd percentile; normal weight = BMI between the 3rd and 85th percentiles; overweight = BMI between the 85th and 97th percentiles; and obesity = BMI >97th percentile.[30]

A BMI at or above the 85th percentile for adolescents was adopted to classify participants as either overweight/obese or underweight/normal, as this was widely used in similar epidemiological studies [4 11 12] and recommended by international organizations (e.g., WHO, Centers for Disease Control, and International Obesity Taskforce) to define obesity.[30 31 32] However, because there are clinical limitations in using BMI to estimate obesity in adolescent populations and the lack of a gold standard to define obesity, [33] we also reported other obesity indices including AO indicators (WC, WHtR, WHR) and %BF. This combination was critical to provide valid and reliable obesity estimates in our adolescent population.

Participants' %BF was measured using the Body Composition Analyzer (TANITA MC 780 multi-frequency segmental body composition analyzer). This device measured participants' body composition parameters by evaluating differences in impedance of body components (e.g., muscle and lean tissue).[34] Various body composition parameters are automatically calculated, including total body muscle and fat mass, total body water, total body fat and water ratios, muscle mass of the arms/legs, BMI, and basal metabolic rate. This technology has been shown to be valid and reliable.[34, 35] Standardized %BF cutoff ratios were used with 25% for boys and 30% for girls.[36]

Data analysis

We used RStudio Desktop 1.3.1093 for all statistical analyses, including mixed-effects logistic regression. Descriptive characteristics were calculated (frequency, percentage, mean, and standard deviation). Next, we compared differences in categorical sociodemographic variables by school type (private vs. public) using chi-square tests.

To address the clustering within schools, simple and multiple mixed-effects logistic regression analyses were conducted. The model included the random effect of schools using R package "lme4" [37] to determine the factors that predict obesity indicators (BMI, AO, and %BF). The factors that were assessed were sociodemographic variables, school type, physical activity, and F/V intake. Variables with a *p*-value ≤0.20 in the simple regression analysis were included in the multivariate regression model (gender, nationality, school type, F/V intake, and physical activity). Results of the mixed-effects multiple logistic regression models were expressed as odds ratios (ORs) with 95% CIs, and *p*-values less than 0.05 (two-sided) were considered statistically significant.

Ethics

Ethical approval to conduct this study was obtained from the University of Sharjah/Research Ethics Committee (REC/15/12/10) and the UAE Ministry of Health and Prevention (MOHAP REC-11). Parental consent was obtained for each student that agreed to participate.

RESULTS

Participants' characteristics and obesity-related indices

Table 1 presents participants' characteristics. Of the 1124 adolescents who were recruited and met the inclusion criteria, 932 participants had complete data (82.9% response rate): 434 (46.6%) attended private schools and 498 (53.4%) attended public schools Participants who had missing and incomplete data were eliminated from the analyses. The most common reason for not participating was lack of interest in this study.

Participants' average age was 15.8±1.43 years; 311 (33.4%) were males and 621 (66.6%) were females. The majority of the participants were UAE nationals (61.1%). More than two-thirds of participants' mothers were not employed (*n*=682, 73.2%) and the majority (60%) had an average family income (based on participants' self-report). Participants' mean F/V score was 3.1±1.83, with 504 (54.1%) reported having <5 F/V servings. The mean physical activity score was 2.3±0.71; 79.7% of participants were classified as inactive.

The prevalence rate of overweight/obesity was 34.7% (*n*=323) (BMI ≥85th percentile), and rates for AO were 47.3%, 22.7%, and 27.1% as evaluated by WC, WHR, and WHtR, respectively. Moreover, 378 (40.6%) participants had excess body fat as estimated by %BF using TANITA (M=27.6%, 12.0%) (Table 1).

Table 1. Characteristics of participating adolescents (*n*=932)

Characteristics	Frequency (%) or mean±SD
Gender	
Male	311 (33.4)
Female	621 (66.6)
Age (years)	15.8±1.4
Nationality	
UAE National	569 (61.1)
Non-UAE National	363 (38.9)
Type of school	
Public	498 (53.4)
Private	434 (46.6)

Mother's employment	
Employed	250 (26.8)
Unemployed	682 (73.2)
Economic status	
Below average	32 (3.4)
Average	559 (60)
Above average	341 (36.6)
F/V score	3.1±1.8
≥5 servings	428 (45.9)
<5 servings	504 (54.1)
PAQ-A	2.3±0.7
Active (mean score ≥2.75)	189 (20.3)
Inactive (mean score <2.75)	743 (79.7)
BMI (kg/m^2)	61.8±33.0
Underweight	79 (8. 4)
Normal	530 (56.9)
Overweight	158 (17.0)
Obese	165 (17.7)
WC (cm)	76.8±13.3
Normal	491 (52.7)
Abdominal obesity	441 (47. 3)
WHR (cm)	0.83±0.07
Normal	720 (77.3)
Abdominal obesity	212 (22.7)
WHtR (cm)	0.47±0.08
Normal	679 (72.9)
Abdominal obesity	253 (27.1)
%BF	27.6 ±12.0
Normal	554 (59.4)
Above normal (excess body fat)	378 (40.6)

Abbreviations: SD, standard deviation; F/V, fruits and vegetables intake score; PAQ-A, Physical Activity Questionnaire-Adolescents; BMI, body mass index; WC, waist circumference; WHR, waist to hip ratio; WHtR, waist to height ratio; %BF, body fat percentage.

Private versus public schools

Table 2 shows the associations between sociodemographic factors, lifestyle variables, and obesity-related indices by school type. Public schools had significantly more Emirati students compared with private schools that had more expatriate students (*p*=0.001). In addition, significantly more participants from public schools had an average family income as compared to private schools (75.1% vs 38.5%). However, above average income was significantly more prevalent in private school (61%) as compared to public school (18.9%) (*p*=0.001). There was no statistically significant difference in F/V score between participants from public and private schools, with more than half of the participants in each school group consuming <5 F/V servings per day (54.6% vs. 53.6%).

With regards to obesity indicators, significantly more participants attending public schools were overweight/obese (BMI ≥85th percentile) compared with those from private schools (37.8% vs. 31.1%) (*p*=0.001). Moreover, participants from public schools had significantly higher AO indicators than their counterparts from private schools, as estimated by WHtR (*p*=0.001), WC (*p*=0.028), and WHR (*p*=0.040) (Table 2).

Table 2. Comparisons between private and public schools (*n*=932)

	Public schools n (%), mean±SD (*n*=498, 53.4%)	Private schools n (%), mean±SD (*n*=434, 46.6%)	p-value[a]
Gender			0.694
Male	169 (33.9)	142 (32.7)	
Female	329 (66.1)	292 (67.3)	
Nationality			<0.001
UAE National	407 (81.7)	162 (37.3)	
Non-UAE National	91 (18.3)	272 (62.7)	
Mother's employment			0.123
Employed	144 (28.9)	106 (24.4)	
Unemployed	354 (71.1)	328 (75.6)	
Economic status			<0.001
Below average	30 (6.0)	2 (0.5)	
Average	374 (75.1)	167 (38.5)	

Above average	94 (18.9)	265 (61.0)	
F/V score	3.0±1.7	3.1±1.9	
≥5 servings	197 (45.4)	231 (46.4)	0.761
<5 servings	237 (54.6)	267 (53.6)	
PAQ-A score	2.2±0.70	2.2±0.6	
Active	403 (81)	340 (78.3)	0.320
Inactive	95 (19)	94 (21.7)	
BMI (kg/m2)			0.001
Underweight	44 (8.8)	35 (8.1)	
Normal	266 (53.4)	264 (60.8)	
Overweight	77 (15.5)	81 (18.7)	
Obese	111 (22.3)	54 (12.4)	
WC (cm)	78.5 ±15.0	74.80 ± 11.0	0.028
Normal	247 (49.6)	247 (57.0)	
Abdominal obesity	251 (50.4)	187 (43.0)	
WHR (cm)	0.83±0.07	0.83±0.06	
Normal	372 (74.7)	348 (80.2)	0.040
Abdominal obesity	126 (25.3)	86 (19.8)	
WHtR (cm)	0.48±0.08	0.46±0.06	
Normal	333 (66.9)	346 (79.7)	0.001
Abdominal obesity	165 (33.1)	88 (20.3)	
%BF	27.6±10.4	25.3±8.9	0.510
Normal	301 (60.4)	253(58.3)	
Above normal (excess fat)	197 (39.6)	181 (41.7)	

[a]P-values significant at <0.05 based on chi-square tests
Abbreviations: F/V, fruits and vegetables intake score; PAQ-A, Physical Activity Questionnaire-Adolescents; BMI, body mass index; WC, waist circumference; WHR, waist to hip ratio; WHtR, waist to height ratio; %BF, body fat percentage

Predictors of overweight/obesity: BMI, AO, and %BF

Table 3 presents the results of the mixed-effects multiple logistic regression analysis with the random effect of schools. Predictors of being overweight/obese (based on BMI) were: being male (adjusted OR [AOR] 3.35, 95% CI: 2.20, 5.10), consuming <5 servings of F/V (AOR 2.41, 95% CI: 1.73, 3.36), and being physically inactive (AOR 2.09, CI: 1.36, 3.22).

Students in public schools had significantly higher odds of AO based on WHR than those in private schools (AOR 1.67, 95% CI: 1.06, 2.66). However, compared with expatriates, Emirati students were significantly less likely to have AO (WHR: AOR 0.62, 95% CI: 0.43, 0.90) and a high %BF (AOR 0.54, 95% CI: 0.30, 0.98). Male participants had a significantly higher odds of AO based on WC (AOR 1.42, 95% CI: 1.01, 2.00) and WHtR (AOR 2.72, 95% CI: 1.81, 4.08) compared with female participants. However, males had significantly lower odds of high %BF than females (AOR 0.19, 95% CI: 0.12, 0.33). Compared with ≥5 F/V servings per day, <5 F/V servings was associated with significantly higher odds of AO based on WC (AOR 1.71, 95% CI: 1.27, 2.30) and WHtR (AOR 1.46, 95% CI: 1.05, 2.03). Furthermore, participants who were physically inactive had a significantly higher odds of AO based on WC (AOR 1.63, 95% CI: 1.33, 2.35) compared with those who were physically active (Table 3).

Table 3. Determinants of overweight/obesity based on body mass index, abdominal obesity indicators, and total body fat percentage using mixed-effects[a] multiple logistic regression (*n*=932)

Dependent variable ⇨	BMI Overweight/obese	Elevated WC	Elevated WHR	Elevated WHtR	High %BF
Independent variable ⇩	AOR [95% CI]	AOR [95% CI]	AOR [95% CI]	AOR [95% CI]	AOR [95% CI]
Gender					
Female[b]					
Male	**3.35 [2.20, 5.10]**	**1.42 [1.01, 2.00]**	1.20 [0.85, 1.71]	**2.72 [1.81, 4.08]**	**0.19 [0.12, 0.33]**
School					
Private[b]					
Public	0.60 [0.19, 1.91]	1.07 [0.51, 2.26]	**1.67 [1.06, 2.66]**	1.34 [0.58, 3.09]	0.52 [0.01, 26.91]
Nationality					
Expatriate[b]					
Emirati	1.19 [0.81, 1.75]	0.74 [0.52, 1.04]	**0.62 [0.43, 0.90]**	0.85 [0.57, 1.26]	**0.54 [0.30, 0.98]**
F/V serving					

≥5[b]					
<5	**2.41 [1.73, 3.36]**	**1.71 [1.27, 2.30]**	1.09 [0.79, 1.50]	**1.46 [1.05, 2.03]**	1.27 [0.78, 2.09]
PAQ-A					
Active[b]					
Inactive	**2.09 [1.36, 3.22]**	**1.63 [1.13, 2.35]**	0.99 [0.67, 1.48]	1.41 [0.92, 2.17]	1.31 [0.76, 2.27]

Abbreviations: AOR=adjusted odds ratio; CI=confidence interval; F/V=fruits and vegetables intake score; PAQ-A=Physical Activity Questionnaire-Adolescents; WC=waist circumference; WHR=waist to hip ratio; WHTR=waist to height ratio; %BF= percentage body fat.
[a]With the random effect of schools in the mixed-effects logistic regression; [b]Reference category.
Numbers in bold are statistically significant (p<0.05).

DISCUSSION

This study presents new information regarding the epidemiology and determinants of overweight/obesity among UAE school-aged adolescents. We found a considerably high prevalence of overweight/obesity among participants (34.7%), which supported previous UAE-based epidemiological studies that used BMI to define obesity.[4 11 12] The prevalence rates of overweight/obesity observed in our study was also consistent with studies from other Arab countries that used BMI to classify obesity, including Saudi Arabia (39%),[38] Kuwait (44.3%),[39] Lebanon (32.2%),[40] and Egypt (35%).[41] Conversely, studies conducted in Western countries reported lower obesity rates compared with our study. For example, the obesity rate among adolescents in European countries was between 22%–25%, with the rate for Italy[42] being 23.3% (either overweight or obese) and rates for Greece being 19.1% (overweight) and 3.2% (obesity).[43] In the US, 30% of adolescents were overweight/obese.[44]

In the present study, we also investigated other obesity indicators using AO indices. A concerning finding in our study was that AO indicators were high (WC 47.4%, WHR 22.8%, and WHtR 27.2%). Visceral adiposity (as measured by WC, WHR, and WHtR) is associated with an increased risk for earlier onset of metabolic disorders, and obesity-related morbidity and mortality.[3 8] There are variations in the literature on indices and values used to define AO in adolescents. For example, El-Kassas and Ziade [40] reported central obesity rates as evaluated by WC (41.8%) and WHtR (38.3%), whereas Al Hazza et al.[38] reported abdominal obesity using WHtR (35.9% for adolescent males and 30.3% for females). Abolfotouh et al.[41] reported lower AO rates among Egyptian adolescents using WHR (16.1%), WC (4.5%), and WHtR (16.7%). These variations may be attributable to geographical location, genetic compositions, and differing lifestyles, along with different cut-off values for interpreting AO results.

We found that the majority of the participating adolescents showed low physical activity levels (79.7%) and more than half (54.1%) had low F/V consumption (<5 servings). A recent study in UAE reported that only around 28% of Emirati adolescents had the recommended daily F/V intake.[45] As for the low levels of physical activity, our finding was consistent with a global estimate from the WHO that 81% of those aged 11−17 years did not meet daily physical activity recommendations.[46] It is noteworthy that physical inactivity and low F/V consumption in adolescence may persist throughout adulthood, which will increase the risk for chronic lifelong diseases later in life.[45 46]

Obesity in public versus private schools

Interestingly, we found a higher prevalence of obesity in adolescents from public schools than among adolescents from private schools (as measured by BMI). Differences in obesity rates between private and public schools have been reported in different countries in studies that used BMI. Similar to our findings, a study examining obesity rates among students in Palermo reported more public school students were overweight/obese compared with private school students (age 13 years: 40.8% vs. 34.5%; age 15 years: 36.7% vs. 30.2%).[13] However, other studies have reported contrasting findings. For example, a study in Kenya found that overweight/obesity rates were significantly higher (29.0%) among private school children than those from public schools (11.5%).[16] Similar trends of higher obesity rates in private schools compared with public schools were also observed in studies from India,[17] Pakistan,[15] and Saudi Arabia.[38] A possible explanation for the inconsistent findings related to obesity rates between private and public schools could be differences in sociodemographic, environmental and cultural factors of attending students. For example, in the UAE, public schools are mostly attended by Emirati/national students whereas private schools are mainly attended by expatriates.[19] Therefore, different eating habits among cultures could contribute to these findings. Furthermore, offering unhealthy items in vending machines, poor communication between food suppliers and school personnel, and limited physical activity facilities at schools may be correlated with body weight in adolescents.[47]

Similarly, in our study, public school students had significantly higher AO indicators (WC, WHR, WHtR) than private school students, which were consistent with our results for BMI values. Most previous UAE-based studies reported BMI rates and did not examine these obesity indicators. Similarly, many other studies that compared private and public schools in various countries did not compare AO indicators.[13 16 17 18] Accordingly, our results align with the recommendation from several previous research suggesting that in addition to BMI, other anthropometric measurements should be included as indicators of obesity when screening adolescents in schools (e.g., WC, WHC, and WHtR).[28 33]

Interestingly, we found no significant difference between private and public schools in F/V consumption, with participants from both schools consuming less than the recommended number of daily F/V servings. This finding was inconsistent with previous comparative studies in which participants from public schools were found to consume less F/V compared with participants from private schools. For example, a school-based study from Ethiopia reported private school adolescents consumed significantly more F/V compared with their public school counterparts.[48] Similarly, a Brazilian study among school children aged 10–12 years (151 from public schools, 55 from private schools) showed public school participants had less F/V consumption than those from private schools.[49] A recent mixed methods study from the UAE in which the majority of the sample was from public schools (24 public, 10 private) reported that only 28% of participants (n=620) met the WHO recommended daily F/V intake.[45]

Low consumption of F/V among school-aged adolescents is a common problem in different regions around the world.[46] Despite governmental guidance regarding adoption of a unified school nutritional policy across all schools in the UAE, there is no mechanism to encourage students to increase F/V consumption, and no monitoring mechanism to control types of food offered at school canteens. Examining environmental factors in both private and public schools (e.g., types of snacks, beverages, and content of students' lunch boxes) is recommended to better understand factors that contribute to the low F/V consumption among adolescents.

In our study, variations were noted in sociodemographic factors, nationality, and economic status between participants from private and public schools. These personal factors could play an important role in determining obesity rates in adolescents,[42 45 50] and therefore warrant further attention. Understanding the differences between private and public schools and the sociodemographic structure among adolescents is essential to build focused interventions that overcome barriers to healthy choices, especially in public schools that demonstrated increased obesity rate.

Determinants of obesity in participants

Physical activity and F/V intake were significant determinants of overweight/obesity, and showed independent relationships with different obesity indicators including BMI and AO (WC) after adjustment for all other variables in the model. Other studies have also shown that low levels of physical activity and unhealthy dietary practices predicted obesity among adolescents.[5] Rapid urbanization and lifestyle changes in the UAE have increased exposure to fast/processed foods, sedentary lifestyle along with reduced F/V consumption and less physical activity.[3 13 17] Adolescents tend to spend most of their time playing computer games, doing homework and similar activities instead of spending time on exercise and sports.[45] Therefore, promoting healthy lifestyles for adolescents is a public health priority as the WHO recommends at least 60 minutes of moderate-to-vigorous physical activity each day, and a dietary intake of at least 400 grams of F/V each day (roughly equivalent to five servings of F/V per day).[51] Therefore, there is a need to enforce school policies that motivate adolescents to consume the recommended intake of F/V and engage in physical activities for better health outcomes. In the school environment, guidelines for food consumption inside schools, canteen food menus, and diet and exercise self-efficacy must be explored in future studies.[5 45]

Considering gender differences should also be highlighted, as male participants in our study were more likely to have higher BMI and AO (above normal WC and WHtR) and less likely to have high %BF compared with female participants. These findings were consistent with previous studies.[52, 53] For example, significantly higher AO (measured by WHR and WC) was reported in adolescent boys compared with girls in Poland.[52] A cross sectional, school-based study from China involving 830 boys and 796 girls aged 7–16 years showed that more boys were obese (based on BMI: 15.2% vs. 6.9%) and boys had more central obesity (based on WC: 27.4% vs. 11.7%) compared with girls.[53] Similarly, a study from Brazil involving adolescents from private and public schools showed boys had significantly higher BMI and AO (measured by WC) than girls.[54] Focused nutritional and physical activity programs that reflect differences in lifestyles and perceptions of overweight and obesity among male adolescents are needed to promote better health outcomes.[53] Addressing this issue should involve multiple approaches targeting behavior change (e.g., food labeling, planning "exercise-friendly" cities).

Consistent with previous findings,[14] our study showed adolescents in public schools were more likely to have AO (based on WHR) compared with those in private schools. AO has been associated with visceral fat mass, higher blood pressure, and cardiovascular risk factor clustering, and should be measured along with BMI.[53 54] Among adolescents in Poland (141 boys and 168 girls aged 16–18 years), AO (WC, WHR, WHTR) was associated with family environment and modifiable lifestyle factors.[52] In our study, school type predicted WHR but not other important obesity indicators (e.g., BMI), AO indicators (WC, WHtR), and %BF. Therefore, our results regarding the effect of school type on obesity should be interpreted with caution. It is necessary to further investigate school environmental factors that could affect obesity in adolescents that consider obesity indicators in addition to BMI (e.g., AO and %BF). Unlike many other countries, adolescents in the UAE come from diverse ethnic backgrounds; therefore, it is essential to investigate the possible contributions of lifestyle factors and parental and cultural practices to obesity.

In our study, being Emirati was associated with lower odds of AO (based on WHR) and high %BF compared with expatriates after adjusting for all other factors. These results need further verification as we did not collect information on participants' genetic composition, which could explain the differences observed between Emirati and non-Emirati adolescents who have diverse ethnic backgrounds. Such an investigation could also include all obesity indicators that were considered in this study (BMI, AO, %BF). This comprehensive research could provide evidence to support policy makers in their efforts to develop targeted interventions to combat the impact of obesity and its sequelae on health and well-being among adolescents.

The results from the present study concerning the high obesity prevalence and its determinants confirm the need for a strong and unified policy that considers students' diverse sociodemographic characteristics, school type and environment, and educational polices when initiating campaigns to combat obesity. Government health campaign interventions and strategies must be established at the federal level to support schools to identify overweight and obese adolescents and increase their awareness about the negative impact of obesity on health outcomes in adolescents.[5 45] A unified and collaborative health promotion model is needed where UAE health officials, teachers, parents, students, and social media are involved as early as possible.[5 51 46] Furthermore, it is recommended that a surveillance system for obesity indicators for UAE adolescents is implemented to monitor the effectiveness of policies aiming to counteract obesity in this population.

Strengths and limitations

Our study is among the first in the UAE to provide valid estimates of obesity by considering BMI, AO indicators, and %BF. This study highlights the urgent need to screen for obesity in our schools and emphasizes the importance of health promotion campaigns and practices, especially in public schools. Further, the present findings focus on the importance of considering F/V intake and physical activity among adolescents as important predictors of obesity, which can be used to inform the direction of public health policy geared toward improving lifestyle of adolescents.

Many males in higher secondary education move to vocational and technical schools to build their skills, meaning fewer males stay in secondary schools.[19] This trend was reflected in this study where there were fewer male participants than female participants. This limits the generalizability of the study findings. Furthermore, we expected to recruit more adolescents from private schools we as invited more private schools to participate; however, fewer private school participants were recruited for this study. This might be attributable to limited access given by school administration to classes in the private schools cluster. Additional genetic, family, dietary pattern, stress, and social factors should be examined in future studies to provide a comprehensive picture of the determinants of obesity in adolescents.

Despite the use of multiple obesity indices in this study to provide a valid picture of obesity among the UAE adolescent population, we used international cutoff points to classify participants into overweight/obese and normal/underweight groups. Given the overwhelming health risks associated with obesity in adolescents, there is an urgent need for a standardized definition of obesity in adolescents so that trends can be monitored and comparisons made between adolescents of different ethnic groups. Subsequently, established gold standards can be used to determine obese adolescents in clinical practice as well as in relevant epidemiological studies.

CONCLUSIONS

Our study showed a high prevalence rate of overweight/obesity among school-aged adolescents in the UAE (as measured by BMI), which confirms that obesity remains a widespread problem in UAE schools. This study underscores the importance of early screening of AO indicators (WHtR, WC, and %BF) in the routine assessment of adolescents in addition to BMI, because AO is associated with high blood pressure, metabolic syndrome, and cardiometabolic risks. It is also necessary to promote healthier lifestyles (e.g., healthy eating by increasing F/V intake and increased physical activity) among children and adolescents to help curb obesity trends and prevent the development of chronic diseases. Additional studies are needed to observe the changes in obesity rates necessary to achieve the UAE Vision 2021 National Agenda of a world-class healthcare system by reducing the prevalence of obesity among children to support a healthy population in our schools.

Finally, obesity in adolescents is multifactorial; therefore, further research is needed to examine the contributions of modifiable and non-modifiable risk factors to obesity among adolescents in different cultures. Future research should establish cutoff values for different obesity indicators to yield better screening and diagnosis of obesity among adolescents.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

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Ethical Considerations Ethical approval to conduct this study was obtained from the Research Ethics Committee of the principal investigator's institution, the UAE Ministry of Health and Prevention, and the UAE Ministry of Education. Parental consent was obtained for each student that agreed to participate in this study.

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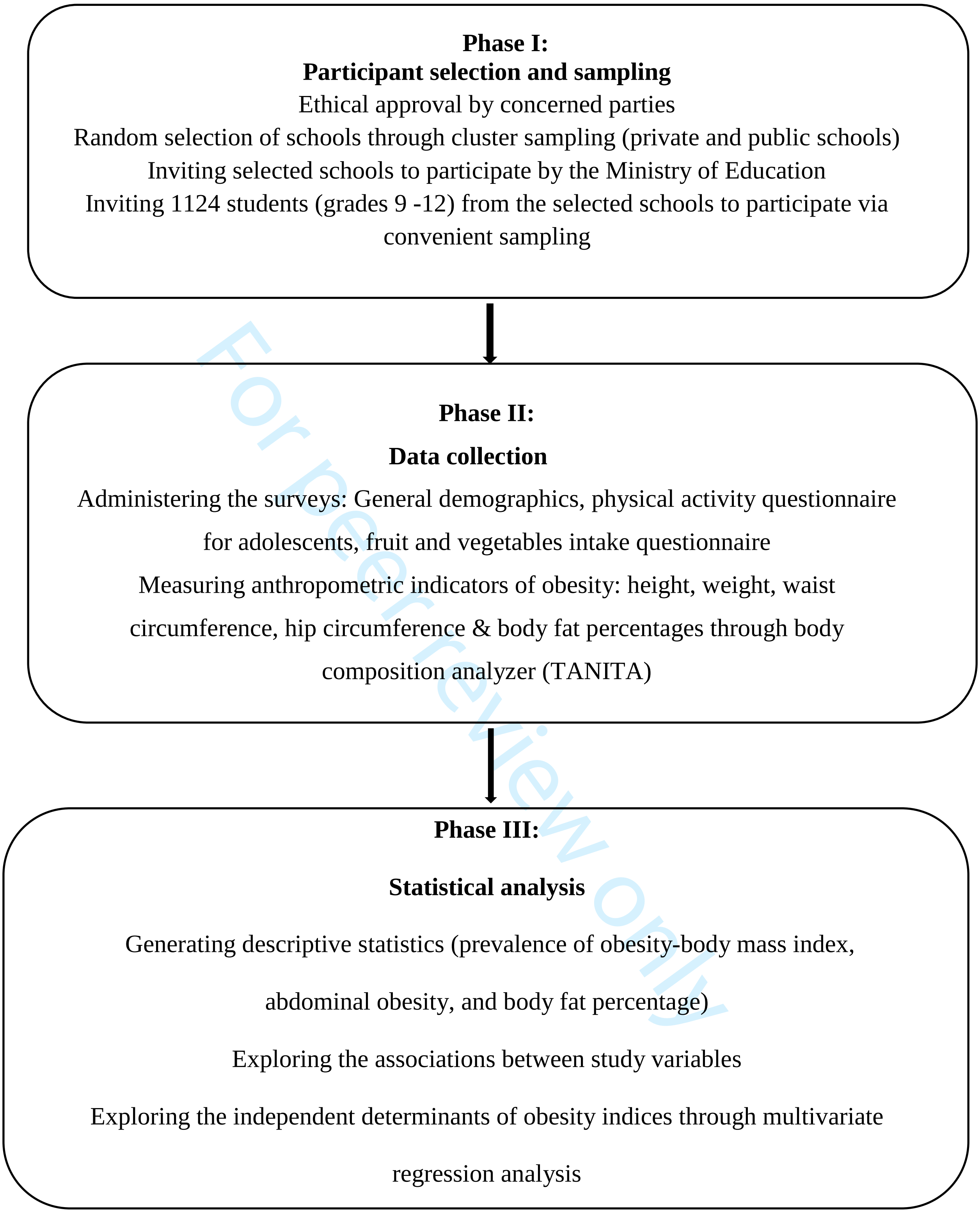

Figure 1 Flow diagram of data collection process and analysis

STROBE Statement—checklist of items that should be included in reports of observational studies

Prevalence and determinants of overweight/obesity among school-aged adolescents in the United Arab Emirates: A cross sectional study of private and public schools

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1	See title page and abstract Prevalence and determinants of overweight/obesity among school-aged adolescents in the United Arab Emirates: A cross sectional study of private and public schools
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3	See abstract section
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-7	See background section
Objectives	3	State specific objectives, including any prespecified hypotheses	7	In this study, we explored the epidemiology of overweight and obesity in the total population and compared obesity figures between private and public schools. We also aimed to determine factors that contributed to overweight and obesity in participants including sociodemographic factors (sex, age, nationality, parents' employment and socioeconomic status); school type (public vs. private); and lifestyle factors (F/V consumption, physical activity levels).
Methods				
Study design	4	Present key elements of study design early in the paper	7	We adopted a quantitative correlational design
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-8	See subjects and methods
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up		

		Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	8	
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	Not relevant	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9-11	See measurement section (page 9-10), also data analysis section (page 11)
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*9-10*	Full descriptions of all variables measured provided –under measurement section
Bias	9	Describe any efforts to address potential sources of bias	8-9, 11	We used trained research assistants The same research team collected the data Random selection of school through cluster sampling Multivariate logistic regression (page 11)
Study size	10	Explain how the study size was arrived at	8	See last paragraph of participants and samples

Continued on next page

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11	Data analysis section
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11	Data analysis section
		(*b*) Describe any methods used to examine subgroups and interactions		
		(*c*) Explain how missing data were addressed	11	Results section, paragraph 1 Missing and incomplete data were eliminated from the analyses.
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	11	
		(*e*) Describe any sensitivity analyses	NA	
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11	Results section, paragraph 1
		(b) Give reasons for non-participation at each stage	11	Results section, paragraph 1
		(c) Consider use of a flow diagram	Included as separate file (available online)	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11-12	Participants' characteristics and obesity-related indices Table 1
		(b) Indicate number of participants with missing data for each variable of interest	*NA*	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	*NA*	

Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	*NA*	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	*NA*	
		Cross-sectional study—Report numbers of outcome events or summary measures	11-17	Results section
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-17	Results section
		(*b*) Report category boundaries when continuous variables were categorized	11-17	Results section
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA	

Continued on next page

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA	
Discussion				
Key results	18	Summarise key results with reference to study objectives	16-20	Discussion section
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	21	See strengths limitation section
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	21	See strengths limitation section
Generalisability	21	Discuss the generalisability (external validity) of the study results	21	See strengths limitation section
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	21	This research was funded by the University of Sharjah/Research Institute for Medical and Health Sciences\ Health Promotion Research Group (Grant number 150310)

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.