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Time Trends of Overweight and Obesity Among Schoolchildren in Kuwait Over a 13-Year Period (2007-2019): Repeated Cross-Sectional Study

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Time-trends of overweight and obesity among schoolchildren in Kuwait over a 13-year period (2007–2019): repeated cross-sectional study

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Ethical Standards Disclosure: This study was conducted according to the guidelines laid down in the Declaration of Helsinki. The study was a secondary data analysis of completely anonymous data collected by Kuwait Nutritional Surveillance System (KNSS). All procedures of KNSS were approved by the Ethics Committee at the Ministry of Health in Kuwait (No. 98). Because KNSS is a public health activity, measuring weight and height of schoolchildren does not require parental informed consent according to the research regulations in Kuwait.

Abstract:

Objectives: This study aimed to examine age-specific trends in the prevalence of overweight and obesity in schoolchildren in Kuwait over a 13-year period (2007 to 2019) using the World Health Organization (WHO), the Centers for Disease Control and Prevention (CDC) and the International Obesity Taskforce (IOTF) definitions.

Design: Using cross-sectional approach, Kuwait Nutrition Surveillance System (KNSS) objectively measured weight and height of schoolchildren over a 13-year period. Log-binomial regression models were used to examine age-specific trends of obesity and overweight over the study period.

Setting: Public primary, middle, and high schools in all provinces of Kuwait.

Participants: Schoolchildren aged 5-19 years (N 172 603)

Results: According to the WHO definition, the prevalence of overweight and obesity in schoolchildren respectively increased from 17.73% and 21.37% in 2007 to 20.19% and 28.39% in 2019 (P for trends < 0.001). There is evidence that the obesity in females (but not males) has levelled off in the period 2014-2019 according to the three definitions of obesity, which is corroborated by a similar trend in the mean of BMI-for-age Z score.

Conclusion: The prevalence of obesity and overweight in schoolchildren in Kuwait has risen over the last 13 years and trends are similar across all definitions. Obesity is no longer increasing at the same pace and there is evidence that the prevalence of obesity in females has plateaued. The current level of childhood overweight and obesity is too high and requires community-based and school-based interventions.

Keywords: Obesity, Overweight, Children, Middle East, Kuwait, trends

Introduction:

Childhood obesity remains one of the most important public health issues globally. Despite decades of efforts to control its prevalence, childhood obesity continues to cause immediate and long-term adverse health consequences^(1, 2). In the short term, children with overweight or obesity are more likely to suffer from asthma^(3, 4), fatty liver disease⁽⁵⁾, systemic inflammation^(6, 7) musculoskeletal disorders⁽⁸⁾, higher metabolic and cardiovascular risk^(9, 10), including high blood pressure^(11, 12), and type 2 diabetes^(13, 14) in addition to several psychological issues such as depression^(15, 16), anxiety⁽¹⁷⁾, low self-esteem⁽¹⁸⁾, and low academic and cognitive performance^(18, 19). Long-term complications of childhood obesity may include increased risk of developing cardiovascular diseases^(20, 21), type 2 diabetes⁽²²⁻²⁴⁾, some cancers^(25, 26), physical disability^(27, 28) and premature death⁽²⁹⁻³¹⁾. Furthermore, children with overweight or obesity are more likely to have overweight or obesity in adulthood compared to their normal weight peers⁽³²⁻³⁴⁾. Against this background, obesity should be prevented at the earliest possible stage of life to mitigate the risk of many diseases in childhood and adulthood, particularly with the low efficacy of the available treatments^(35, 36).

As per the comprehensive plan for Maternal, Infant and Young Child Nutrition, the World Health Organization (WHO) aims to have zero increase in childhood overweight by 2025⁽³⁷⁾, which is consistent with the other target for obesity and type 2 diabetes between 2010 and 2025 in the ‘WHO Global Action Plan for the Prevention and Control of Non-communicable Diseases 2013–2020’^(38, 39). Assessing the progress on these targets requires data on the trends of obesity and overweight, which is critical for policy development⁽⁴⁰⁾. Although the data on recent trends of childhood obesity are available from Europe, North America, Australia and China, there is a lack of data on secular trends of childhood obesity from the rest of the world, particularly in the Middle East. When data do exist from the Middle East region, it is usually based on literature reviews of individual methodologically heterogeneous studies⁽⁴¹⁻⁴⁶⁾ providing contradictory findings. The only exception is a new report from Iran where the authors examined the trends of waist-to-height ratio in children between 2003 and 2015, demonstrating an increasing trend of the prevalence of abdominal obesity in Iranian children⁽⁴⁷⁾.

Prevalence of obesity has increased substantially in children and adolescents around the world⁽²⁾ but recently, there has been some flattening of trends or probably a reduction in the prevalence of childhood obesity, particularly among children with high socioeconomic status in high-income countries^(2, 48, 49) such as the USA^(50, 51), Canada⁽⁵²⁾, Spain⁽⁵³⁾, Australia⁽⁵⁴⁾, Germany⁽⁵⁵⁾, France^(56, 57), Netherlands⁽⁵⁸⁾, Switzerland⁽⁵⁹⁾ and Sweden⁽⁶⁰⁾. However, there is paucity of data on the recent trends of childhood obesity in Middle Eastern settings, particularly in the oil-rich Arab states in the Gulf region, where the socioeconomic status has improved materially during the last few decades with strong shift towards an obesogenic environment including high energy density foods coupled with low physical activity⁽⁶¹⁾. In these settings, several individual studies have estimated the point prevalence of childhood obesity in various age groups at different points in time and there is a general consensus that the prevalence of childhood obesity is similar to or higher than that in high-income countries in North America or Europe. In Kuwait, for example, it has been reported that 21.6% and 30.5% of schoolchildren have overweight or obesity, respectively⁽⁶²⁾. In a recent study, 42% of female university students had obesity based on their Body Mass Index (BMI) and 62% had excessive fatness as measured by bioelectric impedance analysis⁽⁶³⁾. However, it is not clear whether the weight status of children and adolescents are stabilizing, particularly in school aged children 5-19 years, among which the obesity had increased globally more rapidly between 1975 and 2016 compared to younger preschool children⁽³⁵⁾.

For over a decade, Kuwait Nutrition Surveillance System (KNSS) objectively measured the weight and height of thousands of schoolchildren (5-19 years) annually using standardized protocol. This provides a unique opportunity to examine recent trends of obesity in schoolchildren in Kuwait over several years and to compare them to that reported from other high-income countries. This study used individual data records collected over a 13-year period (2007-2019) by KNSS to, for the first time, examine age-specific trends in the prevalence of childhood obesity in schoolchildren in Kuwait based on BMI using various definitions of childhood obesity including the WHO⁽⁶⁴⁾, the Centers for Disease Control and Prevention (CDC)⁽⁶⁵⁾, and the International Obesity Taskforce (IOTF)^(66, 67).

Methods:

Study site and KNSS:

Kuwait is a small country with a population of 4.7 million with approximately 25% of its population under the age of 19 years. School enrolment is extremely high for both males and females ⁽⁶⁸⁾, with around 25% of students enrolled in private schools. Unlike private schools, public schools are single-sex schools at all levels with total number of students approximately 476 000. There is no clearly recognized race or ethnic classification of the population of Kuwait.

KNSS is a public health activity funded by the government to collect data on the nutritional status of the population by trained data collectors who are employed on a long-term basis for this purpose. The aim of KNSS is to provide nationwide information on the trends of nutritional status on all age groups over time. KNSS is mainly a repeated cross-sectional study that collect data using separate data collection forms on children ≤ 24 months, children > 2 years to < 5 years, schoolchildren (5-19 years) and adults. In 2014, KNSS was reviewed, and all data collection forms were updated except for schoolchildren (More details on KNSS have been published before ⁽⁶⁹⁾). In this age group, only anthropometric measures are conducted with no other data are collected on socioeconomic status, dietary habits, or physical activity. Such data are collected by a different department using global school-based student health survey (GSHS) questionnaire ⁽⁷⁰⁾. Unlike KNSS, weight and height of schoolchildren in GSHS are self-reported. KNSS includes children aged 5-19 years from public primary, middle and high schools in all governorates (provinces) of Kuwait. In each governorate, at least one school for males and one school for females is randomly selected from each primary, middle, and high schools making sure the same school is not selected in two consecutive years. For the current analysis, KNSS data from 2007 to 2019 were used.

Data collection and measurement of weight and height:

Body weight was measured to the nearest 0.1 kg using calibrated digital scales (SECA[®]) without shoes or heavy clothing. Height was measured to the nearest 0.1 cm using a stadiometer (SECA[®]) with full extended knees and shoes off. Sex and date of birth were extracted from the school records. Data on socioeconomic factors, diet or physical activity were not collected at any point in time.

Statistical methods:

Body mass index (BMI) was calculated by dividing the weight in kilograms by squared height in meters. Age was calculated in days by subtracting the date of birth from the date of data collection and then converted into years. First, BMI-for-age Z scores were calculated according to the WHO growth reference curves⁽⁶⁴⁾, and then overweight was defined as >1 standard deviation (SD) but ≤ 2 SD of the WHO growth reference median, while obesity was defined as >2 SD of the WHO growth reference median. Second, BMI-for-age Z scores were calculated according to the CDC growth reference curves⁽⁶⁵⁾, which were turned into percentiles, and the overweight and obesity were defined as ≥ 85 th percentiles and ≥ 95 th percentiles, respectively. Third, the calculated BMI was categorized according to the IOTF definition^(66,67). Unlike WHO definition that uses arbitrarily chosen cut-off points, IOTF definition uses smooth sex-specific BMI curves, constructed to match the values of 25 kg/m^2 (to define overweight) and 30 kg/m^2 (to define obesity) at the age of 18 years. The three definitions of overweight and obesity were used to facilitate international comparisons and to help create a pool of studies that allows developing algorithm that converts the prevalence of overweight and obesity from one definition to another. In this article, the term “overweight” does not include obesity unless stated otherwise.

The age-specific prevalence (95% Confidence Intervals [95% CIs]) of obesity and overweight (including obesity) was plotted using the three definitions of obesity in children over the study period while stratifying by sex. Moreover, the overall and the age-specific mean BMI-for-age of Z scores calculated from the WHO reference curves and their 95% CIs were plotted over years of study while stratifying by sex. With the large number of observations, the regular scatterplot which plots every data point became too crowded to interpret visually, therefore, binned scatterplots was used controlling for age and stratifying by sex generated by STATA command “binscatter” to graphically present the change in the mean BMI-for-age Z score over the study period.

The analysis started by calculating the odds of obesity and overweight (including obesity) over the study period while stratify by sex and adjusting for age. Three separate analyses according to the three definitions of overweight and obesity were conducted to investigate the trends in obesity and overweight (including obesity) over the study period using log-binomial regression models. In this analysis, the prevalence ratio for obesity was estimated while adjusting for age

and stratifying by sex fitting the main independent variable (year of measurement 2007 to 2019) as a continuous variable. In this analysis, a quadratic time (year of study) term was fitted to assess nonlinearity, which was found to be significant. STATA 14.2⁽⁷¹⁾ was used to fit models with both linear and quadratic time terms with obesity (yes=1, no=0) as well as overweight (including obesity) as the binary dependent variables. In these models, the standard error was calculated while taking the clustering effect into account using the variance–covariance matrix (vce) option in STATA. Guided by this analysis, aggregated data were used in NCI's Joinpoint software⁽⁷²⁾ to identify the location of joinpoints for each age group and sex as per the guidelines⁽⁷³⁾. In this analysis, the proportions were calculated within the joinpoint software with all other settings according to the Joinpoint software default. The joinpoints were also investigated using hockey stick regression method using STATA command “*loghockey*”.

Results:

Of all data records, 392 records were excluded because BMI-for-age Z scores were biologically implausible (BMI-for-age Z score < -5 or BMI-for-age Z scores > +5). The total number of schoolchildren included in this analysis was 172 603 of which 85 764 (49.69%) were females. Table 1 shows the distribution of the study participants by age and year of study. The crude prevalence of overweight and obesity over the entire 13-year study period was 19.86% (95%CI:19.15-20.61%) and 25.63% (95%CI:23.20-28.23%), respectively according to the WHO definition, 16.06% (95%CI:15.35-16.81%) and 25.01% (95%CI: 22.62-27.56%), respectively according to the CDC definition, and 20.57% (95%CI: 19.59-21.59%) and 19.59% (95%CI:17.53-21.83%), respectively according to the IOTF definition.

Trends in the prevalence of overweight and obesity in schoolchildren:

According to the WHO definition, the prevalence of overweight and obesity respectively increased from 17.73% and 21.37% in 2007 to 20.19% and 28.39% in 2019 (*P* for trends in odds of each overweight and obesity <0.001). This remained evident while stratifying by sex and adjusting for age. Table 2 shows the prevalence of overweight and obesity by sex and year of data collection during the study period. Supplementary Table (S1) and Table (S2) show the prevalence of overweight and obesity by sex and year according to the CDC definition and the IOTF definition, respectively.

Figure (1) shows the prevalence of obesity and overweight (including obesity) and their 95% CIs over the 13-year period according to the WHO, the CDC and the IOTF definitions among males, females and both sexes. The age-specific prevalence of obesity and overweight (including obesity) and their 95% CIs over the 13-year study period stratified by sex are shown in the supplementary material according to the WHO definition (Figure (S1a) and Figure (S1b)), the CDC definition (Figure (S2a) and Figure (S2b)), and the IOTF definition (Figure (S3a) and Figure (S3b)). All figures clearly indicate that the prevalence of obesity generally increased over the 13-year study period and the trend have slowed down in later years.

The analysis of trends in the prevalence of obesity and overweight (including obesity) in schoolchildren (5-19 years) between 2007 and 2019 after adjusting for age and stratification by sex are shown in Table 3. This analysis confirmed that the prevalence of obesity and overweight (including obesity) increased over the study period according to the WHO, the CDC and the IOTF definitions. To investigate whether the prevalence of obesity and overweight (including obesity) started to level off (nonlinearity), we fitted a quadratic term of the explanatory variable (years of the study) in addition to the linear term. This was statistically significant in the model indicating that the trend is nonlinear. Guided by this and the Figure (1), we conducted a joinpoint analysis to search for one joinpoint around which the increase of obesity has abated. We found one joinpoint around 2013 for both sexes, which was confirmed using hockey stick regression analysis. To investigate this further we omitted data from 2013 and another joinpoint emerged around 2010. Then, we examined the trends before and after 2013 while stratifying the analysis by sex and adjusting for age (data not shown). This analysis confirmed that in males, there was a significant upward trend in the prevalence of obesity and overweight (including obesity) before and after 2013. In females, significant upward trend in the prevalence of overweight (including obesity) before and after 2013 was found, but no significant trend was found after 2013 in the prevalence of obesity, which suggest that the prevalence of obesity may have stabilized in females. These findings remain the same when the analysis was repeated using the CDC and the IOTF definitions.

Trends in the BMI-for-age Z score in schoolchildren:

The mean BMI-for-age Z scores and their 95% CIs calculated from the WHO reference curves over the 13-year study period in males and females and both sexes are shown in Figure (2).

Supplementary Figure (S4a) and Figure (S4b) show the age-specific mean BMI-for-age Z scores over the study period in males and females, respectively. Figure (3) shows the bin scatter of BMI-for-age Z score over the study period after controlling for age while fitting regression line with quadratic time term. All figures showed an increased in the mean BMI-for-age Z score during the 13-year study period in a pattern consistent with the increase of the prevalence of obesity and overweight demonstrated above.

Discussion:

For the first time, using individual data records of thousands of children, this study examined the age-specific trends in the prevalence of overweight and obesity in male and female schoolchildren aged 5-19 years in Kuwait, an oil-rich country in the Middle East that represents a group of countries in that region where an obesogenic environment has expanded for years⁽⁶¹⁾. Overall, the prevalence of overweight and obesity in schoolchildren (5-19 years) has risen over the past 13 years in Kuwait and that it has recently started to level off in females. These findings are extremely important because there is little data on trends of childhood obesity from Middle Eastern settings except for few literature reviews of methodologically heterogeneous studies that show contradictory findings⁽⁴¹⁻⁴⁶⁾.

There was an increase in the prevalence of childhood obesity as well as overweight (including obesity) in Kuwait according to the three definitions of childhood obesity and overweight (WHO, CDC and IOTF). At the end of the study period in 2019, the prevalence of obesity and overweight was 20.19% and 28.39%, respectively, which is similar to that in Italy⁽⁷⁴⁾ but higher than that reported in several high-income countries^(59,75). In fact, a recent literature review of obesity in schoolchildren at a global level has identified Kuwait as having the highest prevalence of obesity and overweight in Middle East and North Africa (MENA) region⁽³⁵⁾. Over the last few decades, high oil revenue has contributed to substantial improvement in the standard of living for citizens that includes highly subsidized foods. Exclusive breastfeeding during the first six months of birth, which has been linked to lower obesity rates during adolescence⁽⁷⁶⁾, is also low; and the government provides highly subsidized formula-milk⁽⁶⁹⁾. GSHS data suggest that more than 62% of schoolchildren spend three or more hours per day sitting and watching television, playing computer games, or talking with friends. Also, less than 17% of schoolchildren were physically active at least 60 minutes per day; and more than 52% of students

consumed carbonated soft drinks one or more times per day during the 30 days before the survey⁽⁷⁰⁾.

In this study, a significant upward trend in the prevalence of obesity and overweight (including obesity) was found in schoolchildren from 2007 until 2014 in both sexes. At a global level, it has been reported that the obesity in schoolchildren has increased over the last few decades in a higher rate compared to that in preschool children⁽³⁵⁾. It has been suggested that as children get older i.e. from preschool age to adolescence, they gain independence and thus are capable of making their own lifestyle choices such as choosing which foods they consume and the level of physical activity that they participate in, which may explain the rapid increase in the prevalence of obesity in this particular age group^(35, 77, 78). Throughout the study period, girls had a lower prevalence of obesity and higher prevalence of overweight than boys, a pattern that has been reported in Iranian children⁽⁴¹⁾. Several studies have reported higher prevalence of obesity in boys compared to girls in different settings^(53, 79) including Kuwait⁽⁶²⁾. Currently, there are calls to investigate the rapid increase of obesity in boys and whether they are more susceptible to obesogenic pressures⁽³⁵⁾.

Although the prevalence of childhood obesity has increased in the last 13 years, the data suggest that the prevalence may have levelled off in females since 2013 as there was no significant trend in the prevalence of obesity in the period 2014-2019 after adjusting for age. When the analysis was stratified by sex and age, there was no increase in obesity among girls in any age group except a slight increase in those older than 17 years in the period 2014-2019. The prevalence peaked in year 2013 with no clear explanation. Therefore, the analysis was repeated while omitting the data from 2013, which produced similar results. Although several recent reports indicate that the trend in childhood obesity may have slowed down or even decreased in high-income countries^(48-53, 58-60, 75, 80), this issue remains highly controversial and poorly understood. In England, based on data from primary care electronic records, it was reported that the annual increase in the prevalence of obesity stabilized in younger (2-10 years) children but not older (11-15 years) children among which obesity continues to increase with no difference between males and females⁽⁸¹⁾. In the same setting, an earlier study showed that the prevalence of obesity among girls declined between 2005 and 2007 while it remained stable or increased in boys⁽⁸²⁾. Surprisingly, in the same setting, upward trends have been reported for both males and females

since 2012⁽⁷⁵⁾. In Swedish schoolchildren, it was demonstrated that the obesity declined in females not males⁽⁸³⁾. Also, although within a short period of time frame (2007 to 2010), data from the WHO European Childhood Obesity Surveillance Initiative showed upward trend in some countries and downward trends in other countries in Europe over the same period of time⁽⁸⁴⁾. Finally, in children aged 3 to 17 years, a relatively stable rates of obesity were reported in France up to 2012, while since 2011 the rates of obesity have increased in boys in the United States⁽⁷⁵⁾.

The data suggest that obesity in female schoolchildren may be slowing down in recent years according to the WHO, the CDC and the IOTF definitions, which was supported by similar trends in the mean BMI-for-age Z score that showed significant increase over time but started to level off around 2013-2014. This is consistent with several reports from Europe^(82, 83) and a recent global review of trends in childhood obesity, where a higher increase in obesity was observed in boys in comparison to girls between 1975 and 2016⁽³⁵⁾. Our findings highlight the importance of gender differences, which should be considered in the intervention programs designed to combat obesity in children and adolescents^(85, 86). Several plausible reasons for the recent plateau in the trend of childhood obesity have been proposed including the notion that the rates have reached a point of saturation⁽⁸⁰⁾. The other possible reason is the cumulative impact of public health campaigns, which may have resulted in body weight awareness and hence stabilization of the prevalence of obesity in female schoolchildren. However, it is not clear whether this stabilization will be a critical juncture or just a temporary trend. Knowing this may require further monitoring of future trends while including data from different sources. It is noteworthy that upwards trends in childhood obesity have been reported in countries where childhood obesity had plateaued or even declined^(75, 84).

In this study, three definitions of obesity and overweight among children were used to facilitate international comparisons with our data. The WHO definition provided the highest estimate of the prevalence while the IOTF definition showed the lowest estimate of the prevalence of both overweight and obesity among schoolchildren in Kuwait. This is similar to that reported earlier from the region⁽⁸⁷⁾ and Italy⁽⁸⁸⁾. The results of this study also suggest that the WHO, the CDC and the IOTF definitions can all be used to ascertain the trends of overweight and obesity in schoolchildren over time in the region but the interpretation of the magnitude of the prevalence

should take into account the definition used. Using national recently collected BMI-for-age reference data is not recommended to define overweight and obesity in children as it may underestimate childhood obesity providing false assurance that undermined the need for public health interventions ⁽⁸⁹⁾.

The study has several strengths including the large sample size which allowed us to investigate age-specific trends in overweight and obesity after stratification by sex. Also, the data were based on objectively measured weight and height rather than reported weight and height by children or their parents. It has been demonstrated that adolescents and adults underreport weight and overreport height, which leads to lower BMI values ^(90, 91). Moreover, weight and height measurements were conducted by a trained team who are employed on a long-term basis for this purpose hence allowing for consistency of data collection. However, the study has some limitations including the lack of data on socioeconomic status. Given the objectives of this study (i.e. examining the trends of obesity over time), this should cause little concern because we are not looking for specific factors associated with the trends in childhood obesity. Nevertheless, the lack of data on socioeconomic status may conceal different patterns of trend in childhood obesity between those with high and low socioeconomic status. Private schools are excluded from KNSS which may hinder the generalizability of the findings. Additionally, although BMI is a valid, convenient and reliable method of assessing weight status (whereby weight becomes a surrogate for fatness), the ideal definition of obesity is based on the percentage of body fat but this is impracticable for epidemiological studies as it requires body composition analysis using reliable methods such as dual-energy X-ray absorptiometry (DEXA) ⁽⁹²⁾.

In conclusion, the prevalence of obesity and overweight among schoolchildren in Kuwait has risen over the last 13 years and trends are similar across various definitions. The findings of this report indicate that obesity is no longer increasing at the same pace and there is some evidence that the prevalence of obesity in female schoolchildren has plateaued. These findings should not be grounds for optimism as they may reflect a transient trend and nevertheless, the current prevalence is extremely high in both sexes. With this current level of childhood obesity, the country needs to go beyond increasing knowledge and awareness of obesity, hence intensify community-based interventions as well as plan, test and implement school-based interventions to reduce the prevalence of obesity in schoolchildren.

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Figures:

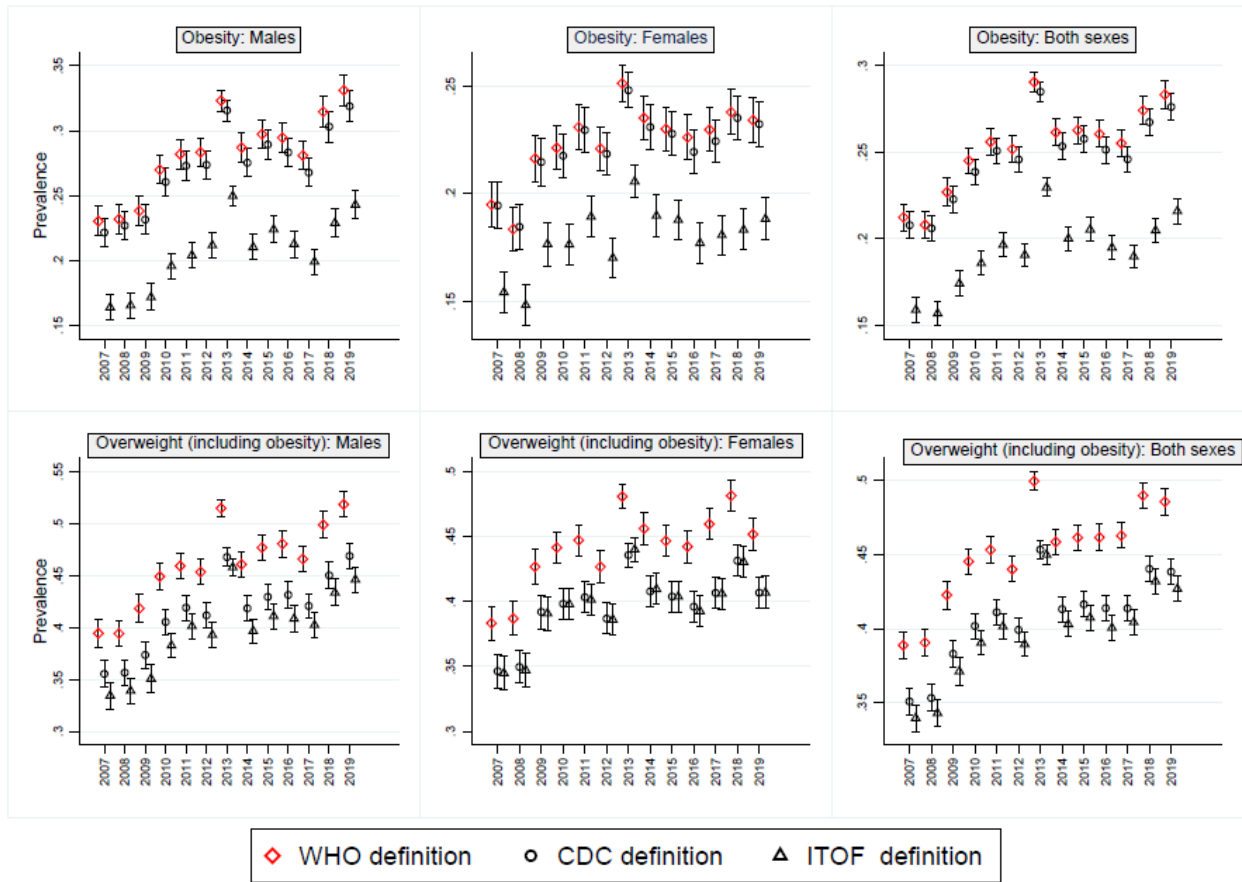


Figure (1): Prevalence of overweight (including obesity) and obesity and their 95% CIs over 13-year period according to the WHO, the CDC and the IOTF definitions among males, females and both sexes.

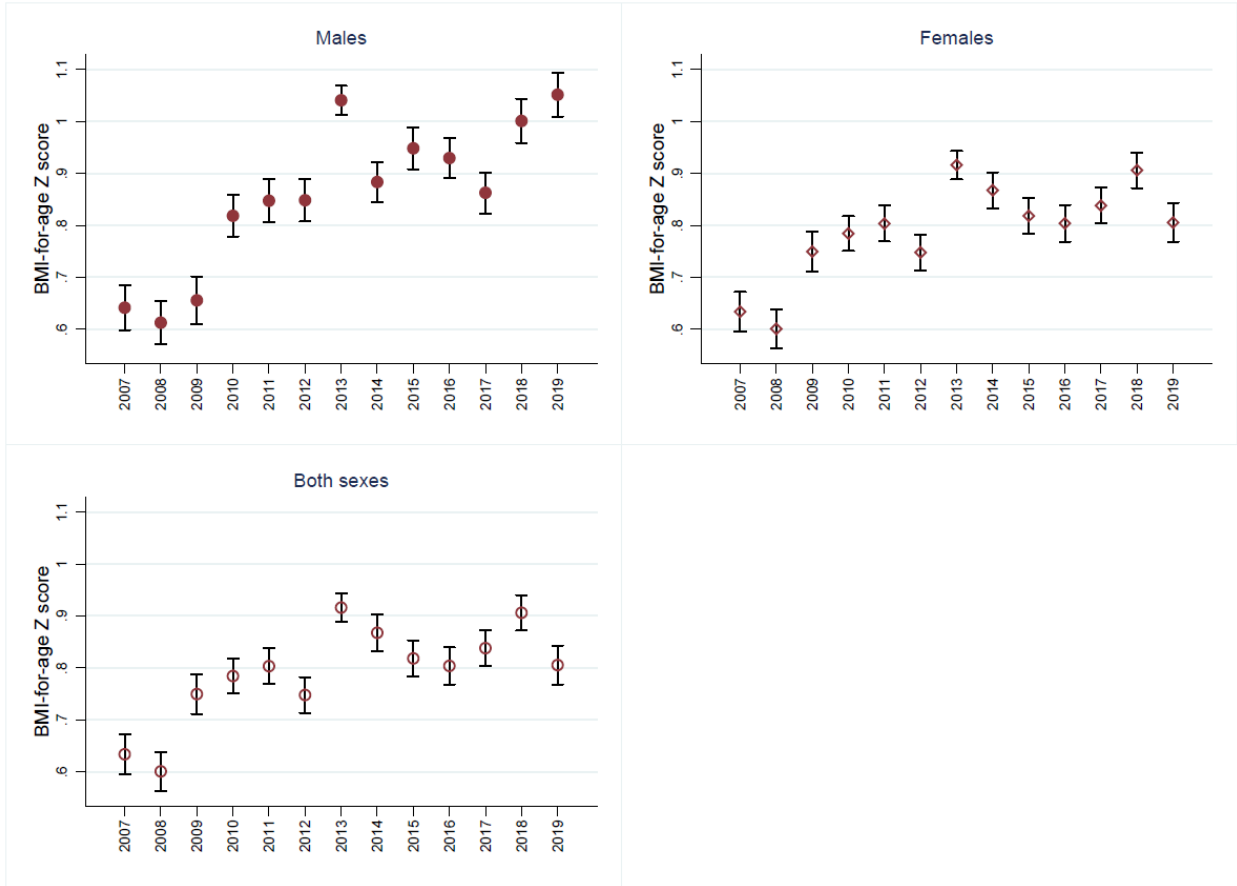


Figure (2): Mean BMI-for-age Z scores and their 95% CIs calculated from the WHO reference curves over the 13-year study period in males and females and both sexes.

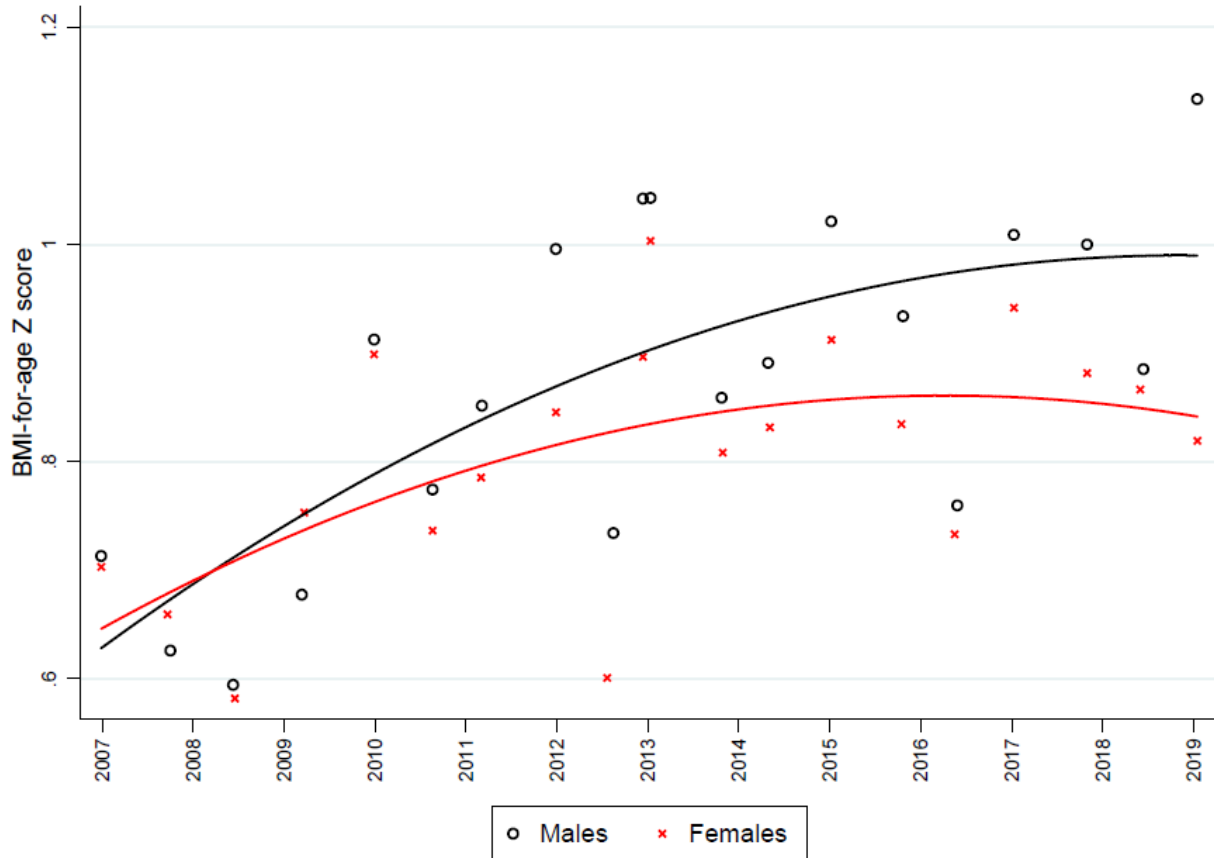


Figure (3): Bin scatter of BMI-for-age Z score over 13-year period after controlling for age fitting regression line with quadratic time term.

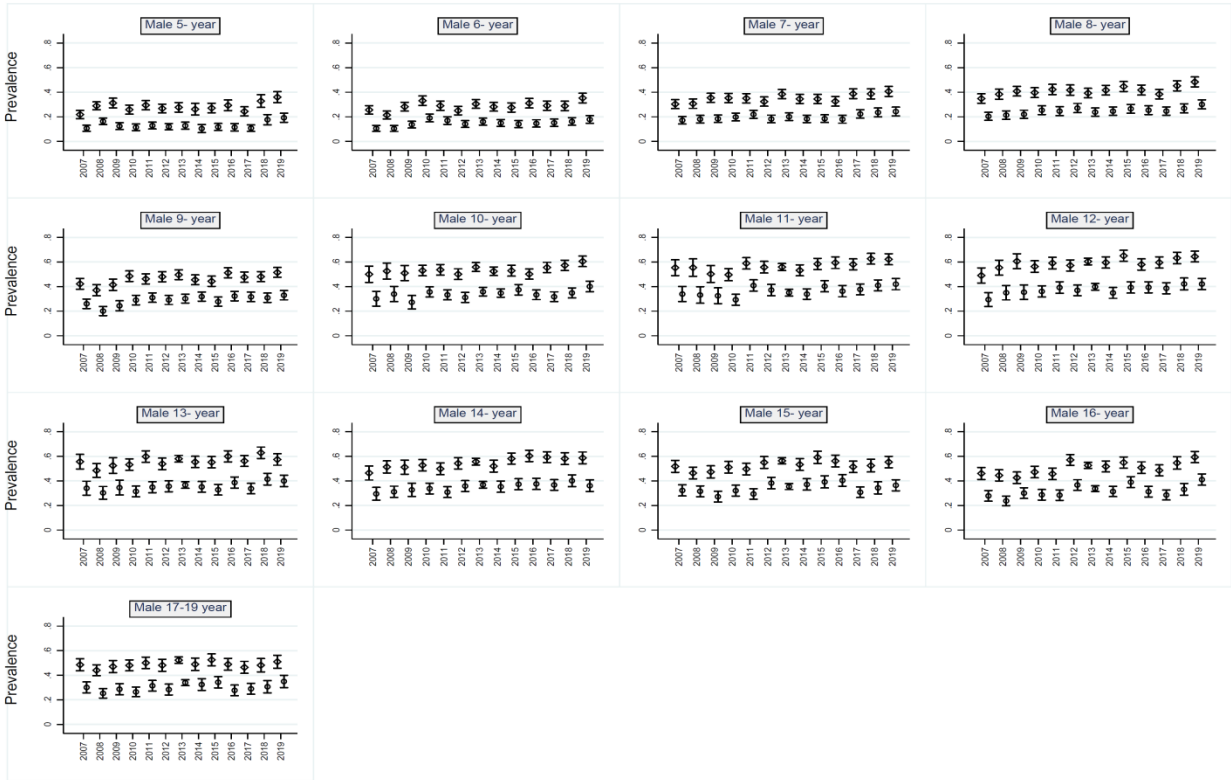


Figure (S1a): Age-specific prevalence of overweight (including obesity) and obesity and their 95% CIs over the 13-year period according to the WHO definition among males.

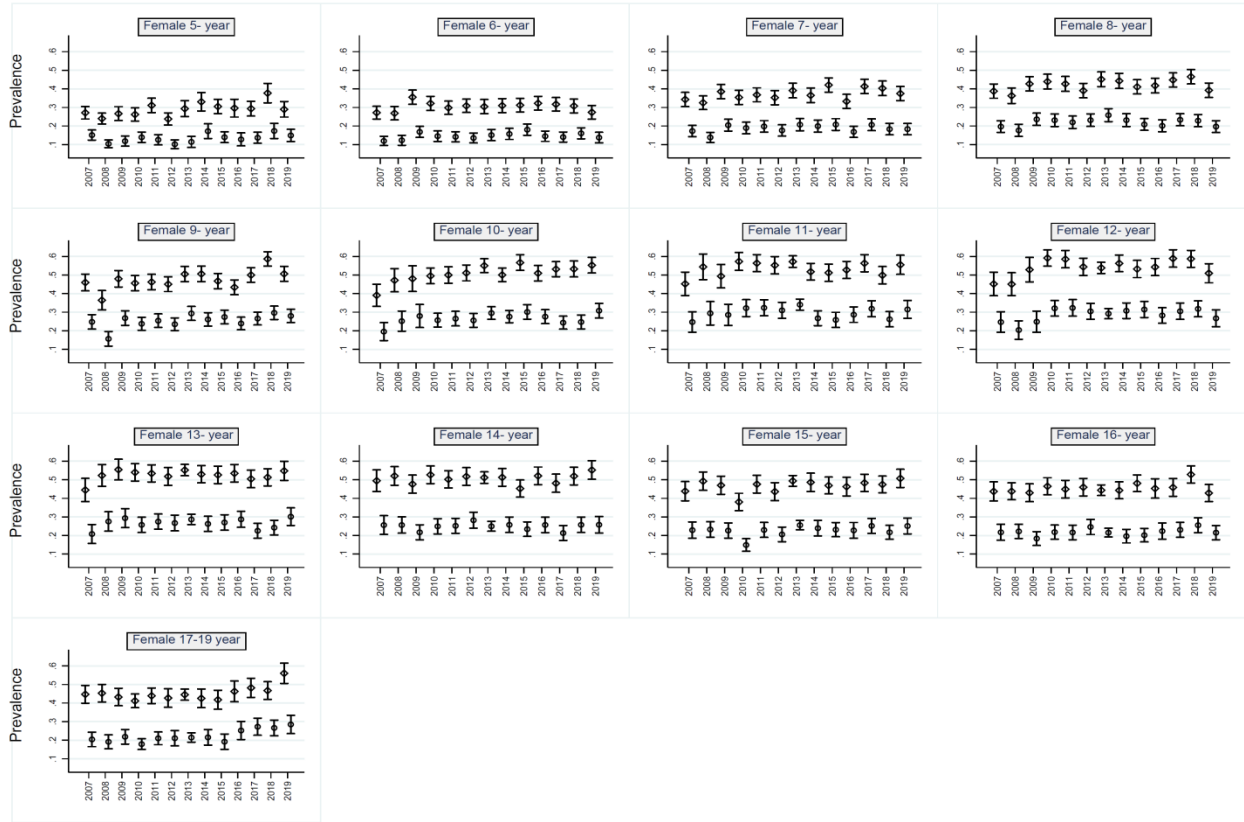


Figure (S1b): Age-specific prevalence of overweight (including obesity) and obesity and their 95% CIs over the 13-year period according to the WHO definition among females.

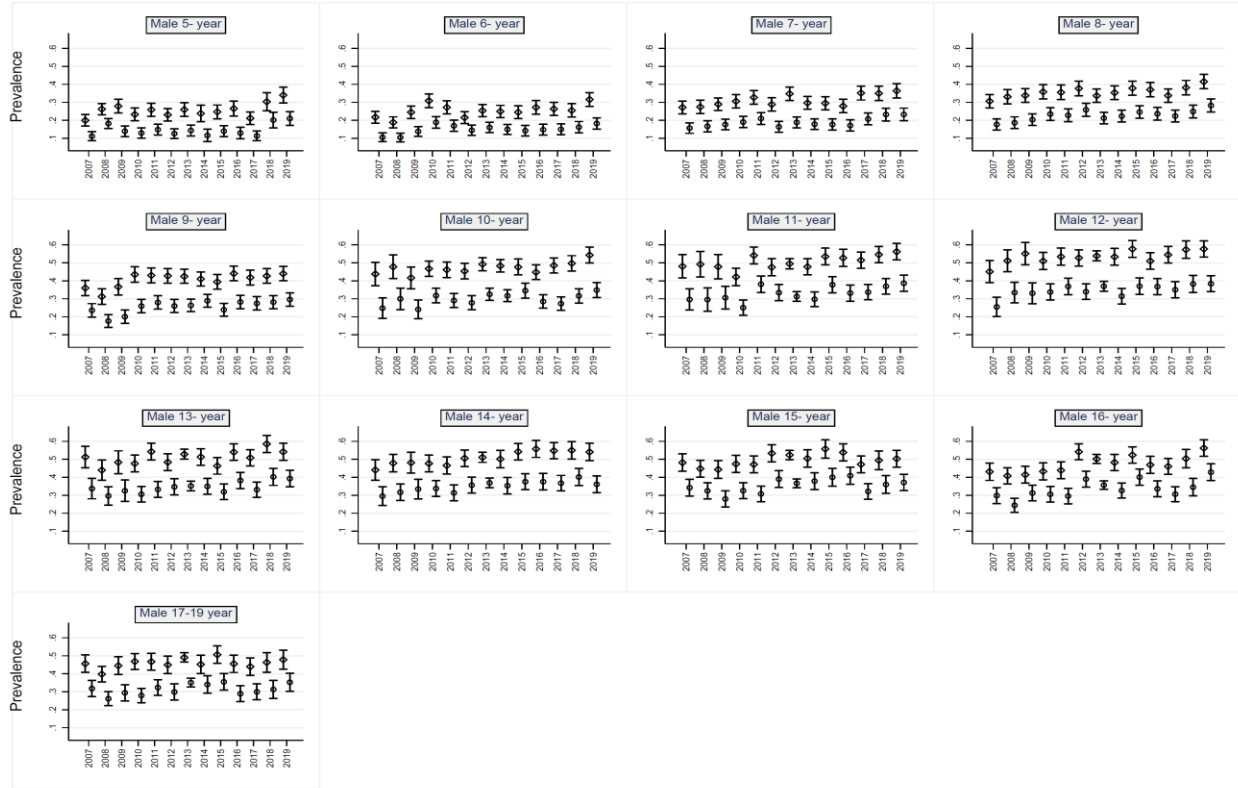


Figure (S2a): Age-specific prevalence of overweight (including obesity) and obesity and their 95% CIs over the 13-year period according to the CDC definition among males.

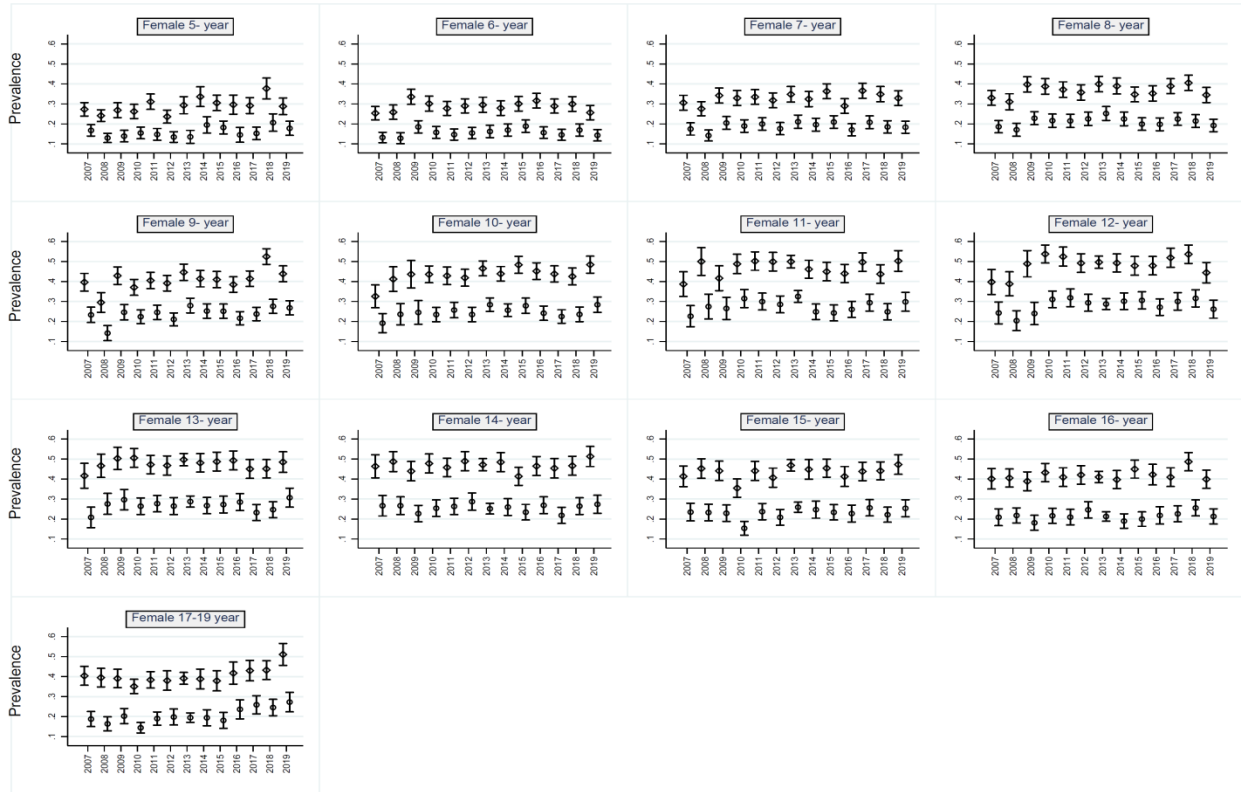


Figure (S2b): Age-specific prevalence of overweight (including obesity) and obesity and their 95% CIs over the 13-year period according to the CDC definition among females.

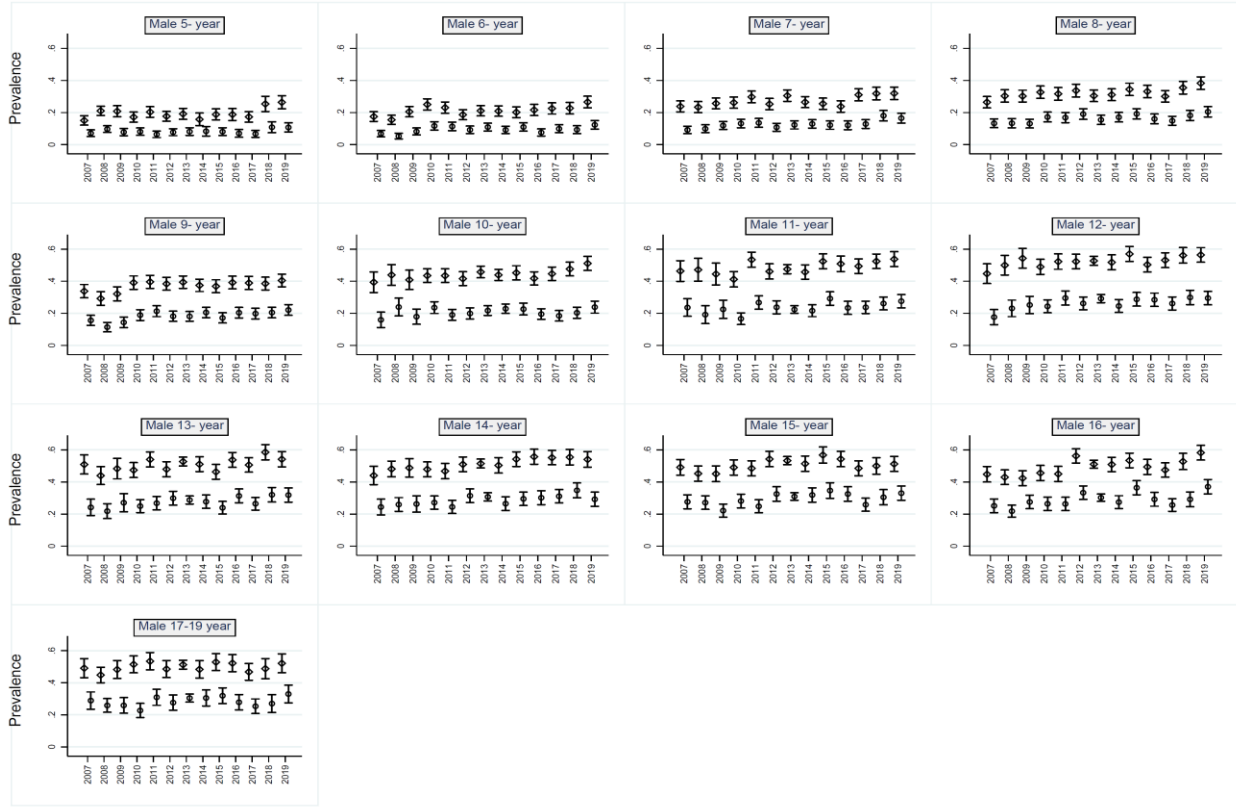


Figure (S3a): Age-specific prevalence of overweight (including obesity) and obesity and their 95% CIs over the 13-year period according to the IOTF definition among males.

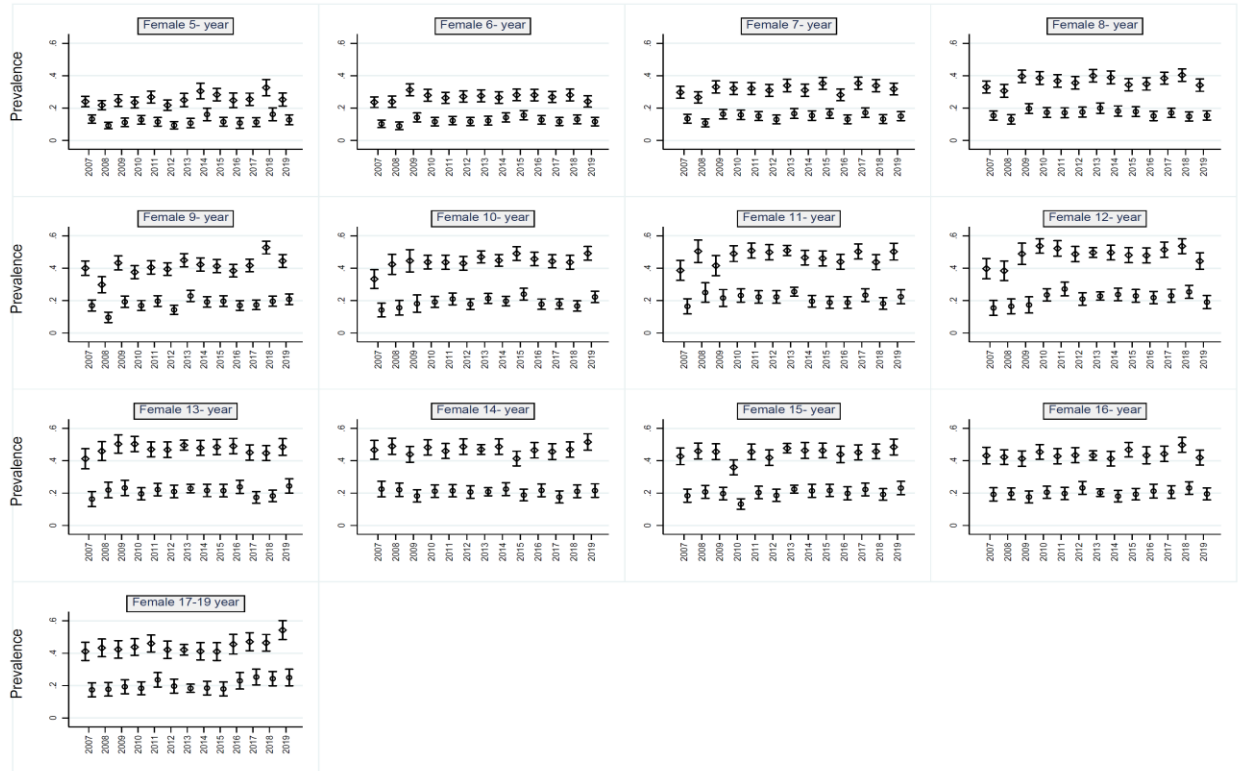


Figure (S3b): Age-specific prevalence of overweight (including obesity) and obesity and their 95% CIs over the 13-year period according to the IOTF definition among females.

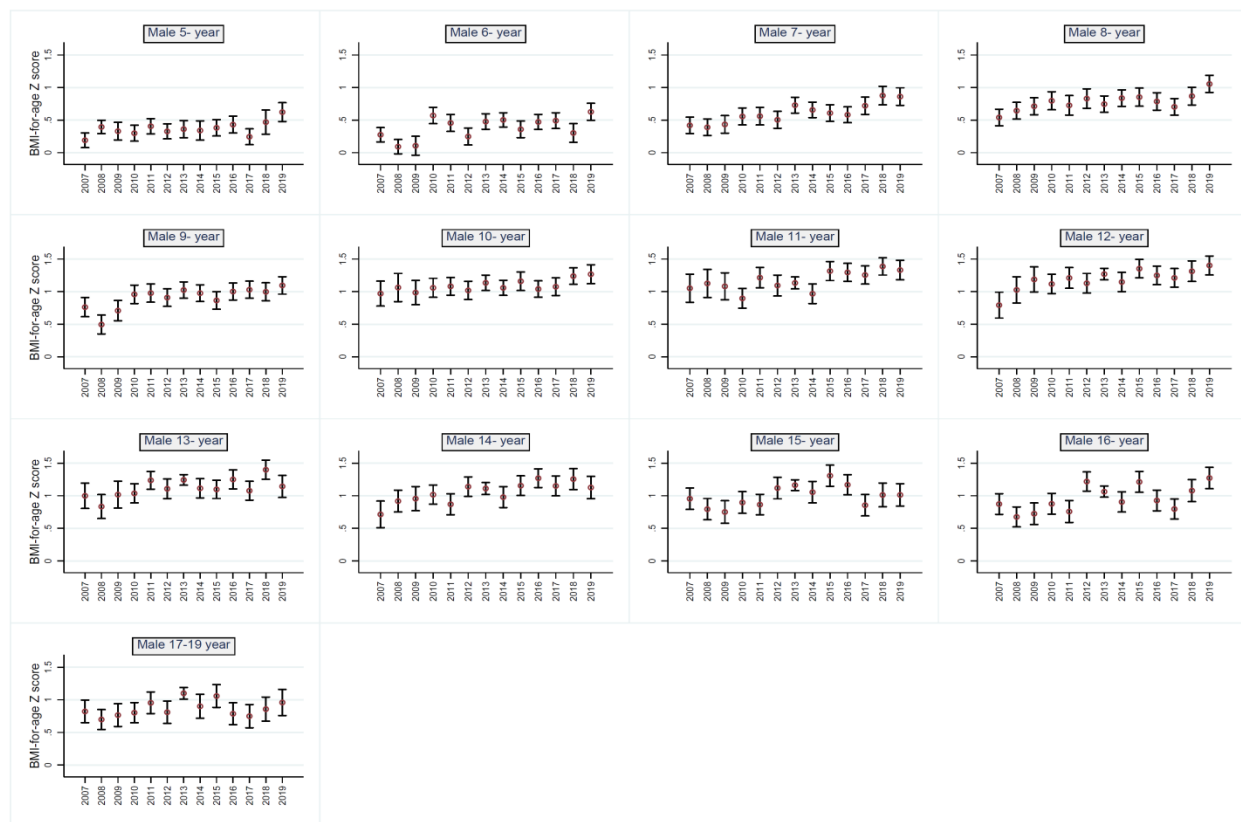


Figure (S4a): Age-specific mean BMI-for-age Z scores over 13-year period in males.

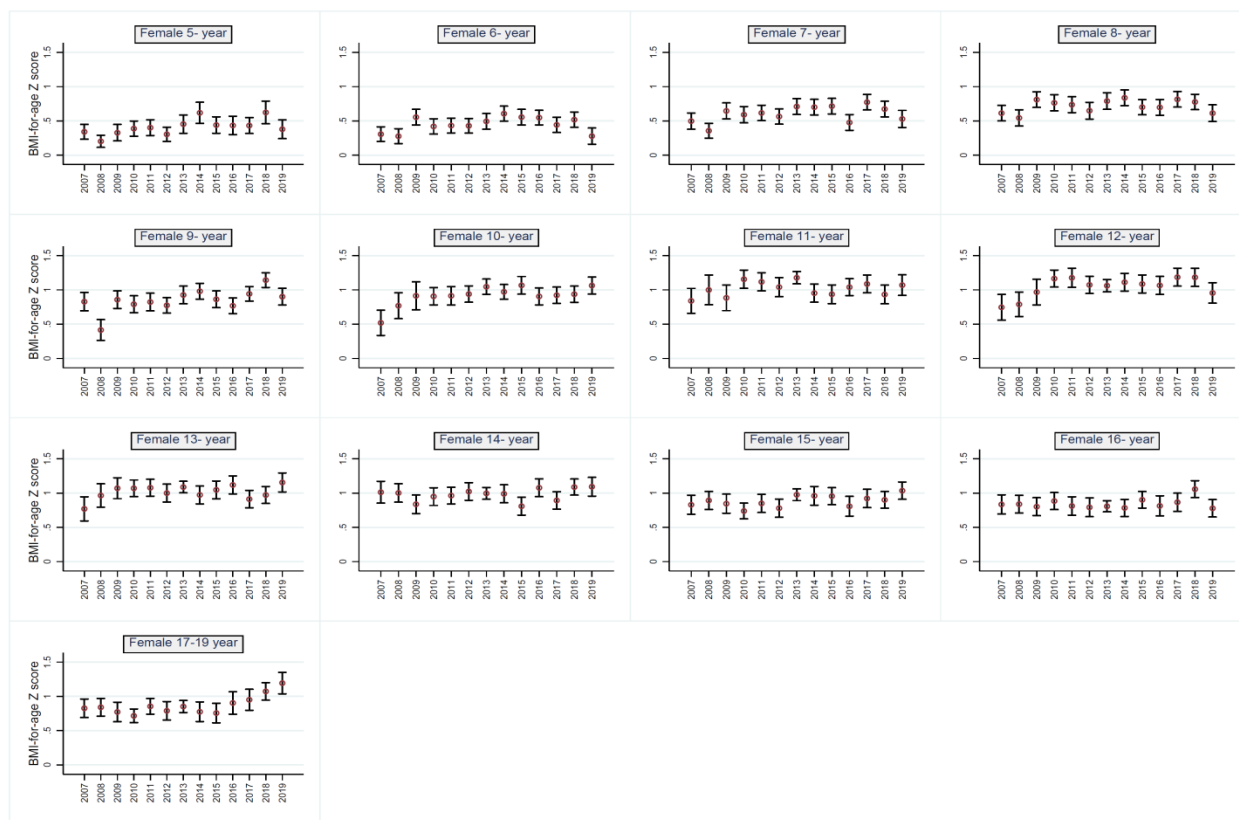


Figure (S4b): Age-specific mean BMI-for-age Z scores over 13-year period in females

Tables:

Table 1 Distribution of the study participants by age and years of the study.

Age	Year													Total
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
5-	1,265	1,598	1,085	1,137	1,116	1,241	952	690	1,038	777	1,031	657	902	13,489
6-	1,268	1,197	1,214	1,167	1,182	1,236	1,185	1,206	1,170	1,161	1,194	1,128	1,149	15,457
7-	1,195	1,191	1,266	1,222	1,241	1,194	1,225	1,220	1,244	1,159	1,217	1,148	1,195	15,717
8-	1,218	1,062	1,234	1,176	1,135	1,150	1,232	1,192	1,222	1,168	1,288	1,208	1,204	15,481
9-	972	780	931	1,096	1,116	1,181	1,195	1,172	1,117	1,180	1,178	1,203	1,198	14,319
10-	487	480	461	1,059	1,010	1,035	1,417	1,520	1,033	1,109	1,129	1,053	1,038	12,831
11-	476	397	454	813	892	870	2,145	960	897	876	921	910	812	11,423
12-	494	515	479	915	850	917	2,274	919	880	910	874	861	828	11,716
13-	518	590	550	884	888	857	2,267	911	888	882	906	869	795	11,805
14-	584	791	698	882	873	880	2,265	846	918	862	885	842	787	12,113
15-	767	831	803	853	861	826	2,641	817	846	796	890	838	841	12,610
16-	765	922	846	890	858	915	2,704	939	940	788	905	835	894	13,201
17-19	828	918	821	1,178	987	789	2,478	752	770	724	770	754	672	12,441
Total	10,837	11,272	10,842	13,272	13,009	13,091	23,980	13,144	12,963	12,392	13,188	12,298	12,315	172,603

Table 2 Prevalence of overweight and obesity in school children (5-19 years) in Kuwait between 2007 and 2019 according to the WHO¹ definition of obesity in children.

Year	Male		Female		Total	
	Overweigh t (%)	Obesity (%)	Overweight (%)	Obesity (%)	Overweight (%)	Obesit y (%)
2007	16.43	23.16	19.02	19.59	17.73	21.37
2008	16.30	23.06	20.48	18.35	18.36	20.74
2009	17.96	23.85	21.04	21.67	19.54	22.74
2010	17.84	26.96	22.00	21.81	19.98	24.31
2011	17.63	28.19	21.72	22.82	19.72	25.45
2012	17.04	28.28	20.58	22.07	18.82	25.15
2013	19.17	32.34	22.90	25.20	20.86	29.10
2014	17.36	28.72	22.09	23.55	19.68	26.18
2015	17.96	29.73	21.66	22.99	19.86	26.28
2016	18.53	29.32	21.62	22.64	20.06	26.01
2017	18.41	28.11	22.97	23.03	20.69	25.57
2018	18.40	31.45	24.25	23.84	21.47	27.46
2019	18.70	33.06	21.72	23.56	20.19	28.39
Overall	17.95	28.61	21.81	22.62	19.87	25.63
P-value	P<0.001		P<0.001		P<0.001	

¹ WHO: World Health Organization; obesity was defined as >2 SD while overweight was defined >1 SD but ≤2 SD of the WHO growth reference median. P-value, testing for trends during the study period.

Table 3 Trends in the prevalence of overweight and obesity in schoolchildren (5-19 years) in Kuwait between 2007 and 2019 using log-binomial regression

		WHO definition PR (95%CI)	p- value	CDC definition PR (95%CI)	p- value	IOTF definition PR (95%CI)	p-value
Overweight (including obesity)							
Males	Year (2007 to 2019)	1.04(1.02- 1.05) **	<0.001	1.04(1.02- 1.05)	<0.001	1.05(1.01- 1.10) *	0.007
Females	Year (2007 to 2019)	1.03(1.02- 1.05) **	<0.001	1.03(1.01- 1.05) *	0.001	1.05(1.01- 1.10) *	
Only Obesity							
Males	Year (2007 to 2019)	1.05(1.02- 1.08) *	<0.001	1.05(1.02- 1.07)	<0.001	1.03(1.02- 1.05) *	<0.001
Females	Year (2007 to 2019)	1.05(1.01- 1.09) *	0.012	1.05(1.01- 1.09) *	0.011	1.03(1.01- 1.05) *	0.003

WHO: World Health Organization; CDC: Centers for Disease Control and Prevention; IOTF: International Obesity Taskforce; PR: Prevalence ratio; 95%CI: 95% Confidence Interval. In all models, we adjusted for age as a continuous variable. After taking clustering into account, quadratic time term was significant ** at 5% level of significance * at 10% level of significance.

Table S1 Prevalence of overweight and obesity in schoolchildren (5-19 years) in Kuwait between 2007 and 2018 according to the CDC reference curves.

Year	Male		Female		Total	
	Overweigh	Obesity	Overweight	Obesity	Overweigh	Obesit
2007	13.38	22.34	15.43	19.48	14.40	20.91
2008	13.00	22.57	16.67	18.35	14.81	20.49
2009	14.19	23.19	17.68	21.47	15.97	22.31
2010	14.47	26.05	18.12	21.24	16.34	23.58
2011	14.52	27.32	17.44	22.61	16.01	24.91
2012	13.82	27.33	16.79	21.83	15.32	24.56
2013	15.22	31.61	18.74	24.83	16.82	28.54
2014	14.28	27.58	17.67	23.13	15.95	25.40
2015	14.06	28.94	17.61	22.75	15.88	25.77
2016	14.74	28.23	17.63	21.98	16.17	25.13
2017	15.24	26.81	18.20	22.48	16.72	24.64
2018	14.67	30.34	19.57	23.53	17.24	26.77
2019	14.98	31.84	17.43	23.38	16.18	27.68
Overall	14.44	27.69	17.71	22.29	16.06	25.01
P-value	P<0.001		P<0.001		P<0.001	

CDC: Centers for Disease Control and Prevention; obesity was defined as $\geq 95^{\text{th}}$ percentiles while overweight as $\geq 85^{\text{th}}$ percentiles but $< 95^{\text{th}}$ percentiles. P-value, testing for trends during the study period.

Table S2 Prevalence of overweight and obesity in schoolchildren (5-19 years) in Kuwait between 2007 and 2019 according to the International Obesity Taskforce (IOTF) definition.

Year	Male		Female		Total	
	Overweigh	Obesity	Overweight	Obesity	Overweigh	Obesit
2007	17.06	16.39	19.08	15.41	18.07	15.90
2008	17.36	16.55	19.90	14.81	18.61	15.69
2009	17.91	17.18	21.44	17.65	19.71	17.42
2010	18.69	19.58	22.17	17.63	20.46	18.59
2011	19.73	20.41	21.23	18.92	20.49	19.65
2012	18.12	21.17	21.61	17.00	19.88	19.07
2013	20.83	24.97	23.45	20.56	22.02	22.98
2014	18.64	21.03	22.00	18.97	20.29	20.02
2015	18.70	22.40	21.62	18.77	20.20	20.54
2016	19.58	21.26	21.56	17.70	20.56	19.49
2017	20.33	19.91	22.55	18.06	21.44	18.98
2018	20.47	22.89	24.73	18.32	22.71	20.49
2019	20.32	24.29	21.88	18.82	21.09	21.60
Overall	19.24	21.06	21.93	18.10	20.57	19.59
P-value	P<0.001		P<0.001		P<0.001	

P-value, testing for trends during the study period.