

Weight status among Iranian adolescents: Comparison of four different criteria

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Background: Obesity or being overweight is a major health problem in Iran. Only few studies are available that compare the obesity prevalence by four different available criteria. The aim of this study was to determine the prevalence of overweight and obesity among Isfahani adolescents based on four different definitions. **Materials and Methods:** This cross-sectional study was conducted on 3002 Isfahani students (1377 males; 1625 females) aged 11-18 years. Anthropometric measurements including weight and height were measured and body mass index (BMI) was calculated. Sex-specific BMI-for-age reference data of the Iranian national data, Center for Disease Control data (CDC2000), International Obesity taskforce data (IOTF), and recent World Health Organization (WHO) data was used to define overweight and obesity. **Results:** The mean age of the studied population was 14.8 years and the mean BMI was 20.3 kg/m². Girls were on an average 1.4 years older and had almost one unit higher BMI than boys. Underweight was prevalent among almost 38.5% and 25.5% of adolescents as per WHO2007 and national Iranian cut-off points, respectively. The prevalence rates reached 39.5% and 45.8% by IOTF and CDC2000 criteria, respectively. The highest prevalence of overweight was obtained by IOTF cut-points (30.5%), while CDC2000 criteria, WHO2007, and national Iranian cut-points gave similar prevalence results (4.7%, 4.0%, and 4.4%); 2.4% of the studied population were found to be obese by WHO2007 definition, while this rate was 0.8%, 0.5%, and 0.8% by IOTF, CDC2000, and national Iranian cut-points. **Conclusion:** Almost all definitions revealed coexistence of underweight, overweight, and obesity among Isfahani adolescents. Huge differences exist between different criteria for assessing weight status among children. To understand the best appropriate criteria for Iranian adolescents, future studies should focus on the predictability of obesity related co-morbidities by these criteria.

Key words: Adolescents, body mass index, obesity, overweight, prevalence, weight

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INTRODUCTION

Obesity has become a global epidemic; the prevalence rate of obesity is rising dramatically in the Asia, including in Iran. Obesity is a medical condition in which excessive body fat accumulates up to the extent that may have adverse effects on health, leading to reduced life expectancy and increased health problems.^[1,2] According to the World Health Organization (WHO) report, 20% of the world population consists of adolescents, of which 84% live in developing countries.^[3] The nutrition transition in the Islamic Republic of Iran is occurring rapidly and obesity is an emerging problem, while malnutrition and under-nutrition in high school children remains an important problem.^[4,5] The appropriate practice of evidence-based health promotion in developing countries might require taking into consideration childhood overweight and

obesity and its complications in addition to nutritional deficiencies. Hence, childhood obesity and its related co-morbidities, notably the metabolic syndrome, will increase the impact of a number of risk factors for adolescent diseases. It is reasonable to increase our knowledge about the prevalence of these disorders in developing countries, many of which still wrestle with the public health effects of malnutrition and micronutrient deficiencies.^[6] The prevalence rate of overweight and obesity in young Iranian women has been reported to be 22% and 16% in urban and rural areas of Kerman among 15-39-year-olds, respectively^[7] and >19% in female adolescents in Islamshahr.^[8] However, there are great differences between provinces.^[9] Recent estimates show the prevalence of obesity in this country is increasing.^[10] The health status of adolescents in Iran has improved in many areas; however, rapid lifestyle changes has made them prone to non-communicable

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diseases in adult life.^[11,12] According to Moayeri *et al.*,^[13] the prevalence of overweight and obesity in males and females in Tehran was 17.9% and 7.1%, respectively. In another study, the prevalence rate of overweight and obesity among female adolescents were reported 13.3% and 4.4%, respectively.^[14] This prevalence rate was high in some large cities, but lower in others.^[7]

Although the prevalence of childhood overweight and obesity is rising, so far, only few comparisons have been made of the prevalence of obesity and overweight according to their definitions. Therefore, more reports are required to show the diversity of obesity patterns across countries with different economic development and cultural backgrounds. There is no global consensus on a cut-off point for defining overweight or obesity in children and adolescents. Usually, for clinical practice and epidemiologic studies, childhood overweight and obesity are assessed by means of indicators based on weight and height measurements, such as weight-for-height or body mass index (BMI).^[15] The US Center for Disease Control and Prevention (CDC) defines “overweight” as being $\geq 95^{\text{th}}$ percentile and “at risk of overweight” as being between the 85^{th} and 95^{th} percentiles of BMI for age.^[16] The European Childhood Obesity Group classifies overweight as being $\geq 85^{\text{th}}$ percentile of BMI and obesity as being $\geq 95^{\text{th}}$ percentile of BMI.^[17] The International Obesity Task Force (IOTF) used data from six national studies conducted in different countries to provide percentile curves that passed through the widely used cut-off points of 25 kg/m^2 and 30 kg/m^2 for adult overweight and obesity, respectively.^[18] In addition, Hosseini *et al.*,^[19] reported some nationally specific cut-off points for defining overweight and obesity among Iranian children.

Although several studies have reported the prevalence of childhood obesity from different parts of the country, some points need to be considered in the interpretation of the findings of these studies. Most, not all, of these studies have very small sample sizes and are nationally unrepresentative. Each one has used a different definition, which makes cross-study comparisons difficult. The objective of the present study was to assess the prevalence of overweight and obesity among Isfahani adolescents using national (Iranian national curves of BMI for age (Hosseini *et al.*)^[19] and three international criteria (WHO, CDC, IOTF).

MATERIALS AND METHODS

Study population

This cross-sectional study was carried out among a sample of 3002 Isfahani students (1377 boys and 1625 girls, aged 11-18 years) who were randomly selected from guidance and high school students by cluster random sampling method over 6 months in 2010. High schools were selected based on the size of the population in each region. In each

cluster (guidance and high school), the students were selected by systematic random sampling and sample frame was the list of students in each school. The study protocol was approved by food security research center of Isfahan University of Medical Sciences (IUMS), Isfahan, Iran (registry number: 288259).

Anthropometric measurements

Weight was measured to the nearest 0.1 kg by a digital scale (Soehnle, Germany) with the subjects wearing light clothes and without shoes. Height was measured to the nearest 0.1 cm by a tape fixed on the wall. BMI was calculated as weight in kilograms divided by height in meters squared.

Waist circumference (WC) was measured at the narrowest level, and hip circumference was measured at the maximum level over light clothing by using an un-stretchable measuring tape, without any pressure to body surface; measurements were recorded to the nearest 0.1 cm. Waist to hip ratio (WHR) was calculated was by dividing WC by hip circumference.

Overweight and obesity were defined based on suggested cut-points by four different criteria. We used CDC2000,^[20] recently published cut-points by WHO,^[21] and Iranian National cut-points.^[19] Based on these cut-off points, underweight was defined as those with BMI $< 5^{\text{th}}$ percentile, overweight as those with BMI between 85^{th} and less than 95^{th} percentile and obesity as those with BMI $\geq 95^{\text{th}}$ percentile. Underweight, overweight, and obesity were also defined by the use of IOTF suggested cut-off points for BMI^[18,22] in 2000 and 2007.

Assessment of other variables

The students were asked to answer a brief self-report socio demographic questionnaire. Data about physical activity was obtained using PAQ-C questionnaire^[23] designed for older children; participants also filled a questionnaire about their sleeping behavior such as sleep duration.

Statistical analysis

Data were processed, summarized, and analyzed using SPSS version 17. Prevalence rates and standard deviations were calculated and reported. Gender differences were searched for by the use of chi-square test. Mean prevalence of underweight, overweight, and obesity was compared between different criteria using analysis of variance (ANOVA), and the difference between each two criteria was examined using Bonferroni post hoc test. $I < 0.05$ was considered statistically significant.

RESULTS

The mean age of the studied population was 14.8 years and the mean BMI was 20.3 kg/m^2 . In the 11-14-years category,

girls were older and had higher BMI than boys, while, in the 15-18-years category, no significant differences were found between girls and boys in terms of age and BMI [Table 1]. In both the age groups combined, girls were on an average 1.4 years older and had almost one unit higher BMI than boys. There was a significant difference in WHR between boys and girls, either within the age groups or in the whole population. However, this was not the case for sleeping duration. Almost half of the whole population had moderate physical activity and it was significantly different between two genders.

Prevalence of underweight, overweight, and obesity, separately by sex and age groups are indicated in Table 2. Four different criteria were used to obtain prevalence rates. The highest prevalence of underweight among adolescents aged 11-14 years was seen by the use of IOTF cut-off points (45.8%), followed by CDC2000 cut-off points (39.6%). Both the criteria indicated that the prevalence is higher among

boys than in girls (IOTF: 50.3% vs. 39.3%; CDC2000: 44.7% vs. 32.4%). In this age category, the use of Iranian national and WHO2007 cut-offs revealed that 25.3% and 38.5% of adolescents were underweight, respectively, with significant gender differences [Table 2]. Among adolescents aged 15-18 years, the use of IOTF, CDC2000, and WHO2007 cut-offs resulted in higher prevalence of underweight (27.5%, 19.3%, and 23.9%, respectively), while the prevalence rates obtained by national Iranian cut-off points were far from these figures (7.1%). All criteria indicated a higher prevalence of underweight among boys than in girls aged 15-18 years. The use of IOTF criteria revealed that overweight is prevalent among 30.5% and 36.7% of adolescents aged 11-14 years and 15-18 years, respectively, with the higher prevalence among girls than among boys in both the age groups (11-14 years age group: 35.6% vs. 27.0% and 15-18 years age group: 40.0% vs. 31.6%) [Table 2]. When we used national Iranian, CDC2000, and WHO2007 cut-off points, we reached similar prevalence rates of overweight

Table 1: General characteristics of Isfahani adolescents¹

	11-14 years				15-18 years				Whole population			
	Boys	Girls	Overall	P value	Boys	Girls	Overall	P value	Boys	Girls	Overall	P value
Age (years)	11.7±0.8	12.9±1.1	12.2±1.1	<0.001 ²	15.7±0.7	16±0.9	16.0±0.9	<0.001	14.0±2.1	15.4±1.7	14.8±2.4	<0.001
Weight (kg)	41.5±10.9	47.6±12.7	44.0±12.0	<0.001 ²	59.3±14.3	53.2±9.3	55.6±11.9	<0.001	51.8±15.7	51.8±10.5	51.8±13.1	<0.001
Height (cm)	147±8	153±9	149±9	<0.001 ²	169±8	159±6	163±9	<0.001	160±14	158±8	159±11	<0.001
BMI (kg/m ²)	18.9±3.7	20.0±4	19.3±3.8	<0.001 ²	20.6±4.1	20.9±3.3	20.8±3.6	0.12	19.9±4.0	20.7±3.5	20.3±3.8	0.14
WHR	0.7±0.01	0.8±0.01	0.7±0.01	<0.001 ²	0.7±0.01	0.7±0.01	0.7±0.01	<0.001	0.7±0.01	0.8±0.05	0.8±0.06	<0.001
Sleeping duration (h/d)	7.8±1.2	6.8±1.3	7.8±1.2	<0.03 ²	7.7±1.1	7.5±1.1	7.5±1.1	0.09	7.8±1.2	7.5±1.1	7.6±1.2	0.1
Physical activity (%)												
Light	29.4	37.9	32.3	<0.001 ³	37.1	44.2	41.8	<0.001	13.4	43.0	38.8	<0.001
Moderate	53.5	44.8	50.5		46.7	44.5	45.3		50.0	44.6	47.0	
Vigorous	17.0	17.2	17.1		16.1	11.1	12.8		16.5	12.3	47.0	

¹Data are mean±standard deviation unless indicated. ²Gender differences were calculated using independent student t test. ³Gender differences were calculated using chi-square test

Table 2: Prevalence of underweight, overweight, and obesity, separately by sex and age groups, among Isfahani adolescents by the use of different criteria¹

	11-14 years (n = 992)				15-18 years (n = 2010)			
	IOTF	CDC2000	WHO2007	National	IOTF	CDC2000	WHO2007	National
Underweight (%)								
Boys	50.3±0.5 ^{b2}	44.7±0.5 ^b	48.4±0.5 ^b	30.0±0.4 ^a	35.8±0.5 ^a	26.3±0.4 ^b	32.2±0.5 ^a	9.5±0.3 ^c
Girls	39.3±0.5 ^b	32.4±0.4 ^b	36.8±0.5 ^b	18.5±0.3 ^a	22.1±0.4 ^a	14.8±0.3 ^d	18.4±0.4 ^{ad}	5.5±0.2 ^b
Overall	45.8±0.5 ^a	39.6±0.4 ^{bd}	38.5±0.5 ^{ad}	25.3±0.4 ^c	27.5±0.4 ^a	19.3±0.3 ^b	23.9±0.4 ^c	7.1±0.2 ^d
P value	0.001 ¹	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
Overweight (%)								
Boys	27.0±0.4 ^a	3.4±0.2 ^b	3.1±0.2 ^b	3.1±0.2 ^b	31.6±0.5 ^a	8.3±0.3 ^b	6.9±0.2 ^b	7.4±0.3 ^b
Girls	35.6±0.5 ^a	6.6±0.2 ^b	5.4±0.2 ^b	6.3±0.2 ^b	40.0±0.5 ^a	6.4±0.2 ^b	6.1±0.2 ^b	5.9±0.2 ^b
Overall	30.5±0.5 ^a	4.7±0.2 ^b	4.0±0.2 ^b	4.4±0.2 ^b	36.7±0.5 ^a	7.1±0.2 ^b	6.4±0.2 ^b	6.5±0.2 ^b
P value	0.004	0.02	0.07	0.01	<0.001	0.11	0.46	0.18
Obesity (%)								
Boys	0.3±0.1 ^b	–	1.5±0.1 ^a	0.3±0.1 ^b	3.5±0.2 ^a	2.6±0.2 ^{ad}	5.4±0.2 ^{ac}	3.5±0.2 ^a
Girls	1.5±0.1 ^a	1.2±0.1 ^a	3.6±0.2 ^a	1.5±0.1 ^a	1.4±0.1 ^b	0.9±0.1 ^b	3.1±0.2 ^a	1.4±0.1 ^b
Overall	0.8±0.1 ^b	0.5±0.1 ^b	2.4±0.1 ^a	0.8±0.1 ^b	2.2±0.1 ^b	1.5±0.1 ^b	4.0±0.2 ^a	2.2±0.1 ^b
P value	0.05	0.008	0.03	0.01	0.002	0.002	0.01	0.002

¹Gender differences were calculated using chi-square test. ²Values in presented in each row for every age group, with different subscript letters are statistically significant (P<0.05)

in both age. Overweight was more prevalent among girls than among boys in the age category of 11-14 years and while overweight prevalence was higher among boys than among girls in 15-18 years children. This difference was not significant using CDC2000 and national Iranian criteria when applied for 11-14-years adolescents. Obesity was more prevalent among boys than among girls in the age category of 11-14 years and 15-18 years by all definitions.

Prevalence of underweight, overweight, and obesity among the whole studies population of adolescents are provided in Table 3. Underweight was prevalent among almost 33.5% and 30.4% of adolescents by the use of IOTF and WHO2007 cut-off points, respectively. When we used CDC2000 and Iranian national criteria, the prevalence rates reached 26.0% and 13.1%, respectively. All definitions revealed higher prevalence of underweight among boys than among girls. The highest prevalence of overweight was obtained by IOTF cut-off points (34.6%), followed by CDC2000 criteria (6.3%), while WHO2007 and national Iranian cut-points resulted in a similar prevalence (5.6% vs. 5.8%). There were no significant gender differences in the prevalence of overweight by the use of different definitions, except for IOTF criteria that indicated a higher prevalence among girls than among boys (38.9% vs. 29.6%). Also, 3.5% of the studied population was found to be obese by WHO2007 definition, while this rate was 1.8%, 1.2%, and 1.7% by IOTF, CDC2000, and national Iranian cut-off points. Gender differences in the prevalence of obesity were not significant using all four criteria.

DISCUSSION

Our findings indicated that underweight is prevalent among almost 33.5% and 30.4% of adolescents by the use of IOTF and WHO2007 cut-off points. The prevalence rates reached

13.1% and 26.0% by Iranian national and CDC2000 criteria, respectively. The highest prevalence of overweight was obtained by IOTF cut-points (34.6%), followed by CDC2000 criteria (6.3%), while WHO2007 and national Iranian cut-points resulted in a similar prevalence (5.6% vs. 5.8%). In addition, 3.5% of the studied population was found to be obese by WHO2007 definition, while this rate was 1.8%, 1.2%, and 1.7% by IOTF, CDC2000, and national Iranian cut-points. Gender differences in the prevalence of obesity were not significant using all four criteria.

Overweight and obesity has long been considered as a predisposing factor that affects individual's health. However, the importance of obesity and overweight among children has not been accentuated as much until recently.^[24] Overweight children and adolescents are at greater risk of being overweight as adults, and adults who are overweight are at higher risk of numerous health problems including hypertension, coronary heart disease, gallbladder disease, non-insulin dependent diabetes, and some forms of cancer.^[25] In Iran, an increasing trend in the prevalence of obesity has recently been documented in Iranian youth^[26] and adults.^[9] Also, it has been reported that the prevalence of metabolic syndrome among Iranian children is comparable to those in the western countries.^[27] A high prevalence of the hypertriglyceridemic waist phenotype among Iranian children has also been documented,^[28] which could make them susceptible to cluster metabolic abnormalities. Therefore, childhood obesity is a major concern in Iran, which should be taken into account by health sector to use a preventive approach in this regard.

There is a lack of agreement about the definition of overweight and obesity in childhood and adolescence,^[29] and the absence of a universal definition has lead to

Table 3: Prevalence of underweight, overweight and obesity among Isfahani adolescents

	Definitions used			
	WHO2007	IOTF	CDC2000	National
Percent of underweight (n)				
Girls	23.1±0.4(375) ^a	26.4±0.4(429) ^a	19.2±0.3(313) ^d	8.8±0.2(143) ^c
Boys	39.1±0.5(538) ^a	42.0±0.5(578) ^a	34.0±0.4(469) ^b	18.2±0.3(251) ^c
Overall	30.4±0.5(913) ^a	33.5±0.5(1007) ^b	26.0±0.4(782) ^c	13.1±0.3(394) ^d
P value	<0.001 ¹	<0.001	<0.001	<0.001
Percent of overweight (n)				
Girls	5.9±0.2(96) ^b	38.9±0.5(632) ^a	6.4±0.2(105) ^b	6.0±0.2(98) ^b
Boys	5.3±0.2(73) ^b	29.6±0.4(408) ^a	6.2±0.2(86) ^b	5.5±0.2(77) ^b
Overall	5.6±0.2(169) ^a	34.6±0.5(1040) ^b	6.3±0.2(191) ^a	5.8±0.2(175) ^a
P value	0.47	<0.001	0.81	0.61
Percent of obesity (n)				
Girls	3.3±0.2(53) ^a	1.4±0.1(23) ^b	0.9±0.0(16) ^b	1.4±0.1(23) ^b
Boys	3.8±0.2(52) ^a	2.2±0.1(30) ^b	1.5±0.1(21) ^b	2.2±0.1(30) ^b
Overall	3.5±0.2(105) ^a	1.8±0.1(53) ^b	1.2±0.1(37) ^b	1.8±0.1(53) ^b
P value	0.44	0.11	0.18	0.11

¹Gender differences were calculated using chi-square test. ²Values in each row with different subscript letters are statistically significant ($P<0.05$)

the inability to monitor the worldwide development of childhood obesity. Distribution-based cut-off values, such as 85th and 95th percentiles of BMI, has been proposed and commonly used in literature.^[28] WHO has released the updated cut-off points for percentiles of BMI in 2007. In May 2000, the International Obesity Task Force (IOTF) Childhood Obesity Working Group published standard definitions for overweight and obesity in childhood.^[18] These cut-off points were, however, not selected on the basis of their empirical relation to risk factors, rather, they were derived by identifying age- and sex-specific BMI values corresponding to cut-offs for overweight (BMI = 25) or obesity (BMI = 30) in adults. The results of previous reports from Iran and other Middle East countries^[6] have always been difficult to interpret as they have relied on different definitions, and, until now, there is no report on the prevalence of overweight comparing Iranian national cut-off points with those of WHO2007, CDC2000, and IOTF in children and adolescents. Dorosty *et al.*,^[26] however, did compare Iranian national reference cut-off points with those of IOTF, but this was done only in children aged 2-5 years residing in the rural provinces of Iran. Therefore, the information provided by this study shed light to some extent on the magnitude of the problem based on different definitions.

Our findings reflect the difference in the prevalence estimates based on different definitions. In the whole population, estimates of underweight obtained from Iranian cut-points were lower than those obtained by using CDC2000 or IOTF, while no significant difference in the estimates was found between Iranian cut-off points and WHO2007 cut-offs. Getting back to the prevalence of overweight and obesity, estimates obtained by the use of Iranian cut-points were the same as those found by CDC2000 criteria, while lower than IOTF and WHO2007 cut-offs. Other investigators also showed a discrepancy in estimates based on different criteria in other countries. Kuczmarski *et al.*,^[30] showed that the prevalence of overweight and obesity are always lower with IOTF criteria than the national criteria, even in USA. Reilly *et al.*,^[31] showed that IOTF criteria lead to a greater underestimation in boys. Dorosty *et al.*,^[26] showed that the prevalence of overweight by using IOTF cut-off points was significantly higher in 2-3-years old Iranian children than when using Iranian cut-off points. However, we did not include children aged 2-3 years in the present study. The recently recommended cut-off points for BMI in Iranian children have provided us the opportunity to identify the prevalence based on national criteria. Our study gives appropriate data against that estimates from other studies in the Middle East and elsewhere can be compared with using the same methodology.

The double burden of disease we found in the current study is not unique for Iranian children. Among Turkish

adolescent girls, the prevalence of underweight, overweight, and obesity have been reported to be 11.1%, 10.6%, and 2.1%, respectively.^[32] In a similar study in Qatari adolescent girls, the rates were 5.8%, 18.9%, and 4.7%, respectively.^[33] The prevalence of underweight among Chinese youngsters aged 15-20 years has been reported to be 35.9%.^[34] Therefore, despite the rising trend of obesity worldwide, problems of malnutrition and nutrient deficiencies continue to dominate the public health nutrition agenda in our area.

This study has several strengths. First, using a population representative sample of Isfahan, we found the coexisting high prevalence of underweight and overweight in Iranian population of children and adolescents. Second, the lack of definition-based comparative studies from this part of the world makes our study findings interesting.

In conclusion, this study indicates the coexisting high prevalence of underweight and overweight among high-school students of Isfahan, Iran. Because nutritional patterns and physical activity behaviors develop during childhood, preventive approaches addressing children and adolescents are required to deal with the problem of underweight, overweight, and obesity.

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