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The Prevalence of Childhood Underweight, Overweight, and Obesity based on Four Different Criteria

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ABSTRACT

Background: Childhood/adolescence under- and over-nutrition are among the major public concerns worldwide. This study aimed to determine the prevalence of underweight, overweight, and obesity among children living in Yazd, Iran using different criteria. **Methods:** This community-based cross-sectional study was conducted among children and adolescents aged 6-18 years. Body weight, height, waist, and hip circumference were measured. Furthermore, the body mass index (BMI) and waist to hip ratio were calculated. Afterwards, BMI was classified according to four criteria including the US center for disease control and prevention (CDC), world health organization (WHO), the international obesity task force (IOTF), and Iranian national cut-points. **Results:** The mean age of the included children was 11.32 ± 3.89 years. Overall, the highest rate of underweight was estimated by IOTF %16.9 and the lowest rate was estimated by the national criteria %1.2. Furthermore, the highest and the lowest rates for overweight were obtained by CDC2000 %19.0 and WHO criteria %12.2, respectively. The highest and lowest rates for obesity were obtained by the national %22.3 and the CDC2000 criteria %11.3, respectively. The selected criteria were significantly different in estimating underweight, overweight, and obesity ($P < 0.05$). **Conclusions:** All the mentioned criteria showed high rate of overweight and obesity among children and adolescents in Yazd. Furthermore, the highest rate of obesity was detected by national criteria. The national distribution of BMI in Iranian children is skewed to overweight and obesity.

Keywords: *Obesity; Overweight; Underweight; Children; Prevalence*

Introduction

Recently, the rates of obesity and overweight have increased, so that more than 500 million obese people exist in the world (Batch and Baur, 2005, Wang and Lobstein,

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2006). Obesity is defined by excessive body fat (Herouvi *et al.*, 2013) and childhood obesity is characterized by the body mass index (BMI) at or above the 95th percentile based on age and gender (Barlow, 2007). Overweight or obese children are more probable to become obese in adulthood compared to the normal-weight children. Actually, more than half of the obese children will be fat in adulthood while only 10% of children with normal weight will become obese (Whitaker *et al.*, 1997b). Childhood obesity can be assessed as one of the most important risk factors causing several non–communicable diseases (NCDs) in adulthood such as depression, hypertension, hyperlipidemia, type 2 diabetes (T2DM), and cardiovascular diseases (CVDs) (Ebbeling *et al.*, 2002, Li *et al.*, 2003, Mohammadi *et al.*, 2019b, Ramachandran and Snehalatha, 2010). Moreover, the persistence of childhood obesity will increase the morbidity and mortality rate in adulthood (Field *et al.*, 2005, Guo *et al.*, 2002, Inge *et al.*, 2013, Whitaker *et al.*, 1997a). Although it is proposed that obesity kills more people than underweight (World Health Organization, 2020), either childhood or adulthood underweight poses an economic burden on the societies (Lazzeri *et al.*, 2014). Underweight in children is considered as a serious health concern, leading to considerable effects on the communities' development and well-being (Schönbeck *et al.*, 2014). Indeed, underweight in adults leads to scoliosis, osteoporosis, and psychiatric disorders (Mak and Tan, 2012). Among children, underweight increases the risk of infectious diseases and causes higher risks of maternal mortality and delivery complications in girls (Han *et al.*, 2010). Childhood obesity and overweight can be caused by some reasons that are classified into modified and non-modified factors (Bracale *et al.*, 2012). Although modified factors, including low parental education level, extreme media usage, migration, and excessive food consumption can be controlled, management of non-modified factors such as genetic factors is not possible (Bracale *et al.*, 2013, Deckelbaum and Williams, 2001, Lawlor *et al.*, 2008, Lob-Corzilius, 2007). In recent decades, the rapid changes of lifestyle specifically nutritional transition and sedentary lifestyle are the most common causes of the increased rate of childhood obesity in a transition country like Iran (Dorosty *et al.*, 2002, Hajian-Tilaki *et al.*, 2011, Kelishadi *et al.*, 2003b). Lifestyle is considered as a modified risk factor for underweight and obesity. Thus, it is suggested that eating behavior and physical activity are associated with body weight status (Kumar *et al.*, 2004, Levin *et al.*, 2003).

The prevalence of obesity, overweight, and underweight were estimated in different parts of Iran. In a cross-sectional study over 2000 population in Shiraz, 7% of the students aged 11-17 years were obese (Basiratnia *et al.*, 2013). Moreover, the prevalence rate of obesity and overweight were reported as 15% and 11.8% in the north of Iran, respectively (Hajian-Tilaki and Heidari, 2013). A study indicated that the macro-level policy influences school environment as well as the sociocultural, family, and individual factors that contribute to childhood obesity reasons in Iran (Mohammadpour-Ahranjani *et al.*, 2014). Additionally, the findings of CASPIAN study in Iran revealed that the prevalence of underweight was 13.9% based according to the criteria set by the center for disease control (CDC). This study reported that the prevalence of overweight was 8.8, 11.3, and 10.1% by CDC, IOTF, and national cut-off points, respectively (Kelishadi *et al.*, 2008). Moreover, a cross-sectional study among US children revealed higher prevalence of overweight according to the cut-off points set by WHO (2006) compared to the CDC (2000). However, the WHO (2006) set a lower rate of underweight than the CDC criteria (Mei *et al.*, 2008). Different criteria were used to consider the prevalence of obesity in Canada. The prevalence of overweight and obesity is higher

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based on the cut-off points set by WHO (35%) in comparison with those defined by IOTF (26%) and CDC (28%) criteria (Shields and Tremblay, 2010).

Given the lack of adequate data regarding the prevalence of obesity, overweight, and underweight of children and adolescents in central Iran, we aimed to assess the weight status of children and adolescents aged 6-18 years living in Yazd, Iran. In this study, the BMI status and prevalence rates of underweight, overweight, and obesity were assessed by four different criteria such as national (Iranian national curves of BMI for age), CDC, WHO, and IOTF.

Materials and Methods

Study design and population: In this study, we used the data set provided by the Iranian Children and Adolescents' Psychiatric Disorders (IRCAP) survey (Mohammadi *et al.*, 2019a), which was granted by the national institute for medical research development (NIMAD; grant No. 940906). This community-based cross-sectional study was carried out among 1035 children and adolescents aged 6-18 years selected by clustered random sampling method from Yazd province.

Data collection and measurements: In the present study, anthropometric indices were measured by trained nurses. Furthermore, the occupation, parents' education level, and children's demographic data were collected. Anthropometric parameters were assessed according to the standards. Body weight was measured on a calibrated digital scale, to the nearest 0.1 kg. In order to measure body weight, subjects wore slight clothes without shoes. Height was measured by a fixed tape on the wall with straight body position to the nearest 0.1 cm. Waist (WC) and hip circumferences were measured by an un-stretchable tape to the nearest 0.1 cm. BMI was calculated by dividing weight to height squared and waist to hip ratio (WHR) as WC divided by hip circumference. Furthermore, BMI was classified by the US center for disease control and prevention (CDC 2000) (Kuczmarski *et al.*, 2002), world health organization (WHO) (Pölczmann *et al.*, 2016), the Iranian national cut off points (Hosseini *et al.*, 1999), and the international obesity task force (IOTF) cut off points (Cameron, 2007, Cole *et al.*, 2000). Based on these criteria, underweight, overweight and obesity were defined as BMI < 5^{th}, BMI between 85^{th} and 95^{th}, and BMI ≥ 95^{th}, respectively.

Ethical considerations: The ethical approval of the current study was obtained from National Institute for Medical Research Development (NIMRD) (the Ethics Code of IR.NIMAD.REC.1395.001). Moreover, written informed consents were obtained from the participants and their parents.

Data analysis: In this study, the prevalence rate and standard errors were reported. Analysis of variance (ANOVA) was used to compare the mean of underweight, overweight, and obesity according to different criteria among participants. Chi-square test was used to find gender differences. In addition, differences between every two criteria were analyzed by the Bonferroni post hoc test. P-value of < 0.05 was considered as significant. The collected data were analyzed by SPSS software.

Results

Of 1035 participants, 997 individuals (553 girls and 444 boys) were included in the analysis. **Table 1** shows **t**he baseline characteristics of children and adolescents in the whole population and among the different age categories based on gender. In the whole population, the participants' mean age was 11.32 ± 3.89 years. Additionally, the mean of body weight (kg), height (cm), BMI (kg/m^2), and WHR were 43.94 ± 20.52, 145.73 ± 20.42, 19.53 ± 5.04, and 0.86 ± 0.25, respectively. The parents' occupation and education level were also reported. Most mothers were house-wife (73.9%) and most fathers were self-employed (61.4%). Furthermore, either mothers or fathers

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had diploma or higher degrees (79.5 % and 76.3 %, respectively).

Table 2 reports the prevalence of underweight, overweight, and obesity in the whole study population and between different genders. As this table represents, IOTF cut-off points revealed the highest rate of underweight %16.9 followed by WHO criteria %12.3. While the analysis based on gender indicated higher prevalence of underweight according to the criteria set by WHO in boys %17.6 and based on IOTF cut-off points in girls %19.3. In this case, WHO criteria showed a significant gender difference between the groups ($P < 0.001$). Moreover, the CDC 2000 and WHO cut-off points obtained the highest and lowest rates of overweight in the whole population %19 and %12.2, respectively). In both girls and boys, the WHO criteria revealed the lowest prevalence of overweight, while the highest prevalence was reported by IOTF cut-off points in boys %17.8 and CDC 2000 criteria in girls %21.5. Additionally, except for IOTF, other criteria demonstrated significant differences in terms of gender ($P < 0.05$). When the mentioned criteria were used to assess the prevalence of obesity, the national cut-off points obtained the highest rate %22.3. However, the prevalence of obesity decreased to 20.4%, 11.7%, and 11.3% by WHO, IOTF, and CDC criteria, respectively. Furthermore, in boys, the national cut-off points revealed the most prevalence of obesity %26.8 and the national and CDC 2000 cut-off points showed significant differences with regard to gender ($P < 0.05$).

The prevalence of underweight, overweight, and obesity are presented separately by gender and age groups in **Table 3**. In order to approximate the prevalence of underweight in the 6-10 year-old children, the IOTF cut-off points presented the highest prevalence in the whole population %19.5, girls %22.2, and boys %15.7. On the contrary, the national cut-off points could estimate the lowest prevalence in the overall population and in both genders. The prevalence of underweight in 11-18 year-old adolescents showed the highest rate by WHO criteria in the overall population and among boys with a significant gender difference ($P < 0.001$). However, the IOTF cut-off points estimated the highest prevalence rates in girls %16.8. The national criteria showed the lowest prevalence of underweight in 11-18 year-old adolescents. The estimation of overweight prevalence by the mentioned criteria in 6-10 year-old children showed the highest prevalence by CDC 2000 in the overall population and in boys (overall: %17.5, boys: %20.7 and by the national criteria in girls %13.6, which was confirmed by CDC criteria %13.1. The WHO cut-off points estimated the prevalence of overweight in the overall, boys, and girls as 8.2, 6.3, and 9.6, respectively; these showed the lowest rates of overweight prevalence in 11-18 year-old children. In contrast, IOTF cut-off points estimated the highest prevalence of overweight in these adolescents (**Table 3**). The national cut-off points obtained the highest obesity prevalence rates in 6-10 year-old children. Moreover, the highest prevalence rates were observed in boys and the overall population aged 11-18 years old. In girls' population, the highest prevalence of obesity was estimated as 17.1 by the WHO cut-off points. Moreover, the lowest prevalence of obesity was observed by IOTF criteria in 11-18 year-old adolescents. Considerable gender differences were reported in all four criteria among the obese 11-18 year-old individuals ($P < 0.05$). Based on the IOTF, CDC 2000, and national criteria, girls showed a higher prevalence of underweight, overweight, and obesity in 6-10 year-old children.

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Table 1. General characteristics of the participations.

Variables	6-10 years		11-18 years		Whole population	
	Boys	Girls	Boys	Girls	Boys	Girls
Age (year)	8.07 ± 1.41[a]	7.4 ± 1.43	14.46 ± 2.29	14.30 ± 2.31	11.69 ± 3.73	11.03 ± 3.97
Weight (kg)	27.74 ± 9.48	30.33 ± 13.20	60.40 ± 21.07	52.49 ± 13.98	46.35 ± 23.52	42.01 ± 17.55
Height (cm)	127.21 ± 11.6	130.66 ± 16.86	163.25 ± 14.63	156.16 ± 9.76	147.74 ± 22.33	144.12 ± 18.62
Body mass index (kg/m^2)	16.81 ± 3.53	16.98 ± 3.66	22.20 ± 5.62	21.27 ± 4.43	19.87 ± 5.51	19.26 ± 4.62
Waist hip ratio	0.87 ± 0.07	0.89 ± 0.46	0.86 ± 0.09	0.82 ± 0.07	0.87 ± 0.09	0.86 ± 0.32
Mother's occupation						
Self-employed	14 (7.4)[b]	12 (6.5)	21 (8.6)	27 (10.4)	35 (8.1)	39 (8.7)
Governmental job and retired	35 (18.5)	33 (17.7)	42 (17.3)	45 (17.3)	77 (17.8)	78 (17.5)
House-wife	140 (74.1)	141 (75.8)	180 (74.1)	188 (72.3)	320 (74.1)	329 (73.8)
Father's occupation (%)[c]						
Self-employed	118 (62.4)	117 (62.9)	153 (62.4)	152 (58.5)	271 (62.4)	269 (60.3)
Governmental job	60 (31.7)	63 (33.9)	69 (28.2)	61 (23.5)	129 (29.7)	124 (27.8)
Without job	4 (2.1)	1 (0.5)	0.0	8 (3.1)	4 (0.9)	9 (2.0)
Retired	7 (3.7)	5 (2.7)	23 (9.4)	39 (15.0)	30 (6.9)	44 (9.9)
Mother's education						
≤ Elementary	9 (4.7)	7 (3.8)	12 (4.5)	32 (12.3)	21 (4.6)	39 (8.8)
< Diploma	28 (14.3)	10 (5.4)	39 (16.1)	45 (17.3)	67 (15.3)	55 (12.4)
≥ Diploma	153 (81.0)	168 (90.8)	192 (79.3)	183 (70.4)	345 (80.0)	351 (78.9)
Father's education						
≤ Elementary	15 (7.9)	10 (5.4)	8 (3.3)	32 (12.4)	23 (5.3)	42 (9.4)
< Diploma	35 (18.5)	19 (10.2)	40 (16.4)	49 (18.9)	75 (17.3)	68 (15.3)
≥ Diploma	139 (73.5)	157 (84.4)	196 (80.3)	178 (68.7)	335 (77.4)	335 (75.3)

[a]: Mean ± SD; [b]: N (%). [C]: The fathers' occupation information were recorded in 880 participants.

Table-2. The prevalence (%) of underweight, overweight, and obesity in children and adolescents based on different criteria

Weight status	WHO	IOTF	CDC 2000	National
Underweight				
Girls	8.1	19.3	9.2	1.1
Boys	17.6	13.7	10.6	1.4
Overall	12.3	16.9	9.8	1.2
P value[a]	<0.001	0.19	0.45	0.70
Overweight				
Girls	14.6	19.3	21.5	20.8
Boys	9.2	17.8	15.6	14.4
Overall	12.2	18.7	19[a]	17.95
P value	0.01	0.53	0.02	0.009
Obese				
Girls	18.99	10.8	8.1	18.6
Boys	22.1	12.8	15.4	26.8
Overall	20.4	11.7	11.3	22.3
P value	0.22	0.33	<0.001	0.002

WHO, world health organization; IOTF, the international obesity task force; CDC, The US center for disease control and prevention; National, Iranian national cut-points. [a]: Chi-square test

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Table 3. The prevalence (%) of underweight, overweight, and obesity separately by sex and age groups.

	6-10 years					11-18 years				
Weight status	**WHO**	**IOTF**	**CDC 2000**	**National**	**P-value**	**WHO**	**IOTF**	**CDC 2000**	**National**	**P-value[a]**
Underweight										
Girls(n=261)	9.6	22.2	11.9	0.0	< 0.001	6.8	16.8	6.8	2.1	< 0.001
Boys(n=291)	7.9	15.7	10.5	0.5	< 0.001	24.9	12.3	10.8	2.0	< 0.001
Overall(n=452)	8.8	19.5	11.3	0.2	< 0.001	15.2	14.7	8.6	2.0	< 0.001
P-value[a]	0.524	0.084	0.641	0.242		<0.001	0.136	0.108	0.948	
Overweight										
Girls	9.6	11.9	20.7	18.8	0.001	19.2	26.0	22.3	22.6	0.269
Boys	6.3	11.5	13.1	13.6	0.90	11.5	22.5	17.7	15.0	0.008
Overall	8.2	11.7	17.5	16.6	< 0.001	15.6	24.4	20.3	19.1	0.004
P-value	0.207	0.907	0.036	0.145		0.013	0.343	0.202	0.025	
Obesity										
Girls	21.1	16.1	7.3	22.9	< 0.001	17.1	6.2	8.9	15.1	< 0.001
Boys	17.8	7.9	9.9	20.4	0.001	25.3	16.6	19.9	31.6	< 0.001
Overall	19.7	12.6	8.4	21.7	< 0.001	20.9	11.0	13.8	22.8	< 0.001
P-value	0.388	0.009	0.313	0.577		0.019	<0.001	<0.001	<0.001	

WHO, world health organization; IOTF, the international obesity task force; CDC, The US center for disease control and prevention; National, Iranian national cut- points. [a]: Chi-square test.

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Discussion

The current study was conducted among children and adolescents living in central region of Iran. We examined the prevalence of underweight, overweight, and obesity based on various criteria. Based on the findings, the prevalence rate of underweight was 16.9% and 12.3% according to the criteria set by IOTF and WHO, respectively. This rate was 9.8% and 1.2% based on the cut-points set by CDC 2000 and national Iranian. The highest prevalence of overweight was estimated by CDC 2000 (19%) compared to other references. The Iranian national cut-off points showed the highest prevalence of obesity (22.3%) followed by WHO definitions (20.4%), while the other two criteria (namely IOTF and CDC 2000) estimated a similar prevalence rate (11.7% vs. 11.3%). Underweight is regarded as the substantial nutritional problem in childhood, which causes impaired immune function and reduces the quality of life. Furthermore, obesity and overweight are considered as global epidemic diseases and predisposing factor affecting the people mental and general health (Kossmann *et al.*, 2000, Mikki *et al.*, 2009, Popkin and Doak, 1998, Ramachandran and Gopalan, 2009).

Overweight children and adolescents are at higher risk of obesity in adulthood and obese adults are at greater risk of several chronic diseases such as CVDs, non-insulin dependent diabetes, hypertension, depression, and some types of cancers (Ahmadi *et al.*, 2015, Ahmadi *et al.*, 2013, Ramachandran and Snehalatha, 2010, Troiano *et al.*, 1995).

Studies investigating the prevalence of overweight and obesity in Iran indicated an increasing rate of obesity and overweight among Iranian youth and adults (Dorosty *et al.*, 2002, Rashidi *et al.*, 2005). In addition, the rate of metabolic syndrome is higher among Iranian children than those who live in the western societies, which may threaten them with serious health problems in adulthood (Esmaillzadeh *et al.*, 2006). No agreement exists over the criteria for assessing obesity and overweight, especially in children (Jebb *et al.*, 2004). Furthermore, we are faced with lack of universal criteria that justifies the difficulties of monitoring the development of obesity in children.

The prevalence of overweight in children and adolescents in Iran (Ayatollahi, 2003, Gargari *et al.*, 2004, Kelishadi *et al.*, 2003a) as well as some Middle Eastern countries (Al-Isa, 2004, Al-Sendi *et al.*, 2003) was examined by many studies, but the interpretation of their findings is usually difficult because most of them use different definitions of overweight and obesity. Indeed, few studies were conducted on the prevalence of obesity and overweight comparing the Iranian national cut-points with those of the international criteria namely IOTF, WHO, and CDC 2000. In a study conducting by Salehi et al. (Salehi-Abargouei *et al.*, 2013) on 837 adolescents living in Zabol (483 males; 354 females) aged 11-15 years, the Iranians' National criteria were compared with the international cut-off points such as IOTF, WHO, and CDC 2000. They reported that the Iranian national cut-points (27.2%), followed by IOTF criteria (25.8%) classified more individuals as underweight; whereas, in the current study, the WHO criteria produced higher underweight prevalence (15.2%) among the 11-18 year-old adolescents than other references. In addition, the highest prevalence of overweight was obtained by IOTF (10.8%) and CDC 2000 (9.4%), respectively; which was consistent with our findings. Indeed, our result showed that in the population aged 11-18 years old, IOTF (24.4%) and CDC 2000 (20.3%) criteria estimated the highest prevalence rates of overweight, respectively. In their study, the WHO definition had the highest rates of obesity (7.5%); while, in our study the Iranian national cut-points (22.8%), followed by WHO (20.9%) indicated the highest prevalence rates. Furthermore, in a cross-sectional study conducted by Bahreini, et al (Bahreini *et al.*, 2013) in Isfahan on 3002 students (1377 males; 1625 females) aged 11-18 years, it was reported that the highest prevalence of underweight was obtained by IOTF cut-points (33.5%), which was in consistent with our study. Actually, the prevalence of underweight was about 15.2%

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among 11-18 year-old participants based on the WHO criteria in our study. However, the IOTF cut-off points revealed the highest rate of overweight as 34.6% in their investigation, while it was 24.4% (based on IOTF) in our investigation in this age group. The WHO references estimated the highest prevalence of obesity (3.5%) among students in their study; whereas, the results in our research indicated that the Iranian national cut-points (22.8%) followed by WHO (20.9%) obtained the highest rates of obesity. Flegal et al. (Flegal *et al.*, 2001) indicated that the IOTF criteria always led to a lower rate of obesity and overweight than the national criteria, which is consistent with our study, specifically for obesity.

The strengths for this study are as the following. The population was within the age range of 6-18 years, who can represent the community of children and adolescents in Yazd City, Iran. Furthermore, no study has ever compared different definitions in evaluating the prevalence of underweight, overweight, and obesity in Yazd. Of the weak points of this study, we can mention that since the data were collected from Yazd province, the findings cannot be generalized to other provinces of Iran. In other words, the prevalence rates of underweight, overweight, and obesity are various in different provinces, depending on the circumstances. Therefore, future studies can be conducted in larger sample size that covers both urban and rural populations.

Conclusion

The aim of this study was to evaluate the prevalence of underweight, overweight, and obesity in children and adolescents in Yazd using several criteria. Based on the findings, the rate of BMI abnormalities was high based on the criteria set by CDC 2000, WHO, IOTF, and Iranian national standard among children in Yazd. Given that the individuals' eating habits and lifestyle develop during childhood, early and accurate assessment of the underweight, overweight, and obesity is important to prevent the development of chronic diseases in adulthood.

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Author contributions

Ahmadi N, Mohammadi MR, Mostafavi SA, Zahedifard M, and Araghi SM participated in data collection. Amiri M and Moghtaderi F were involved in study design, data management and data analysis. Moreover, Amiri M and Moghaderi F wrote the manuscript. Salehi-Abargouei A participated in study design, data analysis, and critical revision of the manuscript.

Conflict of interest

No conflict of interest was declared.

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