



Body Mass Index Percentile Curves for 7 To 18 Year Old Children and Adolescents; are the Sample Populations from Tehran Nationally Representative?

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Abstract

Background: The children's body composition status is an important indicator of health condition evaluated through their body mass index (BMI). We aimed to provide standardized percentile curves of BMI in a population of Iranian children and adolescents. We assessed the nationally representative of sample populations from Tehran.

Materials and Methods: A total sample of 14,865 children aged 7-18 years was gathered. The Lambda-Mu-Sigma method was used to derive sex-specific smoothed centiles for age via the Lambda-Mu-Sigma Chart Maker Program. Finally, the prevalence of overweight and obesity with 95% confidence interval (CI) was calculated.

Results: BMI percentiles obtained from Tehran's population, except for the 10th percentile, seem to be very slightly greater than the urban boys from all over Iran. BMI percentiles have an increasing trend by age that is S-shaped with a slight slope. Only in the 90th and 97th percentiles of BMI for girls, this rising trend seems to stop. Boys generally have higher BMIs than girls. The exceptions are younger ages of 90th and 97th percentiles and older ages of 3rd and 10th percentiles. A total number of 1,008 (13.20%; 95% CI: 12.46-13.98) boys and 603 (8.34%; 95% CI: 7.72-9.00) girls were categorized as overweight and obese. Obesity were observed in 402 (5.27%; 95% CI: 4.79-5.79) boys and 274 (3.76%; 95% CI: 3.35-4.22) girls.

Conclusion: We construct BMI percentile curves by age and gender for 7 to 18 years Iranian children and adolescents. It can be concluded that sample populations from Tehran are nationally representative.

Key Words: Body mass index; Children; Lambda-Mu-Sigma method Percentile curves.

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1- INTRODUCTION

For many years most researches all over the world had been focusing on poverty and malnourishment but recently strong evidence have surfaced indicative of a shift toward obesity and overweight, particularly in developing countries (1-3). Both malnutrition and obesity are major health problems especially among children and adolescents (3, 4). Other than the immediate consequences of obesity in children such as elevated lipid concentrations, high blood pressure and psychological problems (5, 6) overweight in childhood is also related to morbidity and mortality rates in adulthood since body weight and composition in childhood are both known to be important determinants of obesity in adulthood (7, 8). On the other hand malnutrition was reported by World Health Organization (WHO) to be associated with over half of child deaths in developing countries in 2015 (9). Malnourished children present a wide variety of physical and developmental manifestations such as immunologic impairments, developmental delay, permanent cognitive deficits and behavioral changes including irritability, apathy, anxiety and attention deficits (10-14).

So having a clear perception of the children's body composition status seems to be of utmost importance for the policy makers to take measures against these costly problems. Many methods have been proposed to assess the body composition in children and adolescents, of which body mass index (BMI) was found to be the most practical in clinical settings (15-17). For anthropometric indices such as BMI to be applicable in practice in the pediatric age group, standards should better be defined by age and gender, based on local data (15, 16). Therefore, BMI reference percentiles have been published in many different regions such as North America (18), France (19), Britain (20), Italy (15),

Germany (21), Turkish (22) and Sweden (23). Similar survey has also been conducted in Iran in 1990-1991 by Hosseini et al. on a population of 3,301 subjects aged 2-18 years from Tehran (24). Constructing standard curves requires large and representative sample size (25). To achieve this goal, we need participants from all around the country which requires spending resources (staffing, time, money, and etc). However, even in these cases large percentage of missing data are unavoidable (26). Therefore, some studies suggest to overcome this problem, by taking data from the capital of countries as a representative population for construction of the national norms; as the capital cities accepts immigrants from all parts of the country (27). However, such study on anthropometric indices for representativeness of Tehran based on large independent studies has not been carried out. Therefore, the present study was designed with two aims: **First**, to determine whether data on BMI of children and adolescence from Tehran can be representative of the whole country? **Second**, to compare BMI curves based on Tehran population with percentile curves produced by the Centers for Disease Control and Prevention (CDC).

2- MATERIALS AND METHODS

2-1. Study population

To assemble a total sample of 14,865 children and adolescents aged 7 to 18 years, data from two cross-sectional studies were used. The first study sampled 8,848 primary school children aged 7-12 from Tehran during November 2000 to November 2002. Also conducted in Tehran, the second survey collected data from 6,017 secondary school children and adolescents aged 12-18 in 2004. The criteria for being healthy and full detail of procedure of measurement of weight and height are reported in previous studies (28-30).

2-2. Measurements

Trained medical staffs measured height and weight data. Height was measured in centimeters using a stadiometer (SECA Model 207 Germany) with the subject barefoot, standing upright with the heels and back against a vertical scale. Without shoes and heavy outer clothing, weight was measured on a balanced scale (SECA Model 710 Germany) which was daily calibrated. Body Mass Index (BMI) was calculated as the individual's body mass (kg) divided by the square of their height (m^2). To evaluate the representativeness of the mentioned sample, we compared it with the data gathered by Kelishadi et al. through the first Childhood and Adolescence Surveillance and Prevention of Adult Non-communicable diseases (CASPIAN) survey, conducted in a national setting (31).

2-3. Statistical analysis

Since CASPIAN-I survey was conducted on the age group of 6 to 18 years, to compare our data with them, age-compatible subjects were chosen from our survey including the children and adolescents aged 7 to 18 years old. The average differences of BMI percentiles by gender and area between these two datasets are calculated. The figures are calculated by subtracting CASPIAN-I results from our results.

STATA (version 12.0) was used to compute descriptive statistics and to produce the graphs. To develop age-related percentiles for both genders and to smooth and fit the model, Lambda-Mu-Sigma Chart Maker Program (32) was used. The Lambda-Mu-Sigma (LMS) method of Cole and Green was used to derive sex-specific smoothed centiles for age (33). In this method three curves are utilized to demonstrate the trend of changes in BMIs of the study population; the L, M and S curves define the skewness, the median and the coefficient of variation,

respectively, as functions of age. Age- and gender-specific percentiles (3rd, 10th, 25th, 50th, 75th, 90th, and 97th) of BMI were constructed for both our study population from Tehran and study population of the CASPIAN-I survey in 2003-2004 using Lambda-Mu-Sigma Chart Maker Program. Normality of the Z-Scores and goodness-of-fit were examined via de-trended Q-Q plot and Chi square test, respectively.

Finally, prevalence of obesity (BMI>95th percentile) and overweight (BMI>85th percentile) with 95% confidence interval (CI) was measured. Cut-off points for defining obesity and overweight were based on the center of disease control and prevention (CDC) standard values data (34).

3- RESULTS

Two cross-sectional surveys were combined to create a total sample of 14,865 children and adolescents aged 7 to 18 years. Baseline characteristics of the combined study are presented in (**Table.1**).

From the total 7,635 boys included in this sample 4,505 (59.0%) were 7 to 12 years old and 3,130 (42.0%) were aged 13 to 18 years. 4,698 (64.98%) girls aged 7 to 12 years and 2,532 (35.02%) girls aged 13 to 18 years comprised the total 7,230 girls included in this survey. For boys and girls, the mean BMI of the 7 to 12 year old age group was 16.36 ± 2.89 and 15.89 ± 2.85 , respectively. The mean BMI for the age groups of 13 to 18 were 21.05 ± 4.10 (boys) and 19.82 ± 3.70 (girls).

To evaluate the national representativeness of our study (the sample chosen from Tehran), we compared it with the national survey of CASPIAN-I. The average differences of BMI percentiles by gender and area between these two datasets are demonstrated in (**Table.2**). As presented, BMI percentiles obtained from Tehran's population, except for the 10th percentile, seem to be very slightly greater than the

urban boys from all over Iran although the average divergences are less than 0.3 kg/m². However, all Tehran's percentiles are smaller than urban girls derived from CASPIAN-I study, at the most 0.84 kg/m². A total number of 1,008 boys (13.20%; 95% CI: 12.46-13.98) and 603 girls (8.34%; 95% CI: 7.72-9.00) were categorized as overweight and obese.

The prevalence of overweight and obesity in 7-12 and 13-17 years old boys were 9.68 (95% CI: 8.85-10.58) and 18.27 (95% CI: 16.96-19.66), respectively. The prevalence of overweight and obesity in 7-12 and 13-17 years old girls were 6.92 (95% CI: 6.23-7.68) and 11.32 (95% CI: 10.19-12.67). In addition, obesity were observed in 402 (5.27%) boys (95% CI: 4.79-5.79) and 274 (3.76%) girls (95% CI: 3.35-4.22). The prevalence of overweight and obesity was higher in boys than the girls (**Table.1**).

Table.3 presents the 3rd, 10th, 25th, 50th, 75th, 90th, and 97th percentiles of BMI by age and gender in participants. To create a better perception of this table, these values are depicted as curves and compared in (**Figure.1**). As can be seen, overall, BMI percentiles have an increasing trend by age that is S-shaped with a slight slope. Only in the 90th and 97th percentiles of BMI for girls, this rising trend seems to stop. In the 3rd, 10th and 25th percentiles, the differences between the two genders seem to be more prominent in younger ages, while these differences in the 50th, 75th, 90th and 97th percentiles are more significant in older ages and the curves tend to diverge more with increasing age and in higher percentiles. Boys generally have higher BMIs than girls. The exceptions are younger ages of 90th and 97th percentiles and older ages of 3rd and 10th percentiles where girls show higher BMIs than compared to boys.

Table 1: Baseline characteristics of the reference population of children and adolescents (7635 boys and 7230 girls and aged 7–18 years)

Variables	Age (years)	
	7-12	13-18
Children included, (number)		
Boys	4505	3130
Girls	4698	2532
Weight, mean (SD), kg		
Boys	29.50 (±8.38)	58.33 (±15.15)
Girls	27.73 (±7.92)	48.28 (±11.51)
Height, mean (SD), cm		
Boys	133.2 (±10.3)	165.6 (±11.5)
Girls	131.0 (±10.3)	155.3 (±8.7)
BMI, mean (SD), kg/m ²		
Boys	16.36 (±2.89)	21.05 (±4.10)
Girls	15.89 (±2.85)	19.82 (±3.70)
Overweight and obese, n (weighted % of 7635 boys and 7230 girls)		
Boys	436 (9.68)	572 (18.27)
Girls	325 (6.92)	288 (11.37)
Obese, n (weighted % of 7635 boys and 7230 girls)		
Boys	171 (3.80)	231 (7.38)
Girls	182 (3.87)	92 (3.63)

SD: Standard deviation.

Table 2: Average differences of BMI percentiles based on Tehran data and CASPIAN-I according to gender and area

Gender & area	Percentiles						
	3 rd	10 th	25 th	50 th	75 th	90 th	97 th
Boy							
Urban Iran	0.102	-0.006	0.1654	0.152	0.213	0.298	0.022
All over Iran	0.343	0.244	0.257	0.137	0.244	0.584	0.859
Girls							
Urban Iran	-0.171	-0.225	-0.287	-0.456	-0.572	-0.580	-0.840
All over Iran	-0.189	-0.243	-0.272	-0.396	-0.414	-0.518	-0.856

Table 3: Percentile values of body mass index (kg/m²) by age and gender for Iranian children

Age (year)	Number	Percentiles						
		3 rd	10 th	25 th	50 th	75 th	90 th	97 th
Boys								
7	494	12.07	12.71	13.56	14.54	15.91	17.53	19.32
8	701	12.27	12.97	13.89	14.98	16.49	18.30	20.35
9	764	12.50	13.26	14.26	15.46	17.12	19.14	21.48
10	990	12.76	13.58	14.67	15.98	17.82	20.07	22.74
11	1096	13.14	14.03	15.21	16.66	18.69	21.20	24.24
12	460	13.68	14.66	15.94	17.54	19.79	22.58	26.02
13	554	14.33	15.38	16.78	18.52	20.99	24.06	27.88
14	521	14.91	16.03	17.52	19.39	22.03	25.32	29.43
15	537	15.38	16.56	18.12	20.08	22.84	26.28	30.55
16	558	15.72	16.94	18.55	20.57	23.41	26.93	31.27
17	456	16.01	17.26	18.91	20.97	23.86	27.42	31.77
18	504	16.28	17.56	19.24	21.34	24.26	27.85	32.20
Girls								
7	489	11.53	12.36	13.22	14.38	15.96	17.81	19.78
8	700	11.62	12.50	13.42	14.66	16.37	18.38	20.57
9	835	11.81	12.74	13.73	15.07	16.91	19.10	21.54
10	985	12.15	13.14	14.20	15.64	17.64	20.03	22.74
11	1120	12.61	13.66	14.80	16.36	18.51	21.10	24.07
12	569	13.25	14.37	15.59	17.25	19.56	22.34	25.54
13	398	14.00	15.19	16.48	18.24	20.68	23.61	26.98
14	350	14.74	15.98	17.32	19.14	21.66	24.68	28.11
15	345	15.37	16.63	18.00	19.84	22.38	25.40	28.78
16	397	15.82	17.10	18.46	20.28	22.79	25.74	28.99
17	441	16.16	17.43	18.77	20.55	22.99	25.83	29.10
18	601	16.46	17.71	19.02	20.76	23.12	25.85	29.15

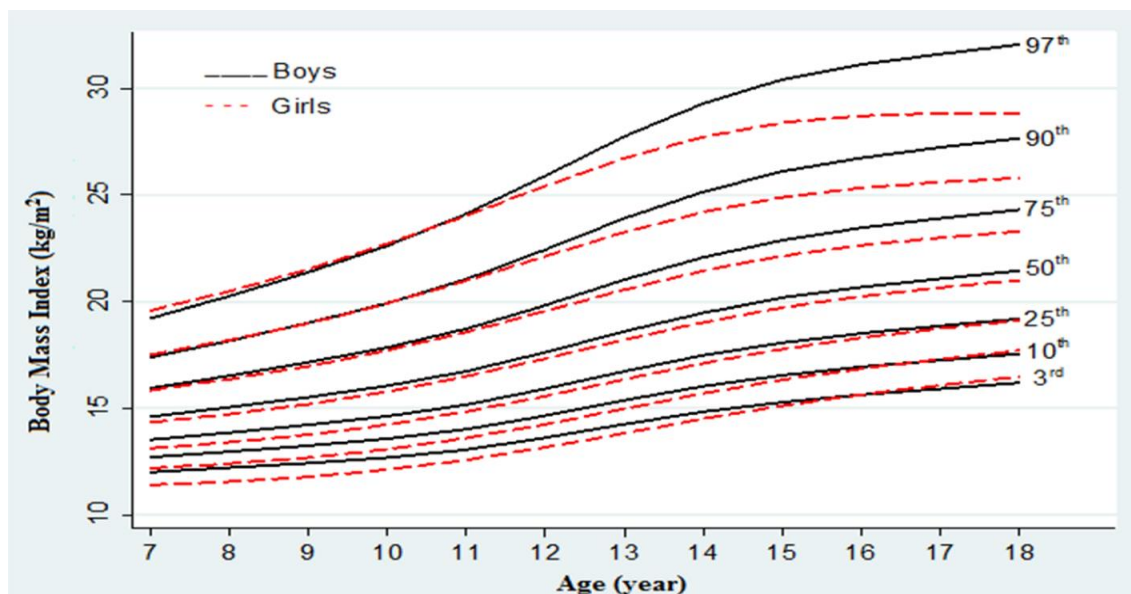


Fig.1: Comparison of BMI percentiles curves for Iranian boys and girls.

4- DISCUSSION

We construct BMI percentile curves by age and gender for 7 to 18 year old Iranian children and adolescents. The differences of these percentiles are in general negligible with CASPIAN I study. Therefore, it can be concluded that sample populations from Tehran are nationally representative.

Data gathered from 14,865, 7 to 18 years old children and adolescents of Tehran were used to develop BMI percentile curves by age and gender. As presented in (Figure.2), these curves are compared to the percentile curves produced by the CDC in 2000 (35). As can be seen, in subjects younger than 12 years old in all the percentiles, our curves are lower than the CDC's data. In the 3rd, 10th, 25th, and 50th percentiles the trend continues to the age of 18 and the CDC's curves stay higher than ours all the way through, but the differences decrease and reaches its lowest around the age of 14 and then the curves diverge again. In the 75th, 90th, and 97th percentiles our data exceeds the CDC's curves around the age of 12 and the differences reach their peaks nearly at the

age of 15 and then curves converge again. The curves derived from our data seem to follow a sharper S-shaped slope compared to CDC's curves. The mentioned differences are very similar in both genders. The differences between the curves mentioned before the age of 12 can be attributed to a higher prevalence of malnutrition in our country during these ages. On another note all of these discrepancies might be due to differences in racial characteristics, diet and lifestyle. Further investigation is required to evaluate these hypotheses. This data shows the difference of BMI levels between Iranian and Americans children and adolescents and warrants specific normal BMI levels for Iranian population.

As explained, in order to evaluate the representativeness of this survey's study population for the whole country we compared our results to the study published by Kelishadi et al. in 2003-4 (31). The survey, also known as CASPIAN-I, was conducted on a sample of 21,111, 6 to 18 year old students. The study population was selected through a multistage random cluster sampling from urban and rural areas of 23 provinces of

Iran. Naturally the subjects aged 7 to 18 years old were selected from their study to be comparable with our study population. The differences are in general negligible and this suggests that our study population selected from Tehran, having evaluated a larger sample size, can be considered representative of the CASPIAN-I study population which assessed a smaller but national sample.

Representativeness of a sample from Tehran for the whole country has also been evaluated on data from national health survey in 1990-1991 by Hosseini et al. (36) as was found in this survey, comparing our results with the CASPIAN I survey. Since same results are yielded through a time period of approximately 14 years and during this period, the differences have not expanded significantly, it can be hypothesized that

this might go on through time and a sample chosen from the capital city will always be representative of the country's whole population.

Prevalence of obesity in present study was 5.27% and 3.76% in boys and girls, respectively. In line with our findings, Mirmohammadi et al. reported the prevalence of obesity were 3.75% and 2.71 in Iranian boys and girls, respectively (37).

In addition Jafari-Adli et al. in their systematic review demonstrated that the range of national reported prevalence of obesity in national studies among children under-18 years was 3.2-11.9% (38). As you can be seen, the result of present study is close to other reports. The prevalence of overweight and obesity in boys were higher than girls.

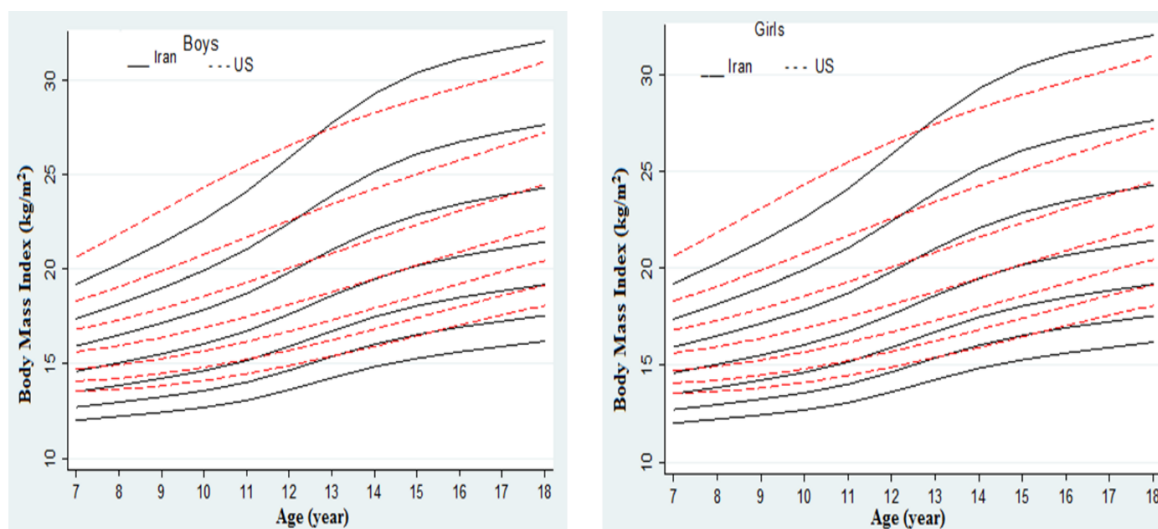


Fig.2: Comparison of BMI percentiles of Iranian children and adolescence with center of disease control and prevention (CDC) standard values data (3rd, 10th, 25th, 50th, 75th, 90th and 97th).

5- CONCLUSION

Data gathered from 14,865, 7 to 18 years old children and adolescents of Tehran were used to develop BMI percentile curves by age and gender. The differences of these percentiles are in general negligible with CASPIAN I study. Therefore, it can be concluded that sample

populations from Tehran are nationally representative.

6- CONFLICT OF INTEREST: None.

7- ACKNOWLEDGMENT

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