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A Comparative Study of Reference Data for Body Mass index of School children in Shiraz (Southern Iran) and CDC Standards

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Abstract

Background: Several methods have been used to estimate adiposity with high precision, but BMI has become the most common marker in identifying overweight and obese subjects. This study was performed to present reference data for body mass index (BMI) of school children aged 6.5-11.5 years in Shiraz, southern Iran.

Methods: The data of present study are based on a random multi stage sample survey of 2397 healthy school children in Shiraz, southern Iran. The participants were 1268 boys and 1129 girls and their heights and weights were measured in 2002-2003 academic year. Joint height-weight measurements were available for 2195 (91.6%) including 1138 boys (89.7%) and 1057 girls (93.6%). Healy-Rasbash-Yang (HRY) distribution-free method was applied to estimate BMI age-related centiles.

Results: Cubic polynomials in age are shown to adequately fit the BMI data (on log scale). Children are now heavier than those born over ten years earlier. Boys BMI lie above girls to around 10 years of age, which is subsequently reversed for overweight and obese centiles.

Conclusions: Comparison of these BMI curves with those of CDC charts showed substantial differences at every age and suggested the necessity for the use of locally based BMI norms for assessing body mass index of children in Shiraz, Southern Iran. Also, a positive secular trend in BMI is seen during the past decade in Iran.

Keywords: Body mass index (BMI); Reference values; School children; Secular trend; CDC charts

Introduction

Weight and height are highly correlated during childhood so that children's weight centile tends to be strongly influenced by their height centile. Both are a reflection of the child's size, tall versus short rather than their shape, fat versus thin.[1] Obesity appears to be worldwide and in many countries has reached epidemic proportions.[2] Of particular concern is the evidence for an accelerated rate of obesity in children,[3] that often tracks into adulthood.[4,5] Several methods have been used to estimate adiposity with high precision, but due to high cost, time consuming and impracticality in clinical setting and difficulty to apply to children,[6] body mass index (BMI) has become the most common marker in identifying overweight and obese subjects.[7] BMI has recently been recommended as a measure of excessive weight in children,[1] which changes substantially with rising age during school years,[8,9] and used routinely to evaluate child obesity.[9,10] Accordingly, child BMI needs to be assessed using age-related reference curves.[1] Age-related pediatric BMI reference values have been reported in several developed and developing countries such as North America,[6,9,11] France,[12] Britain,[1] Sweden,[13] Italy,[14] Germany,[15] China,[16] Dutch,[17] Croasy,[18] Australia,[19] Cyprus,[20] Belgium,[21] and Japan.[22] However, during the last decade several studies have been carried out in Iran to document obesity in childhood,[23-28] and presented this phenomenon in a meaningful fashion in the pediatric age group, providing standards in relation

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to age and gender, based on local data as advocated by Hammer et al.[6] Most of these reference data,[23,24,26] seem to be outdated, because they are based on children born during the 8-year war of Iraq against Iran. The present study, therefore, presented BMI reference data for children born at least 2 years after the cease-fire in Shiraz (southern Iran), one of the 5 principal cities of Iran. The values thus obtained were compared with the results of the recently updated CDC data,[29] since due to lack of appropriate data, American references have been used worldwide. However, since 1994, WHO began planning for new references (WHO Multicenter Growth reference study, 1997-2003) based on a wider sample obtained from other countries (WHO 57th world health assembly provisional agenda item 12-15, A57/18,2004). The paper further compares BMI of our data with those of the Iranian children measured during 1990-1992.[26,27]

Materials and Methods

The data related to a random sample of 2397 healthy school children (1268 boys, 1129 girls) aged from 6.5-11.5 years and selected in a multi stage scheme. The data included a 2% sample of the school children from the four educational districts of Shiraz (southern Iran), during academic year of 2002-2003. Heights and weights were measured to the nearest 0.1 Cm and 0.1 Kg respectively, using a SECA marked stadiometer and the techniques presented by Cameron. Weights were adjusted for the type of closing giving the real weight. The valid measurements for height were available for 1161 boys (91.6%) and 1069 girls (94.7%), and those for weight were obtained for 1141 boys (90%) and 1064 for girls (94.2%). Both valid weight and height measurements were available for 2195 (91.6%) subjects including 1138 boys, 1057 girls. Body mass index was expressed as weight divided by square of height in metric system (Kg/m^2) for each subject,[30] was calculated. Two sample t-tests were used to compare our BMI data with those of the CDC,[29] and Tehran BMI data[26] using SPSS 11.5 software. Healy-Rasbash-Yang [HRY],[31] distribution-free method was applied to estimate age-sex related smoothed BMI percentiles. The BMI data were first normalized by applying log transformation to obtain best fitting (Personal communication with Professor Healy) and the Excel software was used for graphing purposes. We have adopted 5th, 85th and 95th centile as cut-off points for thin, overweight, and obese children respectively, as generally accepted.[10,11,21]

Results

As shown in Table 1, the summary statistics of BMI by age and sex of school children under study were compared with that of the CDC. BMI increased with age, but no differences were found between genders ($P>0.10$). However, our subjects' BMI were significantly lower than that of their peers in USA ($P<0.001$). Smoothed percentiles of boys and girls BMI (Kg/m^2) of our school children are presented by age and sex in Table 2.

The present study provides the first age and sex related reference values for BMI of school children in Shiraz, southern Iran. Fig. 1 compares boys and girls BMI of Shiraz for selected centiles for thin, median, overweight and obese children. Figs. 2a and 2b compared BMI of our children with their peers in the USA. The reference curves for Iran 1990-1992 and the secular trends in BMI of children during the period of 1990-92 to 2003 were presented in Table 3.

Table 1: Number (*n*), mean $(\overline{X})$, standard deviation (*SD*) and 95% confidence interval (95%*CI*) of BMI by age and sex compared to CDC values

Age (Years)*	Boys				Girls				CDC Mean BMI	
	n	$\overline{X}$	SD	95% CI	n	$\overline{X}$	SD	95% CI	Boys	Girls
7 ±	209	15.3	1.4	(15.1,15.5)	167	15.3	1.6	(15.1,15.5)	15.5**	15.5**
8 ±	204	15.5	1.6	(15.3,15.7)	197	15.6	1.7	(15.3,15.8)	15.8**	15.9**
9 ±	229	16.2	2.2	(15.9,16.5)	202	16.1	2.126	(15.8,16.3)	16.3**	16.4**
10 ±	236	16.5	2.3	(16.2,16.8)	234	16.5	2.7	(16.2,16.9)	16.6**	16.9**
11 ±	260	16.8	2.3	(16.6,17.2)	257	17.2		(16.9,17.6)	17.2**	17.5**
All	1138	16.1	2.1	16.0,16.2)(	1057	16.2	2.4	(16.1,16.4)		

*In this Table 7±, 8±, … signify 6.5-7.49,7.5-8.49, etc.

** Age by sex BMI difference between our study and the CDC are significant ($p<0.001$).

Table 2: Smoothed percentiles of BMI (Kg/m^2) for school children in Shiraz, Iran

Age (years) and sex	Percentiles								
	3	5	10	25	50	75	85	95	97
Boys									
6.5	13.6	13.8	14.2	14.7	15.3	16.0	16.4	17.9	18.6
7.0	13.4	13.5	13.9	14.5	15.2	15.9	16.5	18.2	18.9
7.5	13.1	13.3	13.7	14.3	15.1	16.1	16.8	18.7	19.5
8.0	13.1	13.3	13.7	14.3	15.2	16.4	17.2	19.3	20.1
8.5	13.2	13.5	13.7	14.5	15.4	16.7	17.7	20.1	20.7
9.0	13.4	13.7	13.8	14.7	15.7	17.1	18.2	20.7	21.4
9.5	13.6	13.9	14.0	14.9	16.0	17.5	18.6	21.3	22.1
10.0	13.7	14.0	14.9	15.1	16.2	17.8	18.8	21.8	22.7
10.5	13.7	14.0	15.1	15.2	16.3	18.0	19.0	22.1	23.2
11.0	13.6	13.9	15.2	15.1	16.1	18.2	19.2	22.4	23.6
11.5	13.5	13.8	15.2	15.1	16.2	18.2	19.3	22.5	23.8
Girls									
6.5	13.5	13.8	14.2	14.7	15.5	16.4	17.0	18.3	19.0
7.0	13.2	13.4	13.8	14.4	15.1	16.2	16.9	18.4	19.1
7.5	13.0	13.3	13.6	14.3	15.1	16.2	17.0	18.7	19.5
8.0	12.9	13.2	13.6	14.3	15.1	16.4	17.3	19.2	20.0
8.5	13.0	13.3	13.7	14.4	15.3	16.7	17.7	19.7	20.6
9.0	13.2	13.4	13.8	14.5	15.5	17.1	18.1	20.4	21.3
9.5	13.3	13.6	13.9	14.7	15.8	17.4	18.6	21.1	22.1
10.0	13.5	13.7	14.1	14.9	16.0	17.9	19.1	21.8	22.8
10.5	13.5	13.8	14.2	15.0	16.3	18.2	19.6	22.4	23.5
11.0	13.6	13.8	14.2	15.1	16.5	18.5	20.0	23.0	24.2
11.5	13.5	13.9	14.3	15.1	16.4	18.6	20.2	23.4	24.7

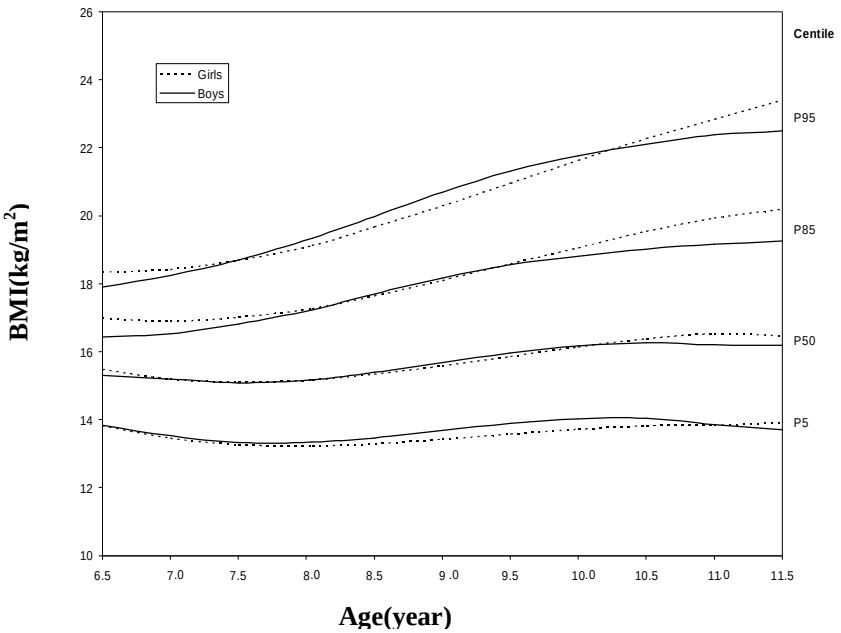

Fig 1: Comparison of body mass index by age charts of schoolboys and girls in Shiraz, Iran for thinness (p5), median (p50), overweight (p85) and obese (p95)

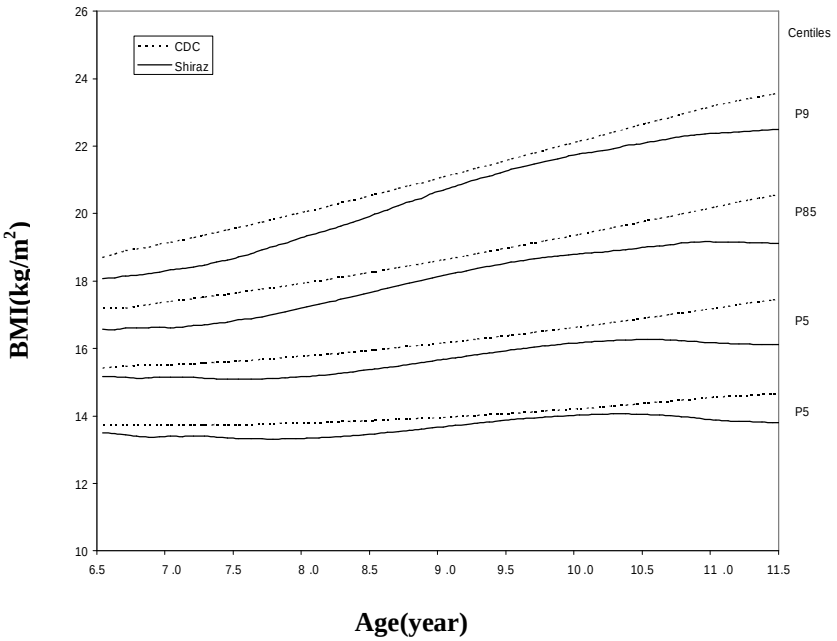

Fig 2a: Comparison of BMI by age charts of schoolboys in southern Iran with their peers in USA (CDC) for selected centiles.

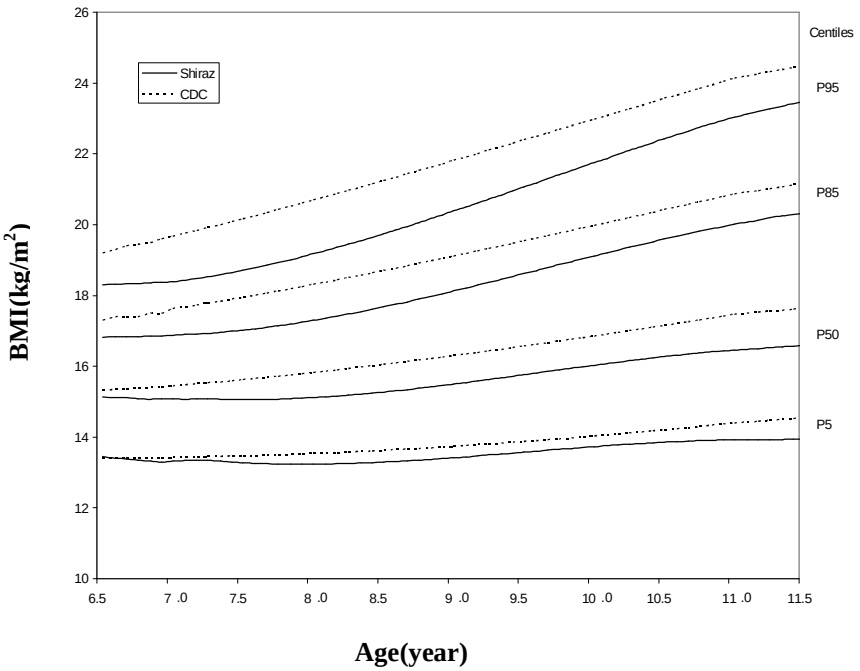

Fig 2b: Comparison of BMI by age charts of schoolgirls in southern Iran with their peers in USA (CDC).

Table 3: BMI equivalent CDC percentiles (BMIECDC) to the 50th centiles of Iranian children by age and sex and BMI secular for the period of (1990 to 2003)

Age (years)	Boys			Girls		
	BMIECDC (2003)	BMIECDC (1990)	Secular trend in Iran	BMIECDC (2003)	BMIECDC (1990)	Secular trend in Iran
7	41.7	23.3	0.7	40	19.4	0.9
8	35	22.5	0.5	34.8	14.5	0.8
9	38.6	22.6	0.7	50	19.5	0.8
10	40.9	24	0.8	34.6	22.2	0.8
11	33.3	25	0.5	33.3	22.8	0.7

Discussion

As Figs. 2a and 2b shows American children were significantly more overweight and obese than our children. There were striking differences in the lower as well as the upper centiles.The median BMI values of our subjects were lower than their American counterparts corresponding to almost 38th CDC centile, while the median BMI values of the Iran study in 1990-92 lay approximately on the 20th centile of the Americans**.** American BMI smoothed centiles were estimated based on the parametric LMS,[32] method, whereas our BMI centiles were obtained using HRY distribution free method. Incidentally, the normalization of BMI data using a log transformation outer centiles was estimated with sufficient precision. However, the normalization procedures were different. The technical and methodological comparison of the two smoothing methods was discussed elsewhere.[33] Age- related and sex-specific centiles of BMI of our subjects were expressed according to CDC growth charts. Table 3 showed a positive secular trend of the order of 0.7 or 0.8 BMI for boys and girls respectively. This may be attributed to the economic developments as well as modernization process in the Iran's post war reconstruction period. However, the fitted models of BMI followed the same style.[26] BMI is a useful index of weight relative to stature.[34] The age-sex related centiles of BMI for school children in Shiraz offer an opportunity to monitor an individual's degree of fatness or thinness and is a practical approach and a simple technology for preventive measures. The population of Iran is extremely young with over 32% below 15 years of age and 12% school-age children.[35]

Iranian children grow and develop differently due to differences in genetic, cultural and environmental factors acting singly or in combination. Therefore, the global recommendation of WHO-standards based on American children can be quite misleading. Our data supports using updated local BMI standards, which concurs with other studies carried out in Iran, in the recent decades.[23-27] Several reasons have accounted for up shifting of BMI in Shiraz school children. These include changing dietary habits and physical activity patterns due to rapid urbanization and modernization and technological transformation. Limited outdoor activities due to specific climate and/or social conditions, cultural preferences among some sub communities and social classes, which consider weight, gain and fat storage as signs of health and prosperity, are other factors contributing to rising BMI. Finally, the untargeted governmental subsidization of the energy-rich foods such as fat and sugar is also responsible for elevated BMI.[36]

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