

Reference curves of anthropometric indices in two national studies conducted among Iranian children in 2003-2004 and 2009-2010: The Caspian study

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Background: Reference percentile curves are usually used as a screening tool to determine growth disorders. Anthropometric indices are population-dependent and may differ according to ethnicity, dietary pattern and lifestyle habits. This study aims to compare the curves of anthropometric measures obtained in two national studies conducted among Iranian children and adolescents in 2003-2004 and 2009-2010. **Materials and Methods:** Anthropometric measures obtained in two nationwide surveys conducted in 10-18-year-old Iranian students were compared. Lambda-mu-sigma (LMS) Chart Maker Pro program was used to develop age- and gender-specific percentiles and to smooth and fit the model. **Results:** In 2003-2004, the mean and standard deviation (SD) of body mass index (BMI) and waist circumference (WC) were 18.98 ± 3.81 kg/m² and 67.50 ± 11.05 cm in boys; and 19.44 ± 3.78 kg/m² and 66.55 ± 9.89 cm in girls, respectively. In 2009-2010, the corresponding figures were 19.16 ± 4.07 kg/m², 69.42 ± 11.43 cm, 19.63 ± 4.11 kg/m², and 67.29 ± 9.69 cm, respectively. Height curves did not show considerable changes in two studies. Comparison of two series of studies showed that the weight, BMI, WC, and waist-to-height ratio were lower in adolescent girls than boys especially in higher percentiles. Moreover, in both genders, weight, BMI, and WC percentiles decreased. **Conclusion:** The growth charts of Iranian children and adolescents aged 10-18 years have changed over 5 years. The reference growth curves change over time in the pediatric age group, repeated surveys should be conducted to update the age- and gender-specific reference curves in different populations.

Key words: Anthropometric indices, children and adolescents, Iran, reference curve

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INTRODUCTION

Childhood obesity is becoming a global health problem.^[1] Nowadays, most chronic diseases are related to body weight and obesity.^[2,3] Cohort studies have shown that growth disorders in childhood and adolescence are associated with weight disorders in adulthood.^[4] The amount of adipose tissue and the diet type^[5] have strong effects on anthropometric indices and cardiometabolic risk factors. Some measurements and cut points are strongly dependent to the age and time; this is of special concern for the pediatric age group experiencing the process of growth. Therefore, reference percentile curves are usually used as a screening tool to determine growth disorders.^[6] Anthropometric indices are population-dependent and may differ according to the dietary pattern and lifestyle habits. Our previous study showed that patterns of anthropometric indices and

cardiometabolic risk factors are different in three ethnic groups (Brazilian, Iranian and German) of children.^[7]

Therefore, definition and determination of age-and gender-specific percentile curves should be considered for children and adolescents in each country. Iran has a young population, 23.4% of them have <14 years of age; hence, gathering information about the changes of growth status in this age group over time is necessary.^[4] The present study aims to compare the curves of anthropometric measures obtained in two national studies conducted among Iranian children and adolescents in 2003-2004 and 2009-2010.

MATERIALS AND METHODS

Data sampling

This study used the data obtained from two nationwide population-based surveys conducted in 2003-2004 and

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2009-2010 in Iran.^[8,9] These surveys were performed as two surveys of a surveillance program entitled: Childhood and adolescence surveillance and prevention of adult non-communicable disease (CASPIAN study). We have previously reported the methodology in detail^[8,9] and we summarize it here. The 2003-2004 and 2009-2010 studies were performed by the same methods in rural and urban areas of 23 and 27 provinces of Iran, respectively. The project team selected students by multistage-random cluster sampling from primary, middle- and high schools of urban and rural areas of different counties. Totally, 21108 students during 2003-2004 and 5312 students during 2009-2010 were collected. Numbers of individuals after exclusion missing data were 15,883 students during 2003-2004 and 5312 students during 2009-2010 that were 10-18 years of age. Our team obtained written informed consent from parents and oral assent from students after full explanation of the procedure of the study. Anthropometric measurements such as height, weight, waist circumference (WC) were determined by standard protocol and by using calibrated instruments. Body mass index (BMI) was computed as weight (kg) divided by the height squared (m²). WC was measured with an un-stretchable tape at middle of the lowest gear and the top of the iliac crest at the end of the normal expiration.

Statistical analysis

In this study, reference percentiles were calculated using the lambda-mu-sigma (LMS) method of Cole and Green.^[10] This method assumes that for independent positive data y_i ($i = 1, 2, n$) at ages T_j ($j = 1, 2, \dots, m$) an age-specific Box-Cox transformation can be applied to the data to make them normally distributed.

The distribution of the y_i at T_j is summarized by the median $M(T_j)$, coefficient of variation $S(T_j)$, and skewness $L(T_j)$, the latter expressed as a Box-Cox power. The quantities L , M and S , are estimated by maximum penalized likelihood and the extent of smoothing required can be expressed in terms of smoothing parameters or equivalent degrees of freedom.

The z-score or the standard deviation score, was calculated as:

$$Z_i = \frac{[y_i / M(T_j)]^{L(T_j)} - 1}{L(T_j)S(T_j)}$$

The measurement 100α centile at age T_j is given by

$$C_{100\alpha}(T_j) = M(T_j) (1 + L(T_j) S(T_j) z_\alpha)^{1/L(T_j)}$$

Where z_α is the corresponding Normal equivalent deviate corresponding to the required centile.

Age-and gender-specific centiles (5th, 10th, 25th, 50th, 75th, 90th, and 95th) of anthropometric measures of Iranian children were calculated for the years of 2003-2004 and 2009-2010. Outlier data were detected with Z-Scores graph and excluded from the analysis since these may affect the overall curve modeling. Normality of the data and goodness-of-fit were examined via detrended Q-Q plot and Q-tests, respectively.

Lambda-mu-sigma Chart Maker Pro program (version 2.54, Medical Research Council, Cambridge, UK) was used to develop age-related centiles for boys and girls and to smooth and fit the model. After developing age and sex specific centiles, the percentile curve graphs were plotted by using SAS 9.2 software. Furthermore, descriptive statistics were calculated using SPSS version 20.0 (Illinois, Chicago, USA).

RESULTS

Mean and SD of anthropometric measurement in both studies are shown in Table 1.

In both years of study, BMI was higher in girls than in boys in most percentiles, especially in the higher ones. The trajectory of 2003-2004 diagrams had almost the same trend in both genders, but in 2008-2009, more differences were documented between 13 and 17-year-old boys and girls.

In both years, the girls’ height was higher than boys until 14 years of age, thereafter; it was higher in boys than in girls. However, boys’ height in 2008-2009 had sharper slope than 2003-2004. In both studies, after the age of 15, the height curves became flat without further change.

In both studies, the mean weight was higher in boys than in girls after the age of 16. In 2009-2010, girls’ weight decreased and in 2003-2004 became flat approximately after 16 years of age.

In both studies, most percentiles of WC were higher in boys than in girls after the age of 15. However Boys’ WC increased with a steeper slope in 2009-2010 than in 2003-2004. Girls’ WC had descending slope in 2009-2010 and ascending slope in 2003-2004 in 75th, 90th, and 95th percentiles.

Table 1: Mean (SD) values of anthropometric indices

Variables	Study year			
	2003-2004		2009-2010	
	Boys	Girls	Boys	Girls
Weight (kg)	48.93±14.77	47.10±11.80	47.78±16.32	46±12.98
Height (cm)	159.06±14.73	154.91±10.39	155.87±15.17	152±11.16
BMI (kg/m ²)	18.98±3.81	19.44±3.78	19.16±4.07	19.63±4.11
WC (cm)	67.50±11.05	66.55±9.89	69.42±11.43	67.29±9.69

SD = Standard deviation; BMI = Body mass index; WC = Waist circumference

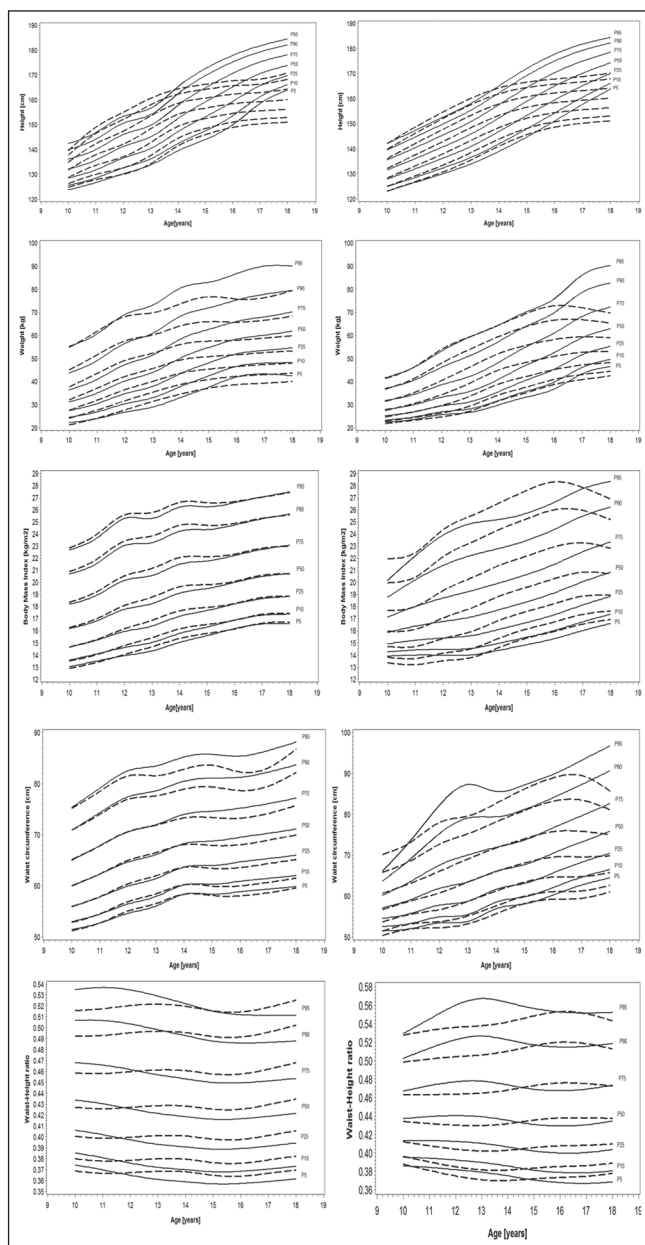


Figure 1: Comparison of age-specific reference curves for anthropometric indices in Iranian children in two studies (--- girl, ---- boy) (P5: 5th percentile, P10: 10th percentile, P25: 25th percentile, P50: 50th percentile, P75: 75th percentile, P90: 90th percentile, P95: 95th percentile)

WHtR in boys was greater than girls approximately up to 12 years of age in 2003-2004, and up to 14 years in 2009-2010 especially in the 90th and 95th percentiles. Whereas after these ages, WHtR became greater in girls than in boys. Figure 1 showed comparison of age-specific reference curves for anthropometric indices in Iranian children in two studies.

DISCUSSION

We compared the anthropometric measures curves of two nationwide studies (in 2003-2004 and in 2009-2010) among Iranian children and adolescents; in both genders different

patterns were documented in anthropometric measures other than height. The main differences are seen in various age groups. In both studies, approximately all percentiles of height and weight were higher in boys than in girls after the age of 15. Moreover, boys' height and weight showed an increasing slope in this age group. In both studies, the girls' height curves reached to plateau after 15 years of age. After the age of 16, the higher percentiles of girls' weight curves showed a downward slope. Girls' BMI is more than boys in both years and this difference become higher in 2009. However, girls' BMI tended to decrease with increasing ages. WC curves in 2009 are less than 2003 in different ages and in both genders. Boys' WHtR is more than girls until 11 years of age in 2003 and 14 years of age in 2009 and after these ages girls' WHtR is more than boys in both years.

According to our results, Height curves did not show considerable changes in two studies. Weight, BMI, WC and waist to height ratio were lower in adolescent girls than boys especially in higher percentiles over 5 years and these anthropometric indices decreased at childhood ages over 5 years in both genders. Girls in adolescent ages tend to have lower body weight and look beautiful. However, boys in adolescent ages tend to increase his muscle and body weight and look stronger.

Height curves approximately have the same shape in both years of the study. Girls' height curves reached the plateau slope and boys' height curves reached the steeper slope, with increasing age in both years. In our previous study on the same data of 2009-2010 showed that the average height-for-age of Iranian children aged 10-19 years was lower than the reference curves of the World Health Organization (WHO 2007)^[11] and that of the United States Centers for Disease Control and Prevention 2000 (USCDC2000).^[12] Likewise, our previous study on the same data of 2003-2004 showed that Iranian children and adolescents were shorter than German children 2003.^[4] A review article concluded that the height of Iranian boys and girls aged <15 years is under the 20th percentile of the US National Center for the Health Statistics.^[13] High prevalence of stunting, especially in girls, has been demonstrated in some parts of Iran.^[14-16] As stunting may contribute to the global burden of disease,^[17] it should be considered as a health priority.

Results of the current study showed a downward shift of girls' weight and an upward shift of boys' weight especially in higher percentiles. Our previous study on the same data of 2003-2004 showed that Iranian children and adolescents had higher weight than their German counterparts.^[4] Weight charts of Iranian children and adolescents were similar to those in neighboring countries such as Turkish and Saudi children and adolescents of both genders.^[18,19] Greater

sugar-sweetened beverages intakes and sedentary lifestyle are some of the underlying reasons.^[20,21]

In the current study, small differences existed in girls' and boys' BMI curves in 2003, whereas in 2009 boys' BMI curves were lower than girls in most percentiles. It revealed that increasing trend after 17 years in boys and a decreasing trend after 17 years in girls especially about percentiles above 50th. Similar trends have also been reported in Turkish schoolchildren and adolescents, but only for girls in 2005.^[18] Data of the two nationwide studies in Iranian students, which was used in the current study, showed that in 2003-2004, the prevalence of overweight and obesity were 8.82% and 4.5% respectively,^[22] whereas they increased to 14% and 6%, respectively in 2009.^[23] This change is comparable with Turkish and Pakistani children and adolescents.^[18,24]

Along with BMI, WC has been used as an index for central adiposity.^[25] It also is related to cardiovascular risk factors.^[26-28] In the current study, we found that in 2003, WC curves had overlap in younger ages of two genders. However, boys' WC curves increased after the age of 15 in comparison of girls' curve. In 2009, boys' charts had the kurtosis, and then curves went upward in comparison with girls' charts. These differences are related to the gender differences in the pubertal stage and fat deposition. Ng and Schwandt defined 79th and 90th percentile as cut-off for WC in Chinese and German adolescents, respectively, for prediction of risk factor clustering.^[29] International Diabetes Federation has recommended 90th percentile as the cut-off value for metabolic syndrome in the pediatric age group.^[30] Our results showed that the shape of the WC percentile curves for Iranian girls and boys were different from other countries like Portugal,^[6] Malaysia,^[31] Poland,^[32] China,^[33] Germany,^[34] Bulgaria,^[35] and Australia.^[36] It seems that, these differences are due to ethnicity, age range, measurement sites, and pubertal stage. This criterion is a confirmatory measure, as an overweight child with low WC has normal body fat percentage.^[37]

Because of ethnic differences in WC, the index of WHtR is also considered for defining abdominal obesity. Values above 0.5 are considered to be high, and related to is cardiometabolic risk factors and markers of inflammation in the pediatric age group.^[25,26,38,39]

It is suggested that cut-off points of WHtR for obesity may be different for 6-12- and 12-18-year old subjects.^[40] Our findings showed that in both study years, the WHtR curves were higher in boys than in girls in younger ages, whereas thereafter the curves were lower in boys than in girls. A study among Mexican children showed that WC was lower in those with lower height percentiles than in those with upper height percentiles.^[41]

Study limitations and strengths: One of the limitations of our study is that because of the large sample size studied, we could not examine the pubertal stage of participants; therefore we could not determine the effects of puberty on anthropometric measures. Our study was not a longitudinal study following the same participants and we used data of two independent samples of Iranian children and adolescents, however the methodologies of both studies were similar, and the data were comparable.

The strength of the present study is comparing data of two national surveys with large sample size of a representative sample of children and adolescents from different provinces in Iran. Using the LMS method increased the quality of findings for comparison of anthropometric reference curves.

CONCLUSION

The growth charts of Iranian children and adolescents aged 10-18 years have changed over 5 years. Girls' weight and BMI curves have been decreasing, and boys' weight, and BMI curves have been increasing after the age of 16 over 5 years. Height curves did not show considerable changes during this period of time. Boys' WC curves have been increasing with sharper slope however girls' WC and WHtR have been decreasing after the age of 15. The reference growth curves of children and adolescents change over time, repeated surveys should be conducted to provide age- and gender-specific reference curves in different ethnic groups.

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AUTHOR'S CONTRIBUTION

RK was the principal investigator of the study and contributed in the study concept and design; conduct, drafting the manuscript, its revision and approving the final draft of the paper. MHB and FAS wrote the manuscript. MKh and SMH analyzed data. GA contributed in the study concept and conduct, as well as in approving the final draft of the paper. RH contributed in the study concept and conduct, as well as in approving the final draft of the paper.

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