Weight, height and BMI references in Elazığ: an east Anatolian city

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The aim of this study was to produce the growth references for Elazığ children aged 6-11 years. Data were collected in eight primary schools of Elazığ in 2007. Age- and gender-specific height, weight and body mass index (BMI) references were produced with LMS (Lambda-Mu-Sigma) method and compared with reported values in an Anatolian and a metropolitan city. A total of 3,342 (1,634 females, 1,708 males) children aged 6-11 years from among 4,258 students were included in the study. Age- and gender-specific height, weight and BMI references were produced. The 3rd– 97th percentiles were detected to be higher than the range of percentiles between 6-11-year-old children. We consider that this first local reference for Elazığ will provide a useful tool for health planning and monitoring of growth and development.

Key words: body mass index, growth, height, percentiles, weight.

Height, weight and body mass index (BMI) provide significant information about growth and development in children and adolescents. These measures are used both for screening and clinical monitoring. Obesity began emerging as a significant problem approximately two decades ago, and several non-pathological risk factors were defined as the cause[1]. Several methods were introduced to produce growth charts over the previous 50 years, and these references were widely accepted and used as an important growth monitoring index[2].

Age- and gender-specific percentiles are used to monitor the growth and development of children who lie outside the extreme centiles of the reference population. Deviation from the normal distribution was usually classified based on percentage deviation from the median of the reference population[3]. This method provides an approximate relationship where cut-off points are based on median and standard deviations (SDs). Growth charts then became an essential tool in monitoring growth. In the early 1990s, the produced growth references were evaluated by the National Center for Health Statistics/ World Health Organization (NCHS/WHO) to obtain standards[4]. In populations where a significant portion of children fall above the upper or below the lower centiles, their height, weight and BMI for age expressed as multiples of the SDs of the reference population rather than as percentages of the median would be much more useful[3]. Body weight and height are used as index anthropometric measures with which we calculate BMI, a measure used frequently to diagnose obesity.

The purpose of this study was to produce local references of height, weight and BMI in an East Turkey province and to compare these references with those of other locations.

Material and Methods

The anthropometric cross-sectional growth data of height, weight and BMI of an Eastern Turkish city, Elazığ, were compared with WHO references and two other cities of the country: Kayseri, which is situated in Central Anatolia, and İstanbul. The methods of the study design

and data collection in Kayseri were presented previously elsewhere [5,6].

Subjects

The Elazığ data were collected between March-June 2007. The sample size of this study was determined as at least 10% of primary school children. Considering that we may lose data for several reasons, we included more children than planned. The primary schools in the city center were divided into eight groups according to their geographical locations. A primary school from each group was selected randomly and all students that could be reached in that particular school were included in this study. A total of 3,342 (1,634 females, 1,708 males) children from eight schools were included in the study. This sample represents 13.6% of the 31,219 students attending primary schools in Elazığ province, and 11.7% of them were reached. The study group then represents more than 10% of the actual primary school population. Participants could represent any socioeconomic level since we did not have a reliable index to note this parameter.

Of the 4,258 students, we reached 3,570 students over three consecutive visits. The outlying data for both boys and girls that lies below and above the 3rd-97th non-smoothed percentiles were removed, and the remaining data were used to obtain age- and gender-specific references; the final sample size was 3,342. The response rate was 78.5%. We obtained permission for this study from the governorship and provincial directorate of national education. Each school was visited three times. In the first visit, students were informed about the study. Parental consent forms and questionnaires were given to the students to deliver to their parents. In the second visit, questionnaires were collected and checked on site for the missing variables. Anthropometric measurements were carried out. For students who were absent in the second visit, a third visit was made. Parents who gave consent were given a questionnaire and then height and weight measurements were performed in at most three consecutive visits if any children were not found at the school on the first visit for any reason. Written consent was obtained from the Ministry of National Education.

Measurements

Weights were measured by the investigators using an auto-calibrated measuring scale (SECA 762; Vogel and Halke, Hamburg, Germany). The school children were bare-footed and lightly clothed (school uniform). The weights were recorded to the nearest 0.1 kg. Heights were measured using a fixed measuring scale (SECA 208; Vogel and Halke). The children were bare-footed, standing on the floor, with heels next to each other, in a position such that the back of their head and body, their shoulders and hips were in contact with the scale. Their heads were in the upright position, looking forward, with a slight contact of the mobile indicator with their hair. The heights were measured and recorded to the nearest 0.1 cm. The data were grouped for each age group from 6-11 years. The age was truncated to the nearest full year, for example as 6 years (6.00-6.99 years), 7 years (7.00-7.99 years), and so forth. BMI was calculated as weight/height^2 (kg/m^2).

The "50p" of weight, height and BMI of Elazığ, Kayseri and İstanbul and WHO references were compared graphically to determine national variations, and comparisons of these variations with WHO references were done (Fig.1 a-f).

Statistics

The unsmoothed means and SDs were determined. LMS (Lambda-Mu-Sigma) method was used to produce age- and gender-specific growth references. Construction of the centile curves was made with the LMS Chart Maker Pro version 2.3 software program (The Institute of Child Health, London), which fits smooth centile curves to reference data using the LMS method. The smoothed centile curves for weight, height and BMI were constructed by the LMS method. This method summarizes percentiles at each age based on the power of age-specific Box-Cox power transformations used to normalize data. The final curves of percentiles are produced by three smooth curves representing L (Lambda; skewness), M (Mu; median) and S (Sigma; coefficient of variation)[7]. Centile values were measured by the LMS Chart Maker Pro version 2.3 software program and centile curves (3rd, 5th, 10th, 25th, 50th, 75th, 85th, 90th, 95th and 97th) were constructed by Microsoft Office Excel® version 2002.

Fig. 1. The comparison of height, weight and BMI of Elazığ, İstanbul and Kayseri children and WHO references for 50th percentiles.

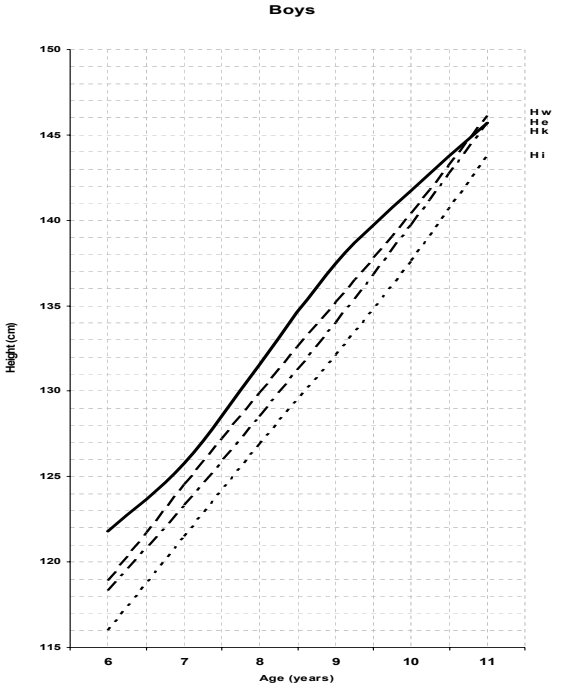

Fig. 1a.
H e: Height of Elazığ children
H i: Height of İstanbul children
H k: Height of Kayseri children
H w: Height of WHO reference

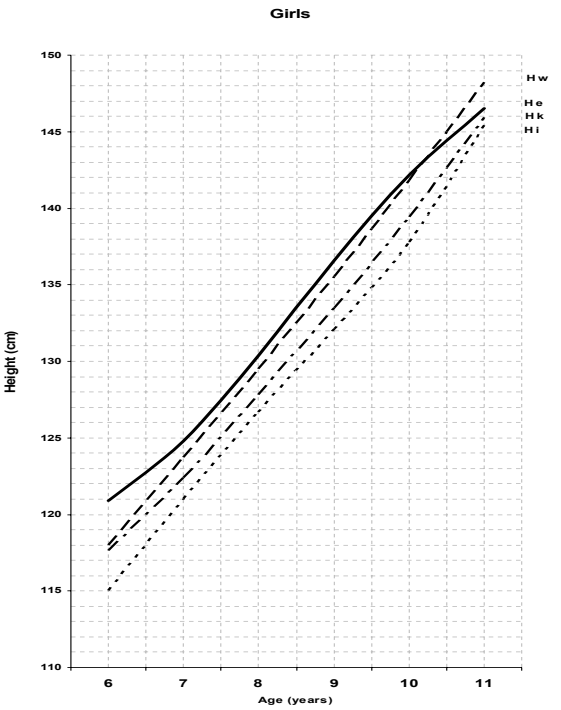

Fig. 1b.
H e: Height of Elazığ children
H i: Height of İstanbul children
H k: Height of Kayseri children
H w: Height of WHO reference

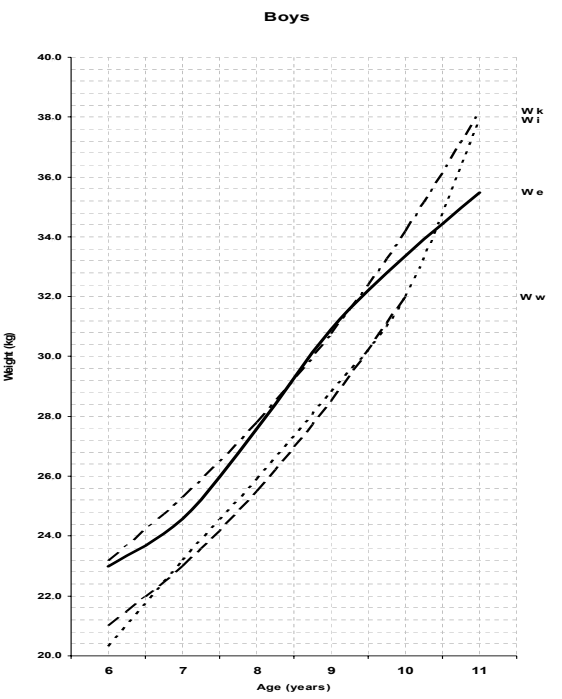

Fig. 1c.
W e: Weight of Elazığ children
W i: Weight of İstanbul children
W k: Weight of Kayseri children
W w: Weight of WHO reference

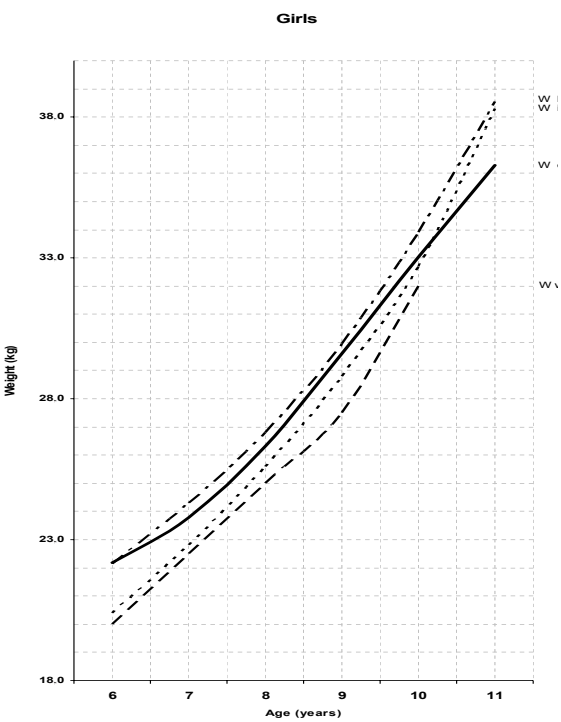

Fig. 1d.
W e: Height of Elazığ children
W i: Height of İstanbul children
W k: Height of Kayseri children
W w: Height of WHO reference

Table I. Age-Specific Height Percentiles of Elazığ Boys and Girls

Age	L	M	S	3rd	5th	10th	25th	50th	75th	85th	90th	95th	97th
Boys													
6	144. 00	121. 8	3. 74	113. 1	114. 2	115. 9	118. 7	121. 8	124. 8	126. 5	127. 6	129. 2	130. 2
7	825. 30	125. 8	3. 87	116. 7	117. 8	119. 6	122. 5	125. 8	129. 1	130. 9	132. 1	133. 9	135. 0
8	346. 80	131. 6	3. 96	122. 0	123. 2	125. 0	128. 1	131. 6	135. 1	137. 0	138. 3	140. 3	141. 6
9	332. 73	137. 5	3. 96	127. 5	128. 7	130. 6	133. 9	137. 5	141. 2	143. 2	144. 6	146. 6	148. 0
10	373. 25	141. 7	3. 90	131. 5	132. 8	134. 7	138. 0	141. 7	145. 5	147. 5	148. 9	151. 0	152. 4
11	188. 77	145. 7	3. 85	135. 5	136. 7	138. 7	142. 0	145. 7	149. 6	151. 6	153. 1	155. 2	156. 6
Girls													
6	-211. 44	120. 9	3. 54	113. 6	114. 4	115. 8	118. 1	120. 9	123. 9	125. 6	126. 8	128. 7	129. 9
7	-118. 31	124. 8	3. 77	116. 6	117. 5	119. 1	121. 7	124. 8	128. 1	129. 9	131. 2	133. 1	134. 4
8	-257. 89	130. 4	4. 06	120. 9	122. 0	123. 8	126. 9	130. 4	134. 0	136. 0	137. 4	139. 5	140. 8
9	922. 44	136. 6	4. 22	125. 8	127. 2	129. 2	132. 7	136. 6	140. 5	142. 6	144. 0	146. 1	147. 5
10	191. 37	142. 2	4. 25	130. 3	131. 9	134. 2	138. 0	142. 2	146. 2	148. 3	149. 7	151. 8	153. 1
11	270. 55	146. 5	4. 24	133. 9	135. 6	138. 2	142. 2	146. 5	150. 6	152. 7	154. 2	156. 2	157. 5

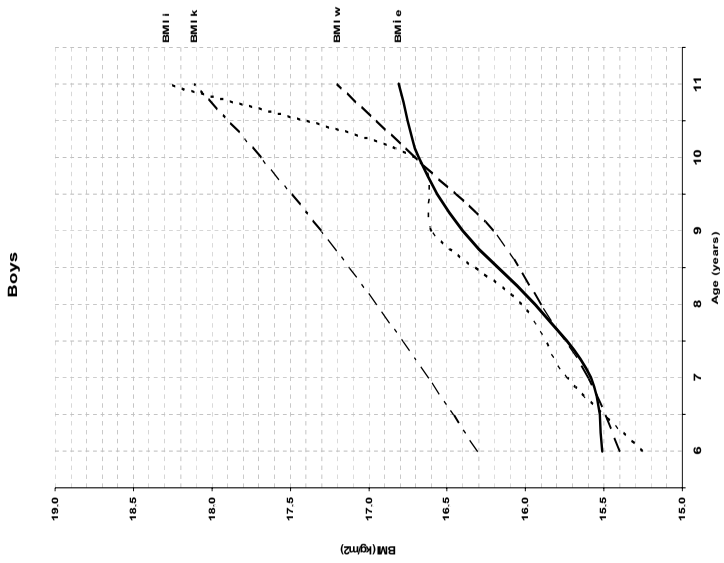

Fig 1 e.

BMI e: BMI of Elazig children
BMI i: BMI of Istanbul children
BMI k: BMI of Kayseri children
BMI w: BMI of WHO reference

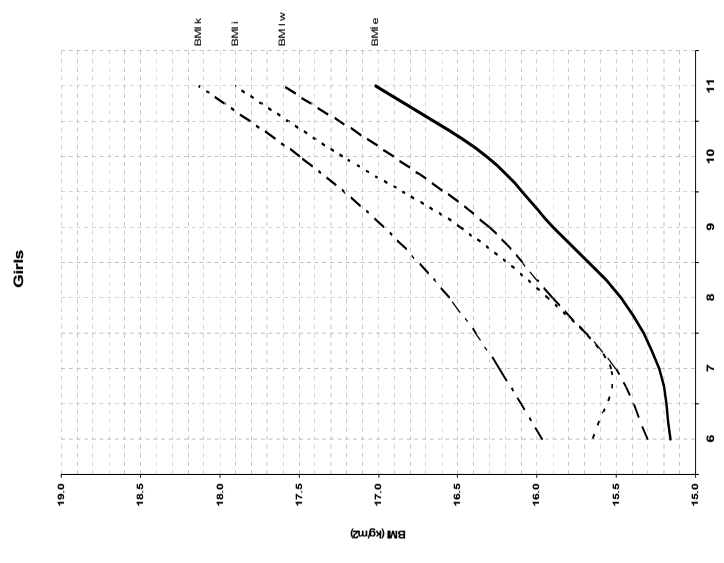

Fig 1 f.

BMI e: BMI of Elazig children
BMI i: BMI of Istanbul children
BMI k: BMI of Kayseri children
BMI w: BMI of WHO reference

Table II. Age-Specific Weight Percentiles of Elazığ Boys and Girls

Age	L	M	S	3rd	5th	10th	25th	50th	75th	85th	90th	95th	97th
Boys													
6	-14. 66	25. 1	12. 29	18. 9	20. 0	20. 0	21. 3	25. 1	25. 1	26. 5	27. 5	29. 2	30. 5
7	-14. 30	27. 0	13. 04	19. 9	21. 1	21. 1	22. 6	27. 0	27. 0	28. 5	29. 7	31. 7	33. 2
8	-13. 73	30. 6	14. 26	22. 0	23. 4	23. 4	25. 2	30. 6	30. 6	32. 5	34. 0	36. 6	38. 5
9	-13. 10	34. 6	15. 59	24. 1	25. 9	25. 9	28. 0	34. 6	34. 6	37. 1	39. 0	42. 2	44. 7
10	-12. 58	37. 7	16. 70	25. 6	27. 6	27. 6	30. 0	37. 7	37. 7	40. 6	42. 8	46. 7	49. 8
11	-12. 12	40. 4	17. 69	26. 8	29. 0	29. 0	31. 7	40. 4	40. 4	43. 6	46. 2	50. 8	54. 3
Girls													
6	-11. 03	22. 2	12. 77	17. 9	18. 4	19. 1	20. 4	22. 2	24. 3	25. 6	26. 6	28. 2	29. 3
7	-99. 39	23. 8	13. 56	18. 9	19. 4	20. 2	21. 8	23. 8	26. 2	27. 6	28. 8	30. 6	31. 9
8	-82. 93	26. 3	14. 74	20. 5	21. 1	22. 1	23. 9	26. 3	29. 2	31. 0	32. 3	34. 5	36. 1
9	-68. 85	29. 6	16. 22	22. 5	23. 2	24. 4	26. 7	29. 6	33. 2	35. 4	37. 1	39. 8	41. 7
10	-57. 38	33. 0	17. 78	24. 3	25. 2	26. 7	29. 4	33. 0	37. 4	40. 1	42. 2	45. 5	47. 9
11	-49. 26	36. 3	19. 32	26. 0	27. 0	28. 7	32. 0	36. 3	41. 5	44. 8	47. 3	51. 3	54. 2

Results

A total of 3,342 (1,634 females, 1,708 males) children aged 6-11 years from eight primary schools were included in the study. The LMS and reference values for the 3rd, 5th, 10th, 25th, 50th, 75th, 85th, 90th, 95th, and 97th percentiles are presented in Tables I-III. The unsmoothed mean and SD of height, weight and BMI of 6-11-year-old boys were 133.3 (9.2), 29.5 (6.6) and 16.5 (2.2), respectively. The corresponding height, weight and BMI of girls were 132.9 (9.8), 28.7 (6.6) and 16.1 (2.2), respectively. The mean (SD) and median (range) of height, weight and BMI for 6-11-year-old children for both genders is shown in Table IV.

The 50p height percentiles of Elazığ children were significantly higher than the previous two Turkish studies and WHO references in both genders (Fig. 1a, 1b). The ranges of difference were higher from 6-10 years (3-5 cm) and all were similar around 11 years.

In boys, 50p weight percentiles were similar in Kayseri boys from 6-10 years but 50p weight percentiles of İstanbul and Kayseri children were higher than those of their Elazığ counterparts at 11 years (Fig. 1c, 1d). In girls, the similarity of 50p weight percentiles of Kayseri and Elazığ children was noted (Lower than Kayseri but negligible difference). After 10 years, the 50p weight percentiles of Elazığ girls decreased significantly.

The main characteristic of 50p BMI percentiles of Kayseri children in both genders was its predominance of about one unit compared with Elazığ (Fig. 1e, 1f), İstanbul children and WHO references. The 50p BMIs of Elazığ and WHO references were similar in boys, but Elazığ 50p BMI was significantly lower than Kayseri, İstanbul and WHO BMI references.

In our study, between 6-11 years, the increase in 3rd and 97th percentile BMI was 0.01 and 4.07, respectively, for boys and 0.49 and 2.93, respectively, for girls (Table III). The corresponding increases in 50th percentile BMI for boys and girls were 1.31 and 1.86, respectively, through 6-11-year-old children. The range between 3rd and 97th percentile BMI was 6.1 and 10.2, respectively, for boys, and the corresponding range for girls was 6.1 and 9.5 (Table III).

Table III. Age-Specific BMI Percentiles of Elazığ Boys and Girls

Age	L	M	S	3rd	5th	10th	25th	50th	75th	85th	90th	95th	97th
Boys													
6	-23. 69	15. 5	0. 94	13. 4	13. 6	14. 0	14. 6	15. 5	16. 6	17. 3	17. 9	18. 8	19. 5
7	-22. 91	15. 6	0. 98	13. 4	13. 6	14. 0	14. 7	15. 6	16. 7	17. 5	18. 1	19. 1	19. 8
8	-20. 45	15. 9	110. 66	13. 4	13. 7	14. 1	14. 9	15. 9	17. 3	18. 2	18. 9	20. 0	20. 9
9	-17. 57	16. 4	125. 33	13. 5	13. 8	14. 2	15. 2	16. 4	18. 0	19. 0	19. 8	21. 2	22. 2
10	-15. 39	16. 7	136. 48	13. 4	13. 8	14. 3	15. 3	16. 7	18. 4	19. 6	20. 5	22. 0	23. 1
11	-14. 02	16. 8	143. 42	13. 4	13. 7	14. 3	15. 4	16. 8	18. 7	19. 9	20. 8	22. 4	23. 6
Girls													
6	-16. 56	15. 2	9. 97	12. 9	13. 1	13. 5	14. 2	15. 2	16. 3	17. 0	17. 5	18. 4	19. 0
7	-16. 03	15. 2	10. 37	12. 9	13. 1	13. 5	14. 3	15. 2	16. 4	17. 1	17. 7	18. 6	19. 3
8	-14. 68	15. 5	11. 37	12. 8	13. 1	13. 6	14. 4	15. 5	16. 8	17. 6	18. 2	19. 3	20. 0
9	-13. 07	15. 9	12. 84	12. 9	13. 2	13. 7	14. 7	15. 9	17. 4	18. 4	19. 1	20. 4	21. 3
10	-10. 89	16. 3	13. 98	13. 0	13. 3	13. 9	14. 9	16. 3	18. 0	19. 1	19. 9	21. 3	22. 2
11	-75. 79	17. 0	14. 14	13. 4	13. 7	14. 4	15. 5	17. 0	18. 8	19. 9	20. 7	22. 0	22. 9

The mean (SD) and median (range) of height, weight and BMI of Elazığ children for both genders is shown in Table IV. The Mean ± 1SD and Mean ± 2SD added and subtracted height, weight and BMI of Elazığ children between 6-11 years in both genders are shown in Table V.

Discussion

The existing data collected from cross-sectional studies can be used to make comparisons both between different populations and in the same population between different periods. The first and comprehensive reference data for Turkish children for growth and development were published more than 30 years ago, but we do not yet have detailed growth references of other geographical regions of Turkey[8]. Regional reference data can be used both for monitoring the longitudinal growth trend of a population and to provide a reference data that can be used to monitor growth.

In this paper, we aimed to produce height, weight and BMI percentiles of an Eastern Turkish city (Elazığ), and to compare these references with another central Anatolian city (Kayseri), a metropolitan city (İstanbul) and WHO references. Two of these cities' inhabitants live at a similar altitude (Elazığ 1067 m, Kayseri 1050 m) and lie over a similar geographic region, although their socioeconomic, urbanization, familial, and genetic properties may differ. Elazığ may be considered as a typical eastern region city[9,10]. The 2006 WHO references were used as an international standard to compare with two Turkish cities[11-13].

Our data indicate that the increase in BMI in 6-11-year-old children is limited, but the increase between 3rd- 97th percentiles is prominent when compared with yearly increase (6-11 years) (Tables I-III). The mean height and weight of girls are lower than boys until 10 years of age, but then become similar or higher than those of boys. This increase in height and weight may be considered as an early sign of the onset of puberty in girls.

The comparison of height and weight percentiles among three Turkish locations and with WHO references shows that for both genders, Elazığ children are the tallest. In the case of weight, the children of Kayseri and Elazığ are the

Table IV. Age- and Gender-Specific Mean and Medians of Height, Weight and BMI

Age	BOYS				GIRLS			
	n	Height (cm) Mean (SD) Median (Min-Max)	Weight (kg) Mean (SD) Median (Min-Max)	BMI (kg/m^2) Mean (SD) Median (Min-Max)	n	Height (cm) Mean (SD) Median (Min-Max)	Weight (kg) Mean (SD) Median (Min-Max)	BMI (kg/m^2) Mean (SD) Median (Min-Max)
6	217	121.9 (4.5) 122.0 (112.0-130.0)	23.6 (3.2) 23.0 (19.0-32.0)	15.9 (1.7) 15.6 (12.4-23.2)	206	121.3 (4.4) 121.0 (113.0-132.0)	22.6 (3.0) 22.5 (18.0-30.0)	15.4 (1.6) 15.3 (12.3-20.4)
7	354	125.6 (4.9) 125.5 (115.0-137.0)	24.9 (3.5) 24.5 (20.0-38.0)	15.8 (1.7) 15.4 (12.6-21.3)	338	124.8 (4.5) 125.0 (115.0-135.0)	24.1 (3.5) 24.0 (19.0-24.0)	15.5 (1.8) 15.1 (11.8-23.1)
8	356	131.6 (5.3) 131.0 (120.0-143.0)	28.3 (4.2) 28.0 (21.0-40.0)	16.3 (2.0) 16.0 (12.4-24.3)	317	130.6 (5.5) 131.0 (120.0-145.0)	26.9 (4.0) 26.0 (20.0-37.0)	15.7 (1.8) 15.5 (12.0-22.2)
9	335	137.9 (5.5) 138.0 (126.0-150.0)	32.0 (5.5) 30.0 (23.0-49.0)	16.7 (2.2) 16.3 (11.7-24.7)	319	136.6 (5.8) 137.0 (124.0-149.0)	30.4 (5.3) 30.0 (21.0-45.0)	16.2 (2.2) 15.7 (12.1-23.6)
10	332	141.5 (5.5) 142.0 (130.0-154.0)	34.5 (6.7) 33.0 (25.0-55.0)	17.2 (2.7) 16.4 (12.9-26.2)	317	142.2 (6.0) 142.0 (129.0-155.0)	34.0 (6.4) 33.0 (23.0-50.0)	16.7 (2.6) 16.2 (11.4-25.4)
11	114	146.0 (5.7) 146.0 (134.0-160.0)	36.8 (6.7) 35.0 (26.0-51.0)	17.2 (2.6) 16.6 (12.0-23.8)	137	146.0 (6.2) 146.0 (131.0-158.0)	37.0 (6.7) 35.0 (27.0-52.0)	17.3 (2.3) 17.1 (13.4-23.0)
6-11	1708	133.3 (9.2) 133.0 (112.0-160.0)	29.5 (6.6) 29.0 (19.0-55.0)	16.5 (2.2) 16.0 (11.7-26.2)	1634	132.9 (9.8) 132.0 (113.0-158.0)	28.7 (6.7) 27.5 (18.0-52.0)	16.05 (2.2) 15.61 (11.41-25.41)

heaviest (both genders) (Fig. 1c, 1d). The similar geographic characteristics of these two cities may be the cause of this similarity. The predominance of relatively high socioeconomic status may be the cause of the heavier children in Kayseri when compared with Elazığ. On the other hand, the issue of whether children in Kayseri and Elazığ are taller than those in İstanbul is controversial since high altitude leads to relatively short stature and wide chest circumference. We can conclude that the altitude of these two cities may be considered as relatively high but not high enough to lead to major differentiation. The lack of data about genetic and hormonal factors in our study limits our comment about which other factors may have influenced the similarity or dissimilarity. We observed significantly low BMI in Elazığ children in comparison to two national data and WHO references for girls, but in boys, BMIs of Elazığ children were similar to WHO references (Fig. 1e, 1f). The BMIs of children in both İstanbul and Kayseri were higher than of children in Elazığ and WHO references. We may thus conclude that obesity risk in these two cities must be considered significantly. Elazığ data on its own provides the first reference for this geographic region and stands as a model for the future more comprehensive growth studies in this region.

In cross-sectional studies, prevalence estimates are used to make comparisons between two specific periods as well as between different groups[11]. The contributions of the present study would be the establishment of growth references for Elazığ and the comparison of these references with another Anatolian city that may reflect the general population of Turkey. With regards to a future growth monitoring study in the same region, the data obtained in this study may serve as a starting point for observations/comments. Among the various methods introduced in previous decades, the LMS method is raised as the most frequently accepted and utilized refined curve-fitting method to obtain growth references representing parallel curves for any anthropometric parameter in children and adolescents[12]. The comparison of our data showed that there were relatively small differences in height and weight among the Elazığ, Kayseri and İstanbul children and WHO references, but the difference between BMI

Table V. The Z Scores of Height, Weight and BMI Deviations for Each Age and Gender

Age	BOYS			GIRLS		
	Height (cm)	Weight (kg)	BMI (kg/m^2)	Height (cm)	Weight (kg)	BMI (kg/m^2)
+ 1 SD						
6	126. 40	26. 80	20. 50	125. 70	25. 60	17. 00
7	130. 50	28. 40	21. 00	129. 20	27. 60	17. 30
8	136. 90	32. 50	21. 40	136. 10	30. 90	17. 50
9	143. 40	37. 50	22. 80	142. 40	35. 70	18. 40
10	147. 00	41. 20	24. 70	148. 20	40. 40	19. 30
11	151. 70	43. 50	24. 10	152. 20	43. 70	19. 60
+ 2 SD						
6	130. 90	30. 00	19. 30	130. 10	28. 60	18. 60
7	135. 40	31. 90	19. 20	133. 70	31. 10	19. 10
8	142. 20	36. 70	20. 30	141. 60	34. 90	19. 30
9	148. 90	43. 00	21. 10	148. 20	41. 00	20. 60
10	152. 50	47. 90	22. 60	154. 20	46. 80	21. 90
11	157. 40	50. 20	22. 40	158. 40	50. 40	21. 90
- 1 SD						
6	117. 40	20. 40	14. 20	116. 90	19. 60	13. 80
7	120. 70	21. 40	14. 10	120. 20	20. 60	13. 70
8	126. 30	24. 10	14. 30	125. 10	22. 90	13. 90
9	132. 40	26. 50	14. 50	130. 80	25. 10	14. 00
10	136. 00	27. 80	14. 50	136. 20	27. 60	14. 10
11	140. 30	30. 10	14. 60	139. 80	30. 30	15. 00
- 2 SD						
6	112. 90	17. 20	12. 50	112. 50	16. 60	12. 20
7	115. 80	17. 90	12. 40	115. 70	17. 10	11. 90
8	121. 00	19. 90	12. 30	119. 60	18. 90	12. 10
9	126. 90	21. 00	12. 30	125. 00	19. 80	11. 80
10	130. 50	21. 10	11. 80	130. 20	21. 20	11. 50
11	134. 60	23. 40	12. 00	133. 60	23. 60	12. 70

values were significantly wide; thus, obesity-related measures and interventions may differ among the three Turkish cities. Additional well-designed and longitudinal studies like the previous ones must be conducted in all regions of Turkey[14-16]. Since there is a secular trend in upward increase both in height and weight, a comparison of growth curves requires both methodological and secular similarity to determine similarity or difference[16].

Our cross-sectional data do not include the nutritional characteristics of children, so we cannot discriminate the children who were breastfed or not. Breast-feeding is considered as an important factor in growth and development[17,18]. Growth references provide smoothed curves of cross-sectional data of a population for a certain period and do not document individual change in size[19]. Growth standards are considered to represent an ideal norm[20,21]. Local data provide a population-specific standard and can be used in health planning and for screening growth in children and adolescents.

The global epidemic nature of overweight and obesity needs primary measures like height and weight determination. Public concern may be concentrated over obesity by providing age- and sex-specific references. Local references would then provide a useful tool for health planning and screening inter-population differences.

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