**Introduction**

Percentiles and Z-score values for age are both useful indices in assessment of growth and either can be used as references. The important point is the availability of standard percentile or Z-score values to be used as references. Provided adequate statistical methods are applied to normalize the anthropometric growth data; Z-scores or standard deviation score (SDS) reference tables and charts are preferred by many researchers because these references, compared to percentiles, are more accurate in assessing children with measurements which lie outside the accepted limits of normality and they also facilitate further statistical analyses (1,2,3,4). Indeed, many countries use growth references constructed as Z-score charts or tables in preference to percentiles (5,6,7).

In recent years, a World Health Organization (WHO) study group has presented new growth charts for ages 0 to 60 months based on measurements of infants and children from eight different countries and has recommended the use of these charts as international references (8). For older age groups, WHO continues to recommend the use of growth charts developed by the National Center for Health Statistics (NCHS) for USA children in 1977 as international reference values (9,10). The WHO group emphasizes that data used for construction of reference growth standards should be based on measurements of children who not only are free of disease but are also reared in a healthy environment that minimizes constraints on growth such as poor diets and infection (8). This same principle was observed in the construction of growth charts for Turkish children prepared in 1978, which are in use in the country for many years (11,12,13,14,15). These charts represent weight and height values of a group of Istanbul children from the higher strata of the population, i. e.
methods of measurements of height for ages 6 to 18 years. The mean number of measurements per child was 5.5±3.3. With the exception of age groups 6, 17.5 and 18 years, each half age group resulted in the final data set used to derive the Z-score values is based on 6007 height measurements for boys and 5657 for girls. The mean number of measurements per child was 5.5±3.3. With the exception of age groups 6, 17.5 and 18 years, half age group included measurements over 100 subjects.

Although the majority of the children were followed for different periods of time, longitudinal data covering ages 6 to 18 were not available for all children. The data were therefore analyzed cross-sectionally. The height data were smoothed as cubic splines by non-linear regression, using penalized likelihood with the program LMS (18,19). Since height-for-age values tend to be normally distributed, the SDS (Z-score) values were calculated using the equation (z=(measurement-mean)/SD).

Results

For each age and sex group, number of measurements, mean and SD values for height in both sexes and Z-score values computed from these values are given in Tables 1 and 2. In Table 3, present data are compared with mean, ±1 and ±2 values for boys and girls in the age groups 9 to 17 years born between the years 1950-1960 (11,12,13). The upward trend in height at almost all age groups can be noted.

Discussion

Assessment of growth is an essential part of pediatric health supervision at all ages and deviations from normal values usually implicate a pathologic condition. Height for age, expressed as centiles or SDS (Z-score) can be considered as the “golden standard” for the assessment of growth in children of school age and of pubertal years. An arrest in height growth can constitute the only sign of disease and the establishment of this deviation can be a valuable tool for early diagnosis. Particularly in communities where chronic malnutrition still prevails and diagnosis and accurate estimation of aberrations in the growth in individual children is of importance, Z-scores or SDS reference tables and charts provide a useful and practical index for growth assessment and follow-up of children, including those which show extreme deviations from the mean values.
This study presents height data obtained from a representative sample of Turkish children aged 6-18 years and adds Turkey to the list of countries which have updated the growth charts for their respective children. Taking into account the existing differences in height-for-age and weight-for-age values due to socioeconomic disparities, the growth charts of Turkish children presently in use in this country, as well as the updated percentile charts which were previously reported and the Z-score tables presented in this paper, were based on measurements of Istanbul children of well-to-do families (11,12,13,16,17). These references are therefore selective, but, in accordance with the recommendations of WHQ, are representative of Turkish children who are born and reared in optimal or near optimal circumstances. It must be added that, as a result of a flow of emigration from all parts of the country during the past 60 years, 17% of the Turkish population now resides in Istanbul and we believe that the diverse composite population of Istanbul City is quite representative of the whole of Turkey (20).

The design of our study largely conforms to the criteria suggested by Waterlow and adopted by WHO, requiring that the reference population be well-nourished, the sampling procedure clearly defined and reproducible, the sample of adequate size, the measurements relevant and of good quality and the data adequately treated (8,9,10,21,22,23,24). Our sample consisted of measurements on a group of children who were followed over variable periods of time and therefore the numbers were not suitable for a longitudinal analysis. To be able to have adequate numbers in each age group, the data were treated cross-sectionally in the analysis. With the exception of age groups 6, 17.5 and 18 years, the number of measurements for each half age group appears to be adequate. We realize that the longitudinal

| Age (yrs) | n  | SD  | -3 SDS | -2 SDS | -1 SDS | 0 SDS | +1 SDS | +2 SDS | +3 SDS |
|----------|----|-----|--------|--------|--------|-------|--------|--------|--------|
| 6.0      | 50 | 4.67| 102.0  | 106.7  | 111.3  | 116.0 | 120.7  | 125.3  | 130.0  |
| 6.5      | 122| 4.83| 104.3  | 109.1  | 114.0  | 118.8 | 123.6  | 128.4  | 133.3  |
| 7.0      | 187| 5.00| 106.6  | 111.5  | 116.5  | 121.5 | 126.5  | 131.5  | 136.5  |
| 7.5      | 186| 5.16| 108.7  | 113.9  | 119.1  | 124.2 | 129.4  | 134.6  | 139.7  |
| 8.0      | 195| 5.33| 110.9  | 116.2  | 121.6  | 126.9 | 132.2  | 137.5  | 142.0  |
| 8.5      | 204| 5.47| 113.1  | 118.6  | 124.0  | 129.5 | 135.0  | 140.5  | 145.9  |
| 9.0      | 207| 5.62| 115.3  | 120.9  | 126.5  | 132.1 | 137.8  | 143.4  | 149.0  |
| 9.5      | 216| 5.76| 117.5  | 123.3  | 129.0  | 134.8 | 140.5  | 146.3  | 152.1  |
| 10.0     | 204| 5.93| 119.8  | 125.7  | 131.6  | 137.6 | 143.5  | 149.4  | 155.4  |
| 10.5     | 175| 6.15| 122.1  | 128.2  | 134.4  | 140.5 | 146.7  | 152.8  | 159.0  |
| 11.0     | 246| 6.44| 124.5  | 130.9  | 137.3  | 143.8 | 150.2  | 156.7  | 163.1  |
| 11.5     | 422| 6.81| 126.7  | 133.6  | 140.4  | 147.2 | 154.0  | 160.8  | 167.6  |
| 12.0     | 464| 7.22| 128.9  | 136.1  | 143.4  | 150.6 | 157.8  | 165.0  | 172.2  |
| 12.5     | 526| 7.63| 131.2  | 138.8  | 146.4  | 154.0 | 161.7  | 169.3  | 176.9  |
| 13.0     | 470| 7.92| 133.9  | 141.8  | 149.8  | 157.7 | 165.6  | 173.5  | 181.4  |
| 13.5     | 479| 7.97| 137.5  | 145.5  | 153.4  | 161.4 | 169.4  | 177.3  | 185.3  |
| 14.0     | 375| 7.76| 141.6  | 149.4  | 157.2  | 164.9 | 172.7  | 180.5  | 188.2  |
| 14.5     | 294| 7.43| 145.7  | 153.1  | 160.5  | 168.0 | 175.4  | 182.8  | 190.3  |
| 15.0     | 279| 7.10| 149.1  | 156.2  | 163.3  | 170.4 | 177.5  | 184.6  | 191.7  |
| 15.5     | 201| 6.84| 151.6  | 158.5  | 165.3  | 172.2 | 179.0  | 185.8  | 192.7  |
| 16.0     | 191| 6.65| 153.5  | 160.1  | 166.8  | 173.4 | 180.1  | 186.7  | 193.4  |
| 16.5     | 122| 6.51| 154.7  | 161.3  | 167.8  | 174.3 | 180.8  | 187.3  | 193.8  |
| 17.0     | 106| 6.41| 155.7  | 162.1  | 168.5  | 174.9 | 181.4  | 187.8  | 194.2  |
| 17.5     | 64 | 6.32| 156.5  | 162.9  | 169.2  | 175.5 | 181.8  | 188.1  | 194.5  |
| 18.0     | 42 | 6.24| 157.3  | 163.5  | 169.8  | 176.0 | 182.3  | 188.5  | 194.7  |

SDS: standard deviation score; n: number of measurements
element in our series constitutes a drawback. However, the 1977 NCHS charts which were accepted as the international standard by WHO were also derived from a population which contained a longitudinal element (25).

Our approach to construction of references is, similar to that of WHO, ‘prescriptive’, rather than ‘descriptive’, since these references will serve as a tool for the diagnosis of inappropriate growth (1,22,23).

Mean values for height for age obtained in this study are compared with those of Turkish children born 30 years earlier and with CDC 2000 Growth Charts for white North American children (11,24,25). The present reference height values for Turkish boys and girls aged 6 to 18 years conformed quite well to the USA standards, the differences being around 0.5-1.0 cm at all ages and not exceeding 2 cm in any age group.

It is reported that stature is a genetically determined trait, with heritability estimated at approximately 80% (26). Several genome-wide association studies on stature have recently been published, mostly on Caucasian-based populations (27,28,29). Turkish children born in the years 1974-1989 were taller than children born in the years 1950-1960. While the effect of genetic make-up cannot be denied, this finding indicates that in Turkey, environmental factors are still at work continuing to affect growth and that even children of high socioeconomic groups, who are born to well-to-do and educated parents, continue to grow taller over time and final height is still a dynamic entity. Indeed, contrary to the generally accepted opinion that height of the population has stabilized in the industrial countries of Western Europe (30), recent publications from some of these countries show the continuation of a positive secular trend in height (5,6).

Our data shows an increase in SD values with age. As expected, these values are highest at pubertal ages and more pronounced in the boys.

The growth reference values need to be re-examined every 5 to 10 years for populations with suspected large secular changes and every 15-20 years for those suspected of little change (7).

### Table 2. SD values, mean values (0 SDS) and values corresponding to Z-scores (±1, ±2, ±3 SDS) for height in Turkish girls aged 6 to 18 years

| Age (yrs) | n  | SD    | -3 SDS | -2 SDS | -1 SDS | 0 SDS | +1 SDS | +2 SDS | +3 SDS |
|-----------|----|-------|--------|--------|--------|-------|--------|--------|--------|
| 6.0       | 41 | 4.51  | 101.5  | 106.0  | 110.5  | 115.0 | 119.5  | 124.0  | 128.5  |
| 6.5       | 138| 4.76  | 103.8  | 108.5  | 113.3  | 118.1 | 122.8  | 127.6  | 132.3  |
| 7.0       | 179| 4.99  | 106.1  | 111.1  | 116.1  | 121.0 | 126.0  | 131.0  | 136.0  |
| 7.5       | 209| 5.17  | 108.4  | 113.6  | 118.7  | 123.9 | 129.1  | 134.2  | 139.4  |
| 8.0       | 222| 5.33  | 110.7  | 116.0  | 121.4  | 126.7 | 132.0  | 137.4  | 142.7  |
| 8.5       | 247| 5.50  | 112.9  | 118.4  | 124.0  | 129.5 | 135.0  | 140.5  | 146.0  |
| 9.0       | 241| 5.75  | 114.9  | 120.6  | 126.4  | 132.1 | 137.9  | 143.6  | 149.4  |
| 9.5       | 243| 6.08  | 116.6  | 122.7  | 128.7  | 134.8 | 140.9  | 147.0  | 153.1  |
| 10.0      | 254| 6.45  | 118.4  | 124.9  | 131.3  | 137.8 | 144.2  | 150.7  | 157.1  |
| 10.5      | 223| 6.77  | 121.0  | 127.7  | 134.5  | 141.3 | 148.1  | 154.8  | 161.6  |
| 11.0      | 265| 6.90  | 124.7  | 131.6  | 138.5  | 145.4 | 152.3  | 159.2  | 166.0  |
| 11.5      | 363| 6.73  | 129.4  | 136.1  | 142.8  | 149.6 | 156.3  | 163.0  | 169.7  |
| 12.0      | 378| 6.38  | 134.0  | 140.4  | 146.8  | 153.1 | 159.5  | 165.9  | 172.3  |
| 12.5      | 430| 6.09  | 137.6  | 143.6  | 149.7  | 155.8 | 161.9  | 168.0  | 174.1  |
| 13.0      | 409| 5.94  | 140.0  | 146.0  | 151.9  | 157.8 | 163.8  | 169.7  | 175.6  |
| 13.5      | 376| 5.88  | 141.6  | 147.5  | 153.4  | 159.3 | 165.2  | 171.0  | 176.9  |
| 14.0      | 319| 5.87  | 142.8  | 148.6  | 154.5  | 160.3 | 166.2  | 172.1  | 177.9  |
| 14.5      | 246| 5.87  | 143.5  | 149.4  | 155.3  | 161.1 | 167.0  | 172.9  | 178.8  |
| 15.0      | 213| 5.88  | 144.1  | 149.9  | 155.8  | 161.7 | 167.6  | 173.5  | 179.4  |
| 15.5      | 188| 5.89  | 144.4  | 150.3  | 156.2  | 162.1 | 168.0  | 173.9  | 179.8  |
| 16.0      | 150| 5.90  | 144.7  | 150.6  | 156.5  | 162.4 | 168.3  | 174.2  | 180.1  |
| 16.5      | 122| 5.90  | 144.9  | 150.8  | 156.7  | 162.6 | 168.5  | 174.4  | 180.3  |
| 17.0      | 110| 5.90  | 145.0  | 150.9  | 156.8  | 162.7 | 168.7  | 174.6  | 180.5  |
| 17.5      | 56 | 5.91  | 145.2  | 151.1  | 157.0  | 162.9 | 168.8  | 174.7  | 180.6  |
| 18.0      | 35 | 5.91  | 145.4  | 151.3  | 157.2  | 163.1 | 169.0  | 174.9  | 180.8  

SDS: standard deviation score, n: number of measurements
findings of our study indicate a continuing upward secular trend in height-for-age values in Turkish children and point, therefore, to a need to update the growth data every decade or so. Analysis of the data revealed that there was a general trend in height to increase with the year of birth. Children born in the later years tended to be a little taller than those born in the preceding years, even within this short range of years. Hence, it is warranted to refer to an upward trend, not just a simple shift between two points in time separated by 30 years.

In conclusion, we believe these updated data will, hopefully, meet the need expressed by many professionals working with Turkish children in and outside Turkey (31,32) and will be of help in their assessment of the growth of individual children and in the diagnosis of growth problems.

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