GROWTH MODELLING OF SCHOOL CHILDREN IN IRAN USING SHIRAZ DATA

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ABSTRACT

Centile values and growth charts for height, weight and arm circumference are presented for school children aged six to 12 years in Shiraz (Iran). The smooth centile values have been derived from the raw data by Healy's nonparametric method. Girls grow faster than boys. Homogeneity of data with population structure and universal rationing imply that these norms are likely to be appropriate to all urban children in Iran. These observations are in favour of using local standards in clinical diagnosis and nutritional screening in order to develop efficient and effective health programmes.

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INTRODUCTION

Anthropometric measurement of children provides one of the best means of assessing health and nutritional condition. Generally, weight, height and arm circumference have come to be considered the most sensitive parameters of children's nutritional status and most practical for the monitoring of individual children or of a population of children.[1]

Combinations of these measurements have been suggested, sometimes to distinguish "types" of malnutrition.[2] Weight and height measurements together are useful to understand the dynamics of malnutrition and long-term or chronic malnutrition.[3] Visweswara Rao[4] has argued persuasively that these measures are adequate for assessing nutritional status and that not much is gained by additional forms of measurement.[5]

Measurement of the mid-upper arm circumference provides a useful indication of growth and nutritional status, giving information paralleling body weight and has the advantage of operational simplicity.[1,6] Research has suggested that this single measurement of upper arm circumference is almost as useful as most other pairs of measurements, such as height and weight.[7]

Like all clinical observations, anthropometric measurements have to be interpreted against reference data. In the absence of local standards NCHS height and weight tables[8] are often used as these fulfil the WHO criteria of a population reference[3] and were proposed as a reference for comparing the nutritional status of different groups.[9] The tables do not, however, include reference standards for arm circumference.

At present there is no reliable data regarding growth pattern of Iranian children. Previous studies were taken from selected clinical groups.[10]

These studies provide no basis for constructing population norms, but suggest that age for age children in Iran may be a good deal smaller than in the United States. If this is so, the general use of American or European norms in clinical work may be seriously misleading. We therefore present the results of a cross-sectional study of school children aged six to 12 years in Shiraz which was conducted during the academic year 1988-89 and based on a representative sample of school children over the four educational regions of the city.

Table I. Smoothed Percentile of Stature (cm) by Age and Sex

Sex and Age	Smoothed Percentile						
	5th	10th	25th	50th	75th	90th	95th
Boys			Stature in centimetre				
6±	106.81	108.24	110.76	113.73	116.88	119.88	121.74
7±	110.23	111.84	114.64	117.93	121.40	124.68	126.72
8±	113.96	115.74	118.82	122.43	126.22	129.78	131.99
9±	117.99	119.94	123.31	127.23	131.34	135.19	137.56
10±	122.31	124.44	128.09	132.33	136.75	140.89	143.44
11±	126.95	129.24	133.18	137.74	142.47	146.90	149.61
12±	131.88	134.57	138.57	143.44	148.50	153.20	156.09
Girls							
6±	104.23	106.10	109.13	112.38	115.50	118.20	119.76
7±	108.61	110.66	114.00	117.58	121.04	124.04	125.78
8±	113.11	115.34	118.98	122.91	126.70	130.01	131.93
9±	117.73	120.15	124.09	128.36	132.49	136.10	138.20
10±	122.48	125.07	129.33	133.93	138.40	142.31	144.60
11±	127.35	130.13	134.68	139.62	144.43	148.64	151.12
12±	132.34	135.30	140.16	145.44	150.58	155.10	157.76

Remark: In all tables 6± ,..., 12± indicate 5.5 to 6.49, ... , 11.5 to 12.49 year old, respectively.

Table II. Smoothed Percentile of Weight (Kg) by Sex and Age

Sex and Age	Smoothed Percentile						
	5th	10th	25th	50th	75th	90th	95th
Boys			Weight in Kilograms				
6±	16.09	16.58	17.59	19.04	20.89	22.96	24.43
7±	17.18	17.76	18.94	20.61	22.73	25.12	26.80
8±	18.50	19.18	20.55	22.48	24.93	27.68	29.68
9±	20.07	20.87	22.47	24.72	27.56	30.75	33.00
10±	21.94	22.88	24.76	27.38	30.69	34.41	37.04
11±	24.17	25.28	27.94	30.56	34.45	28.81	41.90
12±	26.83	28.14	30.75	34.38	38.96	44.11	47.76
Girls							
6±	15.02	15.63	16.75	18.18	19.85	21.58	22.73
7±	16.32	17.05	18.42	20.18	22.22	24.35	25.78
8±	17.78	18.68	20.34	22.48	24.98	27.59	29.34
9±	19.46	20.53	22.54	25.13	28.17	31.37	33.53
10±	21.37	22.66	25.07	28.20	31.90	35.81	38.45
11±	23.56	25.10	28.00	31.77	36.26	41.02	44.26
12±	26.07	27.91	31.38	35.93	41.36	47.17	51.14

Shiraz, one of the five principal cities of Iran, is the centre of Fars province of Iran. The city is located 1000 km south of Teheran (Iran's capital) and 100 km north of the Persian Gulf, at an altitude of 5000 feet (1500 m) above sea level. It has a mediterranean climate and a population of about one million. The city is both the symbol of ancient civilization and the most developed in southern Iran at present.

Local standard growth charts and reference data for Shirazi school children are presented. Comparison of the results with western norms and universal reference data will be published elsewhere.

METHODS AND MATERIALS

Administratively, Shiraz is divided into four educational regions, each with distinct social, cultural, economic and health characteristics. Since an adequate sampling frame of the population was unavailable, a multistage random sampling was applied.[11,12] A 10% sample of schools in each region was drawn. Within each selected school a 1 in 15 sample of children aged between six and 12 was selected, using table of random numbers.

Applying this procedure, a total number of 1207 subjects (642 boys and 565 girls), aged six to 12 years were selected in 1988-89 academic year, in a cross-sectional study, representing a 1 in 150 sample of the school children in the city.

The anthropometric measurements included height, weight and mid-upper arm circumference. Heights and arm circumferences were recorded to the nearest 0.5 cm and weights to the nearest 0.5 kg. They were measured by two trained graduate teachers under supervision of the first author. The subjects were in normal good health at the time of examination. No clinical signs of malnutrition or other serious illnesses were noted. Only 34 subjects (24 boys and 10 girls); constituting a 2.8% of our sample were not well at the time of main survey. These children were examined in later sessions and are included in the analysis.

Stature or standing height was measured by using a meter installed on the wall and a set square (goniometer). In the standard manner the child stood in stocking feet with feet together and back and heels against the upright wall. No upward pressure was exerted on the subjects' mastoid by the examiner to purposefully "stretch everyone in a standard manner" as has been done in other studies.[13,14]

Children's weights were taken without shoes or heavy outer clothing and using a bathroom scale. This type of scale is placed on the ground and children stand on the weighing platform.[1] Standardized examination clothing with approximate weights between 200 to 300 grams were used. Instruments were calibrated before each measurement session.

The upper-arm circumference was measured with a flexible string similar to the Shakir strip which did not stretch.[15] This strip was marked with numbers in terms of metric system.

In addition parents completed a questionnaire for each child. This provides information on social, cultural and economic data on the children's family and the heights and weights of their parents. The analysis of these data will be presented elsewhere. Calculations show that the maximum percent error in estimates of mean values were 1% for height, 3.5% for weight and

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Table III. Smoothed Percentile of Mid-upper Arm Circumference (cm) by Sex and Age

Sex and Age	Smoothed Percentile						
	5th	10th	25th	50th	75th	90th	95th
Boys	Arm circumference in centimetres						
6±	13.79	13.94	14.31	14.64	15.80	16.81	17.54
7±	14.07	14.25	14.68	15.37	16.31	17.41	18.20
8±	14.41	14.62	15.11	15.87	16.90	18.09	18.95
9±	14.81	15.05	15.06	16.44	17.57	18.87	19.97
10±	15.27	15.55	16.16	17.09	18.33	19.74	20.74
11±	15.80	16.11	16.80	17.83	19.18	20.72	21.81
12±	16.40	16.75	17.52	.18.66	20.14	21.82	23.01
Girls							
6±	13.53	13.77	14.26	14.93	15.57	16.63	17.24
7±	13.89	14.17	14.27	15.46	16.36	17.34	18.00
8±	14.30	14.61	15.22	16.04	17.04	18.11	18.84
9±	14.74	15.09	15.77	16.68	17.78	18.95	19.75
10±	15.23	15.62	16.37	17.38	18.59	19.88	20.75
11±	15.77	16.20	17.04	18.14	19.47	20.89	21.85
12±	16.36	16.89	17.76	18.98	20.44	21.99	23.04

2% for arm circumference. Age was recorded to the nearest completed year.

Statistical Package for the Social Sciences[16] was used for basic calculations. Healy's method was applied to calculate smooth age-related centiles which makes no assumption about the nature of the distribution of the measurement at fixed ages.[17]

This method first assumes the 50th centiles can be expressed as a polynomial in age represented by t. For example the 50th centile for height, h (50), might be:

$$h(50) = b_0 + b_1 t + b_2 t^2 + b_3 t^3 + \dots \qquad (a)$$

Second, at any given age the other centiles may be expressed in polynomials of the standard normal deviate, Z, in relation to the 50th centile. That is:

$$h(p) = h(50) + c_1 Z + c_2 Z^2 + c_3 Z^3 + \dots \qquad (b)$$

where h(p) is the p-th centile of heights and Z is the correponding standard normal deviate (SND).

In equation (b) we see that if heights were exactly normally distributed with standard deviation (h), then $c_2 = c_3 = \dots = 0$ and c1 = (h). A term in Z_2 can account for skewness and in Z^3 kurtosis.

Healy's model does not assume that the coefficients $c_1, c_2, c_3, \dots$ are fixed but allows them to vary with age (t), so that the whole model may be written as:

$$h(p,t) = h(50) + (c_{10} + c_{11} t + c_{12} t^2 + \dots) Z^1 + (c_{20} + c_{21} t + c_{22} t^2 + \dots) Z^2 + \dots$$

The published procedure for fitting this model supposes that measurements are made at a continuum
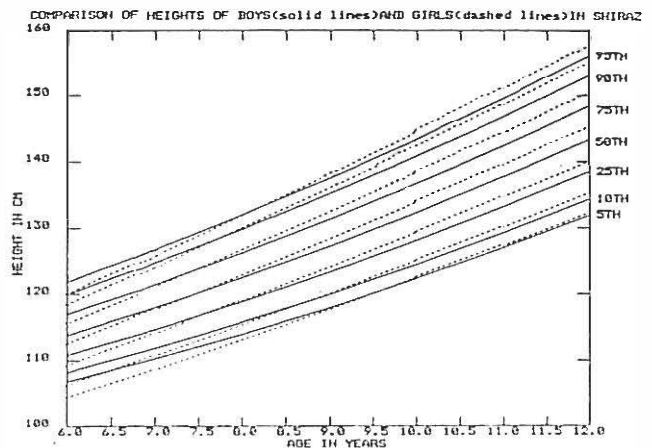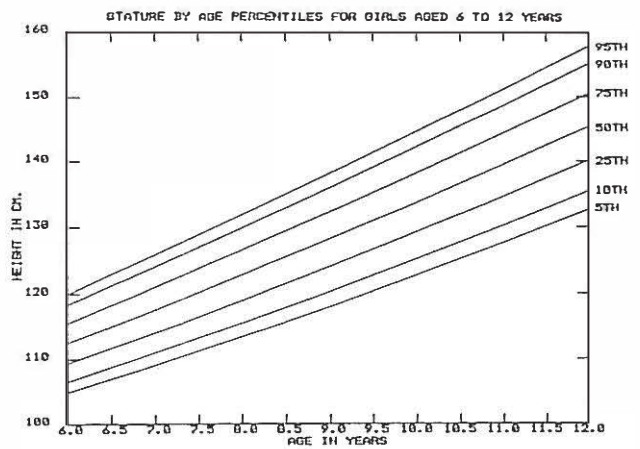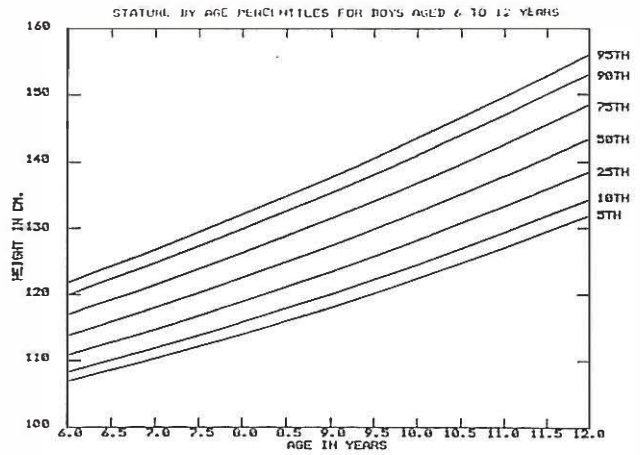

of ages which are not grouped. A special method based on a technique described by Cleveland to smooth a scatter diagram is used to derive raw age related centiles for the data and the model is fitted to these raw centiles by a special "least-squares" technique.[8] In the present data age is only recorded in completed years.

Fig. 1.

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The first step is therefore to compute appropriate raw centiles at each age using SPSS software package. These raw centiles are then fed into the computer program for computation of smoothed centiles.

The main advantage of this method is the great flexibility in allowing for a) the centile curves to vary smoothly in a non-linear manner with age and b) non-normal cross-sectional distributions which may change shape, including changing standard deviation (SD), with age.

The fit of the model to the data depends critically on the degrees of the polynomial in age and in Z. No formal theory exists for determining these values. They could only be determined by repeated experimentation and validation. Goodness of fit was assessed by computing the Z values given by the model for each of the stating centile values. Polynomials were then fitted to the Z's and the resulting curves compared with the straight lines expected if the model fits the data. Although the method is empiric, the quality of fit is immediately apparent.

The whole method has been implemented as an extension to the NANOSTAT statistical package which was developed for WHO and called GROSTAT.[19,20]

RESULTS

A) Height

Smooth percentiles of stature by sex and age is shown in table I which was obtained by fitting the following models:

Boys:
$$Y_i = (94.845 + 1.723z_i + .202z^2_i) + (2.245 + .470z_i)Age_i + .150Age^2_i$$

Girls:
$$Y_i + (83.756 + 1.715z_i - .143z^2_i) + (4.402 + .501z)_i Age_i + .062Age^2_i$$

Figures 1a and 1b display smooth curves for the heights of boys and girls respectively. A comparison of heights of both sexes is shown in figure 1c.

B) Weight

A logarithmic transformation was made to remove the skewness in weight, the smooth percentile was calculated based on the following models. The results are shown in table II.

Boys:
$$Y_i = EXP[(2.632 + .079z_i + .015z^2_i) + (.029 + .008z_i)Age_i + .004Age^2_i]$$

Girls:
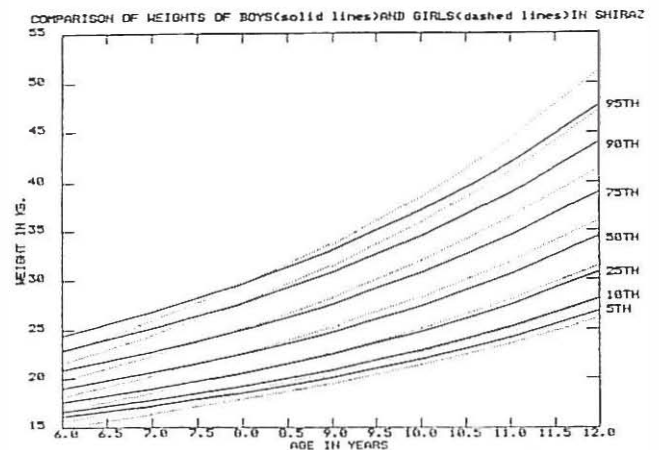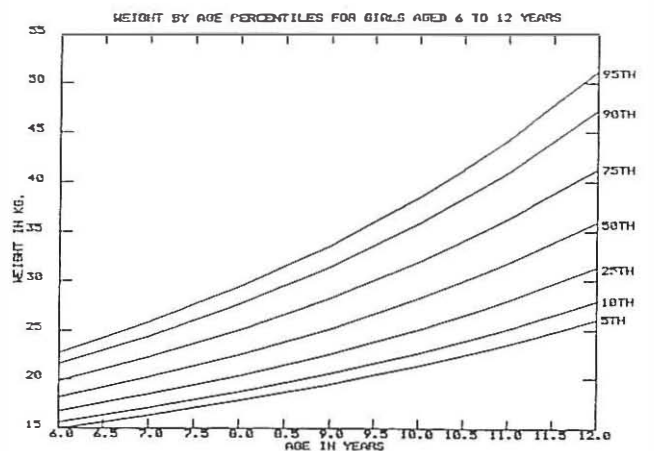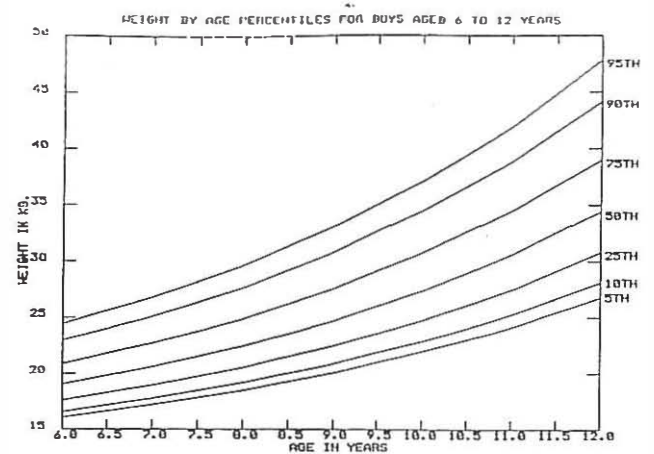$$Y_i = EXP[(2.355 + .047z_i + .006z^2_i) + (.080 + .013z_i)Age_i + .002Age^2_i]$$

Fig. 2.

Smooth curves for boys, girls and the comparison between them are displayed in figures 2a, 2b and 2c respectively.

C) Mid-Upper Arm Circumference

Because arm circumference measurements was skewed, a logarithmic transformation was applied to reduce it before fitting the centile curves. Smooth
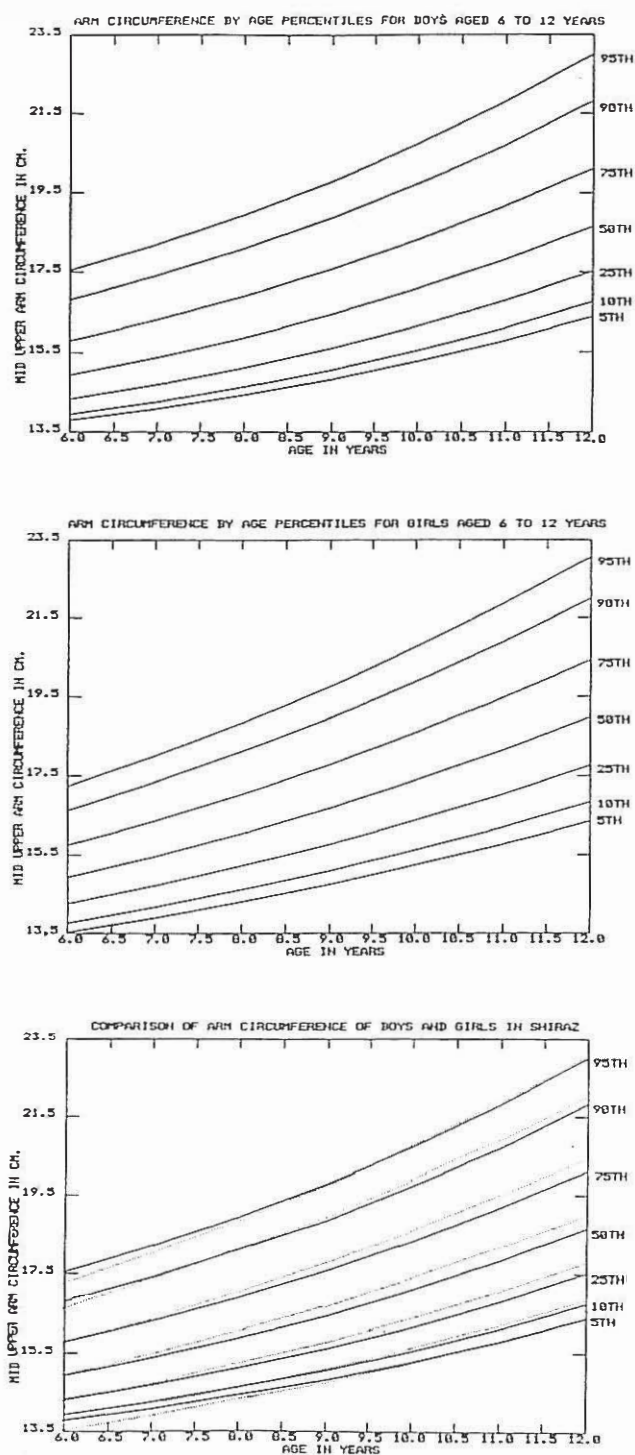
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ARM CIRCUMFERENCE BY AGE PERCENTILES FOR BOYS AGED 6 TO 12 YEARS

ARM CIRCUMFERENCE BY AGE PERCENTILES FOR GIRLS AGED 6 TO 12 YEARS

COMPARISON OF ARM CIRCUMFERENCE OF BOYS AND GIRLS IN SHIRAZ

Fig. 3.

centiles in table III were calculated based on the following fitted models:

Boys:
$$Y_i = EXP\,[(2.601+.043z_i + .015z^2_i)+(.007+.005z_i)Age_i + .002Age^2_i]$$

Girls:
$$Y_i = EXP\,[(2.534+.043z_i + .008z^2_i)+(.022+.005z_i)Age_i + .001Age^2_i]$$

Smooth curves for boys and girls are displayed in figures 3a and 3b repectively and are compared in figure 3c.

DISCUSSION

The authors have examined the appropriateness of Healy's method to constructing growth charts from Iranian data and compared the Iranian growth charts with NCHS in another paper.

Two advantages of an analytic model are first that raw data may be transformed to normal scores and secondly other centile values that may be required can be determined directly from the fitted polynomials. Both these facilities are available in GROSTAT.

Comparison of the growth charts for boys and girls in figures 1c, 2c and 3c show that girls are growing faster than boys in repect of all these parameters in these age groups so that by twelve girls are on average slightly larger than boys, as is well known.

Clearly clinical word in Iran requires more relevant norms. It should be noted, however, that the sample only relates to the 91% of children in this age group attending school. The study does not include chronic ill children or those whose parents did not send them to school. Our data may therefore be regarded as providing standard reference values for normal healthy children in Shiraz. Subsequent analysis (to be published) shows that there are no marked differences between children from different socioeconomic groups in the city. No significant difference is noted among the growth pattern of the originally Shirazi children and other ones who have migrated to the city due to the war or for any other reasons. The homogeneity of the data together with the rationing of staple foods at prices which almost all can afford and has been in force since 1980, suggests that the norms calculated for Shiraz children are likely to be generally applicable to urban children in Iran.

A comparison of the results of this study with two other Asian developing countries, i.e. Bahrain and India, shows that both Iranian girls and boys are markedly taller and heavier for their age than their counterparts and indicates a better health and nutritional status of children in Iran.[21,22]

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