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REFERENCE CHARTS FOR ARM, CHEST AND HEAD CIRCUMFERENCES OF SOUTH IRANIAN INFANTS

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ABSTRACT

The reference charts for mid upper arm (MUAC), chest (CHC) and head (HC) circumferences of a cohort of 317 healthy infants (153 boys and 164 girls) born in Shiraz (Southern Iran) and monitored from birth for 2 years are presented. Centiles for MUAC and HC lie below the Netherlands and US subjects respectively. However, there is no suggestion of ill health for Iranian subjects. The use of locally based MUAC, HC, and CHC charts are essential for clinical work in Iran. Operational simplicity and measurement validity and accuracy suggest that monitoring these measurements should be performed both by health workers in the Iran primary health care system and by mothers for preventive measures as well as child health promotion and development. The paper concludes that the charts presented here are likely to be applied to the urban infant population of Iran due to its structural representativeness and sophisticated methodology.
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INTRODUCTION

Mid upper arm circumference (MUAC) measurement is an excellent indicator of nutritional status and has the important advantage of operational simplicity.[1-4] It is frequently used for screening purposes.[5]

A routine measurement of head circumference (HC) is intended to aid in detection of two groups of disorders characterized by a large head and by a small head.[6-7] This is an important measurement and is suggested to be performed and recorded carefully and regularly.[8]

A new reference for MUAC is provided in the Netherlands.[9] Also, the United States National Center for Health Statistics (NCHS)[10] provides a reference chart for HC in the United States.

At present, no reference data is available on body circumferences in Iran. Any assessment by using external standards may be seriously misleading. The purpose of this paper is, therefore, to construct MUAC, HC and chest circumference (CHC) charts for Shiraz (Iran) infants in a representative sample who were monitored from birth to two years. The value of chest circumference (CHC) needs to be investigated, which this paper intends to perform.

MATERIAL AND METHODS

Nearly all pregnant women in Shiraz (97.5%) give birth in the hospital. A cohort of 317 neonates (164 girls and 153 boys) were selected randomly using probability proportional to size scheme among those born at the 14 maternity clinics of Shiraz during 2 random consecutive weeks from 7th of June to 20th of June in 1996. The selected subjects were healthy singleton neonates whose mothers conceived them in Shiraz and their parents did not intend to migrate elsewhere during the study period. They were visited at homes at target ages 1.5, 3, 4.5, 6, 8, 10, 12, 15, 18, 21 and 24 months and their mid upper arm circumference (MUAC), head circumference (HC) and chest circumference (CHC) were measured by the trained auxologists using techniques presented by Cameron.[11] The circumferences were measured to unit millimeter using a non-extensible strip.

Five trained auxologists observed infants in the first year

Table I. The number of infants, mean (SD) of arm, chest and head circumferences (mm) of boys and girls by mean (SD) of age (months).

Target Ages	Age (Months) Mean (SD)	Boys				Girls			
		N	Arm (mm) Mean (SD)	Chest (mm) Mean (SD)	Head (mm) Mean (SD)	N	Arm (mm) Mean (SD)	Chest (mm) Mean (SD)	Head (mm) Mean (SD)
0.0	0.0 (0.0)	153	107 (10)	329 (19)	349 (14)	164	105 (8)	325 (15)	342 (13)
1.5	1.1 (0.3)	148	121 (11)	373 (21)	377 (14)	162	118 (11)	366 (22)	369 (14)
3.0	2.6 (0.4)	147	138 (13)	411 (21)	400 (14)	160	132 (12)	398 (22)	389 (15)
4.5	3.9 (0.4)	145	141 (12)	426 (20)	415 (13)	156	135 (11)	412 (22)	406 (15)
6.0	5.8 (0.4)	137	144 (12)	441 (23)	431 (14)	150	137 (12)	430 (21)	420 (13)
8.0	8.0 (0.4)	139	146 (12)	458 (24)	445 (13)	148	141 (11)	445 (21)	433 (13)
10.0	9.8 (0.4)	137	148 (12)	467 (23)	454 (13)	151	143 (11)	454 (23)	443 (13)
12.0	11.7 (0.5)	131	150 (13)	474 (24)	463 (13)	147	145 (11)	460 (24)	451 (14)
15.0	14.8 (0.6)	128	151 (12)	485 (22)	470 (13)	142	146 (11)	471 (22)	458 (14)
18.0	17.9 (0.5)	123	152 (12)	490 (22)	477 (13)	139	147 (11)	478 (20)	464 (13)
21.0	20.3 (0.4)	116	153 (11)	498 (23)	480 (13)	134	148 (12)	484 (23)	468 (14)
24.0	23.4 (0.4)	119	154 (11)	506 (23)	485 (13)	134	149 (12)	490 (23)	472 (14)

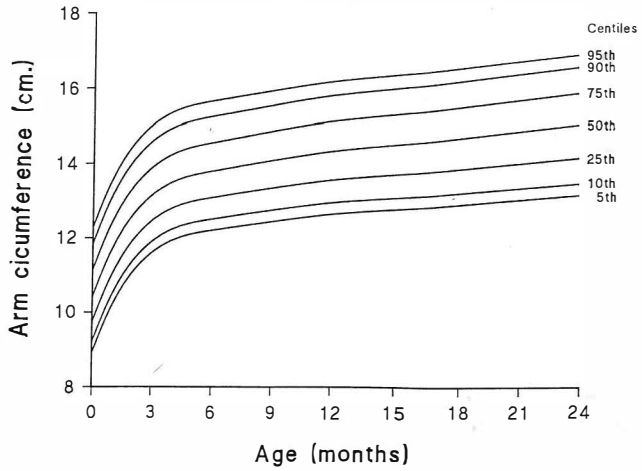

Fig. 1a. Arm circumference by age chart of boys; Shiraz (Iran).

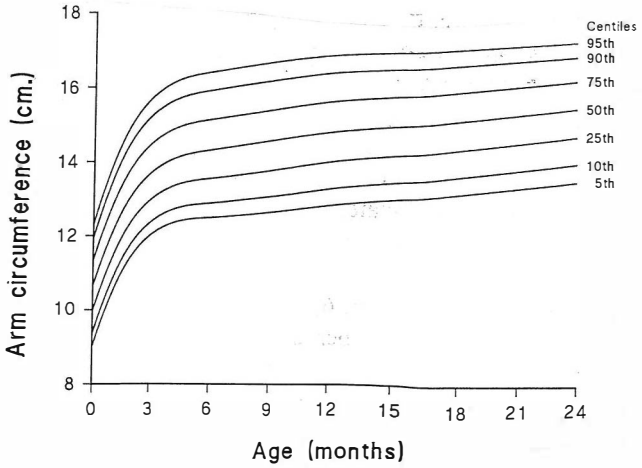

Fig. 1b. Arm circumference by age chart of girls; Shiraz (Iran).

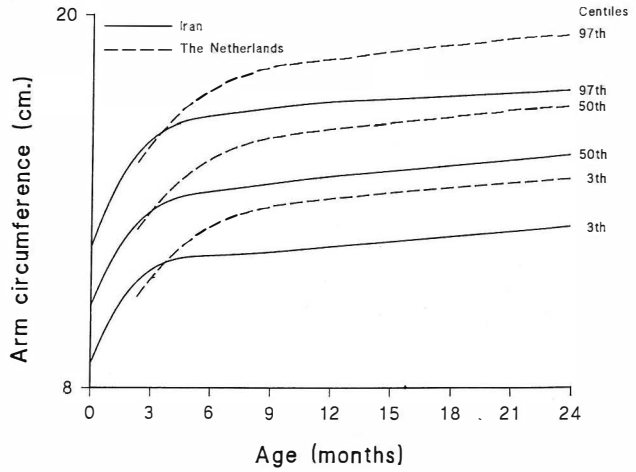

Fig. 1c. Comparison of the arm circumference chart of boys in Shiraz (Iran) and the Netherlands.

of the study. In the second year 4 newly trained auxologists had been replaced. All observers had a first university degree in the area of public health and/or nursing and midwifery with distinction. In addition 4 community medicine experts monitored the subjects for 3 months from birth. Once needed, infants were referred to a consultant pediatrician for the whole study period. A subject was considered as missing if he/she was not in for any reasons when home visit was performed at least 3 times at that occasion or his/her family migrated elsewhere for unseen reasons or decided to leave the study or the baby expired. The selected cohort was a 2.5% sample of neonates born in 1996 in Shiraz.

Infant age was corrected for his/her gestational age (GA) if GA<38 weeks. In this case the infant's age was calculated as:

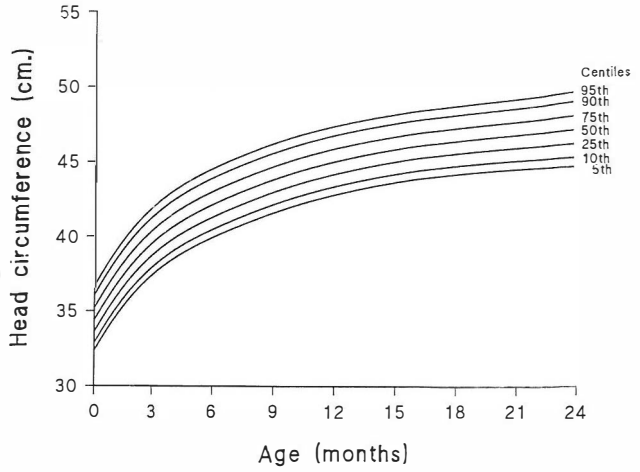

Fig. 2a. Head circumference by age chart of boys; Shiraz (Iran).

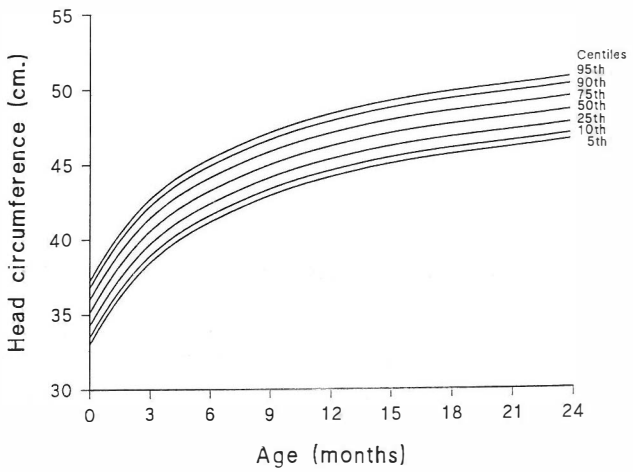

Fig. 3a. Chest circumference by age chart of boys; Shiraz (Iran)

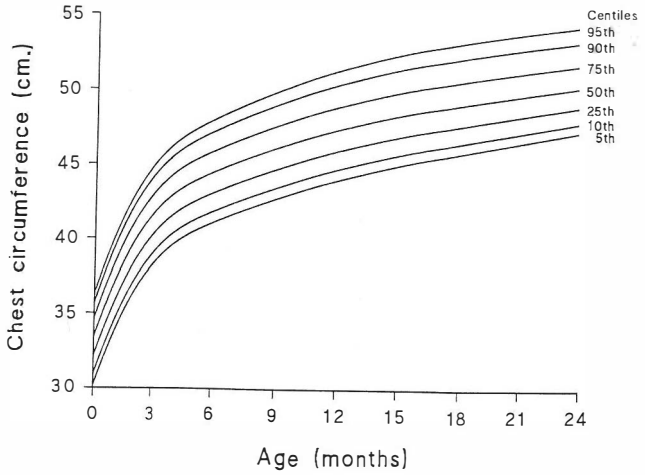

Fig. 2b. Head circumference by age chart of girls; Shiraz (Iran).

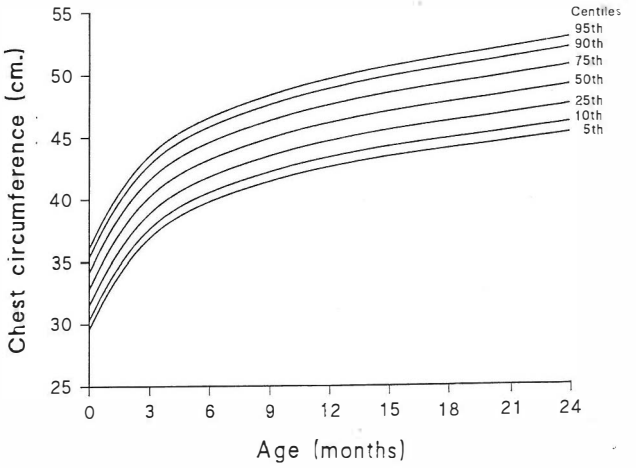

Fig. 3b. Chest circumference by age chart of girls; Shiraz (Iran)

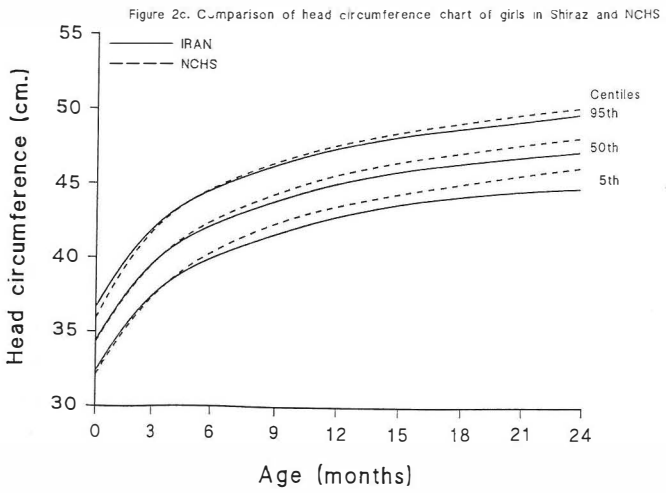

Fig. 2c. Comparison of the head circumference chart of girls in Shiraz and the NCHS chart.

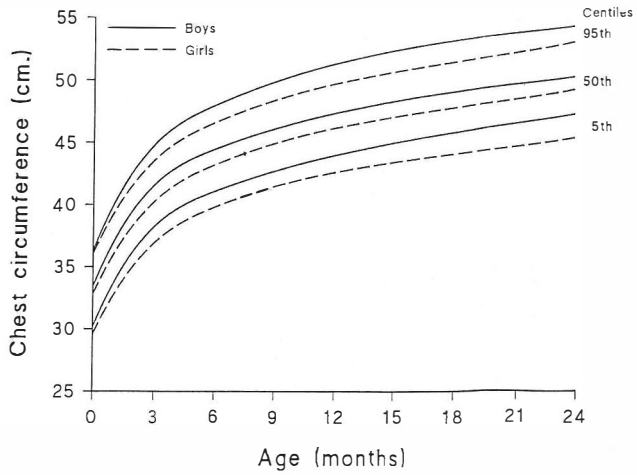

Fig. 3c. Comparison of boys and girls' chest circumference; Shiraz (Iran).

AGE (from EDD) = AGE (from birth) - 40 + GA

where EDD stands for expected date of delivery which is 40 weeks. Observations were included only if AGE from EDD was greater than or equal to zero.

The charts were constructed using an amalgamated

Table II. Smoothed percentiles of infants' head circumference (cm) by sex and age (months).

Sex & Age (months)	Centile						
	5th	10th	25th	50th	75th	90th	95th
Girls							
0.0	32.4	32.9	33.6	34.4	35.2	36.1	36.7
1.5	35.3	35.8	36.6	37.4	38.2	39.1	39.7
3.0	37.4	37.9	38.7	39.5	40.4	41.3	41.9
4.5	38.9	39.4	40.2	41.0	41.9	42.8	43.4
6.0	39.9	40.5	41.3	42.1	43.0	43.9	44.5
8.0	41.1	41.6	42.5	43.3	44.2	45.1	45.7
10.0	42.0	42.6	43.4	44.3	45.1	46.0	46.7
12.0	42.8	43.4	44.2	45.0	45.9	46.8	47.4
15.0	43.6	44.2	45.0	45.8	46.7	47.6	48.2
18.0	44.2	44.7	45.6	46.4	47.3	48.1	48.7
21.0	44.5	45.1	45.9	46.8	47.7	48.6	49.2
24.0	44.7	45.3	46.2	47.2	48.1	49.0	49.7
Boys							
0.0	33.0	33.5	34.2	35.1	36.0	36.7	37.2
1.5	36.2	36.7	37.5	38.3	39.2	40.0	40.4
3.0	38.5	38.9	39.7	40.6	41.4	42.2	42.7
4.5	40.0	40.5	41.3	42.1	43.0	43.8	44.3
6.0	41.2	41.6	42.4	43.3	44.1	44.9	45.4
8.0	42.4	42.8	43.6	44.5	45.4	46.1	46.6
10.0	43.4	43.8	44.6	45.5	46.3	47.1	47.6
12.0	44.2	44.6	45.4	46.2	47.1	47.9	48.4
15.0	45.0	45.5	46.2	47.1	47.9	48.8	49.2
18.0	45.6	46.1	46.8	47.7	48.5	49.3	49.8
21.0	46.1	46.5	47.2	48.1	49.0	49.8	50.3
24.0	46.6	47.0	47.7	48.5	49.4	50.2	50.7

method (AM) for estimating age-related centiles.[12] This method amalgamates the Lambda-Median-Standard deviation (LMS) parametric method[13] and its extension[14] and Healy-Rasbash-Yang (HRY) nonparametric method[15] as extended to model a wide range of ages[16] by applying techniques used in one or the other. The AM method increases the ease and width of the cited methods and provides more realistic charts close to the data using a 4 step algorithm. AMSTAT software specially written to handle the AM method was used to smooth the anthropometric data. Goodness of fit of data was evaluated both by z-score method and counting the number of observations between the centiles. If the centiles are a good fit to data, approximately the correct number of points should lie between consecutive centiles, not only overall but also within subranges of age.

RESULTS

Table I gives summary statistics of the measurements by age. The 3 measurements increase with age more rapidly in the first year but their rates of increase in the second year of life are much lower. This is more pronounced for MUAC which changes little after 12 months of age. For all measurements, girls' means are less than boys.

Tables II, III and IV present smoothed percentiles for MUAC, HC and CHC of boys and girls at target ages respectively.

Figures la and lb provide MUAC charts for age for boys and girls respectively. HC by age charts are presented in Figures 2a and 2b for both sexes. Figures 3a and 3b depict CHC by age charts for boys and girls respectively.

Table III. Smoothed percentiles of infants' mid upper arm circumference (cm) by sex and age (months).

Sex & Age (months)	Centile						
	5th	10th	25th	50th	75th	90th	95th
Girls							
0.0	8.9	9.2	9.7	10.4	11.1	11.8	12.3
1.5	10.7	11.0	11.5	12.2	12.9	13.7	14.1
3.0	11.6	11.9	12.5	13.2	13.9	14.6	15.0
4.5	12.0	12.3	12.9	13.6	14.4	15.1	15.5
6.0	12.2	12.5	13.1	13.8	14.6	15.3	15.7
8.0	12.4	12.7	13.3	14.0	14.8	15.5	15.9
10.0	12.5	12.8	13.4	14.2	15.0	15.7	16.0
12.0	12.7	13.0	13.6	14.3	15.1	15.8	16.2
15.0	12.8	13.1	13.7	14.5	15.3	16.0	16.4
18.0	12.9	13.2	13.9	14.7	15.5	16.2	16.6
21.0	13.0	13.4	14.0	14.9	15.7	16.4	16.7
24.0	13.2	13.5	14.2	15.1	15.9	16.6	16.9
Boys							
0.0	9.0	9.4	10.0	10.7	11.3	11.9	12.3
1.5	11.0	11.3	11.9	12.6	13.4	14.1	14.5
3.0	12.0	12.4	13.0	13.7	14.5	15.2	15.7
4.5	12.4	12.8	13.4	14.2	15.0	15.7	16.2
6.0	12.5	12.9	13.6	14.3	15.2	15.9	16.4
8.0	12.6	13.0	13.7	14.5	15.3	16.1	16.6
10.0	12.7	13.1	13.9	14.7	15.5	16.3	16.8
12.0	12.8	13.3	14.0	14.8	15.6	16.4	16.9
15.0	13.0	13.5	14.2	15.0	15.8	16.5	17.0
18.0	13.2	13.7	14.4	15.2	15.9	16.7	17.1
21.0	13.4	13.8	14.6	15.3	16.1	16.8	17.2
24.0	13.5	14.0	14.7	15.5	16.2	16.9	17.3

DISCUSSION

A comparison of boys and girls' CHC charts is provided in Figure 3c for median and extreme centiles. As can be seen girls' CHC centiles lie under boys. The same result is obtained when girl's MUAC and HC centiles are compared with that of the boys.

Figures 1c and 2c compare boys' MUAC with the Netherlands' chart and girls' HC with the NCHS chart for median and extreme centiles respectively, indicating that our infants lie under European and American norms, especially after the age of 4 months. Median MUAC of both sexes correspond to the 25th centile of the Netherlands' data.[9] The same result is obtained when one compares our HC data to the NCHS data.[10] The difference may be of genetic or environmental factors such as the feeding pattern in Iran. However, it will be noted that the spread of the centiles of Iranian infants is essentially the same as that of their European and American counterparts.

The lower level of Iranian centiles does not suggest serious levels of ill-health such as are found in many developing countries. Our subjects were healthy infants who were monitored during the course of the study and were under health care surveillance provided by the research project.

An advantage of this study lies in providing chest circumference charts for infants. The NCHS only presents HC charts and only recently a European study has provided ref-

Table IV. Smoothed percentiles of infants' mid chest circumference (cm) by sex and age (months)

Sex & Age (months)	Centile						
	5th	10th	25th	50th	75th	90th	95th
Girls							
0.0	29.6	20.3	31.5	32.8	34.2	35.4	36.1
1.5	34.0	34.8	36.0	37.3	38.7	39.9	40.6
3.0	36.9	37.6	38.9	40.2	41.6	42.8	43.6
4.5	38.7	39.4	40.7	42.0	43.4	44.7	45.4
6.0	39.8	40.6	41.8	43.2	44.6	45.9	46.6
8.0	41.0	41.7	43.0	44.4	45.8	47.1	47.9
10.0	41.9	42.7	44.0	45.4	46.8	48.1	48.9
12.0	42.6	43.4	44.7	46.2	47.6	48.9	49.7
15.0	43.4	44.3	45.6	47.1	48.6	49.9	50.7
18.0	44.1	44.9	46.3	47.8	49.3	50.6	51.4
21.0	44.7	45.5	46.9	48.5	50.0	51.4	52.2
24.0	45.4	46.2	47.7	49.2	50.8	52.2	53.0
Boys							
0.0	30.2	30.9	32.1	33.4	34.6	35.7	36.3
1.5	34.1	35.9	37.1	38.4	39.7	40.8	41.5
3.0	38.2	40.0	40.2	41.6	42.9	44.1	44.8
4.5	40.0	40.8	42.0	43.4	44.7	46.0	46.7
6.0	41.1	41.8	43.1	44.5	45.9	47.2	48.0
8.0	42.2	42.9	44.2	45.6	47.1	48.4	49.3
10.0	43.2	43.9	45.1	46.6	48.1	49.5	50.4
12.0	44.0	44.7	45.9	47.4	48.9	50.4	51.3
15.0	45.0	45.7	46.9	48.3	49.9	51.4	52.4
18.0	45.8	46.5	47.7	49.1	50.6	52.1	53.2
21.0	46.5	47.2	48.3	49.7	51.2	52.7	53.8
24.0	47.3	47.9	49.0	50.3	51.7	53.3	54.3

erences for MUAC.[9] Some other studies have used chest circumference as an indicator of low birth weight[17-19] but its use as an indicator of infant growth is original, presenting the value of this measurement for health promotion.

Clearly clinical work in Iran requires more relevant norms. Our data are based on a representative sample of healthy infants which comprises all regions and classes of Shiraz in a well designed longitudinal study. Therefore, the charts provided here may be regarded as standard reference values for healthy urban infants of Shiraz. The representativeness of our data together with their structural demographic as well as socioeconomic homogeneity with the urban population of Iran suggest that the centile standards calculated for Shiraz infants are likely to be generally applicable to urban infants in Iran.

The references provided here have the advantage of operational simplicity and mothers can use them with minimal training to monitor their babies using a very simple graduated inexpensive strip, which may be an efficient tool for preventive as well as infant health promotion purposes.

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