

A Systematic Review of Reference Values for Mid Upper Arm Circumference (MUAC) in Southern Iran

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Abstract

Background: Mid upper arm circumference (MUAC) is an excellent indicator of nutritional status and is frequently used for obesity screening purposes.

Objective: To review the state of art of MUAC studies in Iran and to provide a simple reliable tool for assessing human obesity in southern Iran.

Search strategy: Scientific reports including published papers on MUAC were critically studied. The earliest report on MUAC measurement in Iran dates back to 1987. Since then only 12 papers published and one report on this very crucial measurement compiled, out of which 7 papers provided reference values for MUAC of South Iranians, which covered infancy, school-aged, and adults-aged subjects and favors local MUAC charts.

Data collection and analysis: MUAC of 6550 healthy subjects in Shiraz (Southern Iran) were measured. The data related to 5 different random samples which included to neonates, a cohort of 317 newborn infants who followed for two years, 2 sets of 1207 and 2237 school children and 2282 married adults (1141 couples). Data were analyzed using advanced statistical techniques including Healy-Rasbash-Young (HRY) method for constructing the age – related reference centiles.

Main results: The summary statistics of MUAC (mm) is presented in the forthcoming table

Subjects	Male						Female				P-value
	Year	Age (Years)	N	Mean	SD	%95 CI	N	Mean	SD	%95 CI	
Neonates	1996	Birth	244	106	10	86-126	263	105	13	87-122	<0.01
Infants	1996-1998	0-2	119	154	11	152-156	134	149	11	147-151	<0.005
Children	2002-2003	6-12	1145	185	24	184-187	1062	188	24	187-190	<0.006
Adults	2003	25-55	1141	283	29	287-296	1141	295	35	296-303	<0.0025

Conclusion: MUAC had become thicker during past three decades. However, it was lower than their counterparts in western countries. The necessity of using local MUAC standards covering all age groups for clinical work in Iran is more realistic, which should be updated periodically.

Keywords: Mid Upper Arm Circumference; Obesity; Centile; Iran

Introduction

Measuring MUAC has several advantages. The measuring can be taken quickly and at little cost. It requires neither sophisticated equipment nor anything but the most basic literary level to carry out [1,2]. It is an excellent indicator of nutritional status and is frequently used for screening purposes [3-6].

A reference for MUAC was provided in the Netherlands [7]. Standards for arm circumference of Tanzanian children were also reported [8].

The earliest report on MUAC measurement in Iran dates back to 1978. Weight, height and arm circumference of 400 Esfahan (one of the five principal cities in Iran) children aged 1-24 months attending the city Public Health Center, were measured. Comparing the 80% weight for age as an upper limit for protein- calorie malnutrition (PCM) with the arm for age and age constant arm standard, in the children aged 13-24 months classified as malnourished groups was found to be similar to the total number in the first, second and third degree malnutrition groups by weight. Thus, arm circumference measurement could be used for detection of malnutrition in crisis situations. The values of correlation coefficient (r) between MUAC for and weight, height, head and chest circumference for age is better with weight than other parameters [9]. Foroozani and her colleagues [10] have also compared

their arm circumference data with Wolanskis standard and found that their measurements were lower than the standard.

MUAC of less than 6 months of infants in a community field of Zanjan [11] (North West Iran) were reported. Also 2000 healthy women (age range: 15-49 years) in Mashad (one of the five principal cities in the North East of Iran) were studied to assess anthropometric measurements at reproductive age and the usefulness of MUAC for estimating Body Mass Index (BMI) and screening of women at nutritional risk. The study found a strong correlation between MUAC with weight and BMI, suggesting that MUAC can be used to estimate BMI and detect nutritional disorders [4].

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Data from 700 mothers (aged 18-30) and babies from delivery wards of 12 university hospitals in Tehran (The Iran's Capital) for duration of six months reported and arm circumference of less than 23cm was considered as cut-off point for delivery of low-birth weight. The paper concludes that mothers who are at high risk for delivering low-birth babies can be screened by measuring arm circumference at anytime during pregnancy [12].

Reference values for MUAC in Shiraz

None of these studies provided reference values for MUAC of Iranians. They were not aimed at a specific target population and could not be classified as survey researches on the subject of MUAC. The groups studied were taken from clinics and hospitals etc. This motivated us to carry out several studies on MUAC data and provide reference values for different age groups. Therefore the present paper gives a state of art of MUAC reference data for Shiraz (Iran).

Place of study

Shiraz, one of the 5 principal cities of the Islamic Republic of Iran, is the center of Fars province. The city is located 1000km south of the capital (Tehran) and 100km north of the Persian Gulf, at an altitude of 1500m above sea level. It had a Mediterranean climate and a population of 1.2 million, of whom 84% were literate (Iran Literacy Movement, unpublished report, 1998). The city is both the most developed city in the Southern region and the cultural capital of Iran.

Mid Upper Arm Circumference (MUAC)

The mid upper arm landmark was taken as the point on the lateral border of the acromion and the olecranon when the arm was flexed at 90 degrees. This may be easily determined by marking the lateral border of the acromion and applying a tape measure to this point. The plastic tape was allowed to lie over the surface of the arm, and MUAC was recorded to the nearest mm [13].

Age of subjects

Subjects' ages were calculated exactly as the difference between the date of interview and date of birth in days as recorded in their birth certificate, which is accurate.

Construction of MUAC reference charts

The charts were constructed using an amalgamated method (AM) for age-related centiles [14] This method amalgamates the Lambda-Median- Standard Deviation (LMS) parametric method [15] and its extension [16] and Healy-Rasbash-Yang (HRY) [17] nonparametric method as extended to model a wide range of ages [18] by applying techniques used in one or the other. The method first applies a Box-Cox power transformation [19] of the form of

$$y_i^{(\lambda)} = \begin{cases} (y_i^\lambda - 1) / \lambda & \lambda \neq 0 \\ \log y_i & \lambda = 0 \end{cases}$$

to normalize the data, where y_i 's are the MUAC measurements and λ is the power of the transformation applied. 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 observation 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 sub ranges of age. An amalgamated method (AM) was used to estimate age-related MUAC smoothed centiles [16]. Goodness-of-fit was assessed both graphically and numerically. This method has been implemented in GROSTAT software [20].

Neonates MUAC reference data

The data relate to a representative sample (a 4 per cent random sample) of 507 healthy neonates (244 boys, 263 girls) born in Shiraz in 1996 [21]. MUAC measurements were carried out by five trained auxologists within 24h out of delivery and were taken with the newborn lying down naked.

Table 1 presents summary statistics of MUAC at birth of the neonates. Boys MUAC at birth was significantly greater than girls (P<0.01).

Infants

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 else-where during the study period. They were followed and visited at homes for 24 months measured by the trained auxologists [22,23].

Table 2 gives summary statistics of the MUAC measurements by age of infants. The measurement increases with age more rapidly in

Sex	N	Mean	SD	95% CI	P-value
Boys	244	106	10	86-126	0-01
Girls	263	105	13	87-122	-----

Table 1: Summary Statistics of MUAC at birth (mm) of Shiraz (Iran) healthy, neonates1996.

Target Ages	Boys			Girls		
	N	Mean	SD	N	Mean	SD
0.0	153	107	10	164	105	8
1.5	148	121	11	162	118	11
3.0	147	138	13	160	132	12
4.5	145	141	12	156	135	12
6.0	137	144	12	150	137	12
8.0	139	146	12	148	141	11
10.0	137	148	12	151	143	11
12.0	131	150	13	147	145	11
15.0	128	151	12	142	146	11
18.0	123	152	12	139	147	11
21.0	116	153	11	134	148	12
24.0	119	154	11	134	149	11

Table 2: The number of infants, Mean, Standard Deviation (SD) of MUCA (mm) of boys and girls by target ages (man), Shiraz 1996-1998.

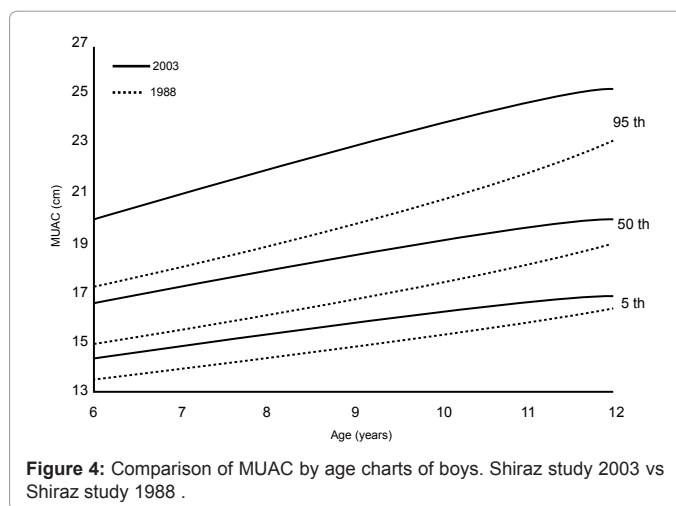
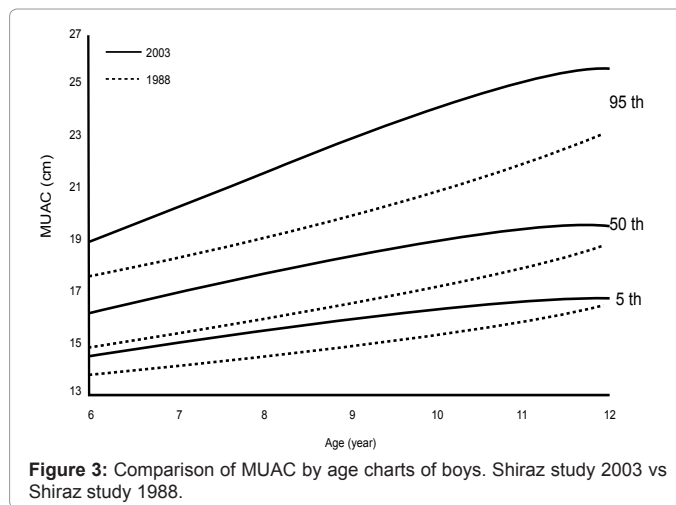
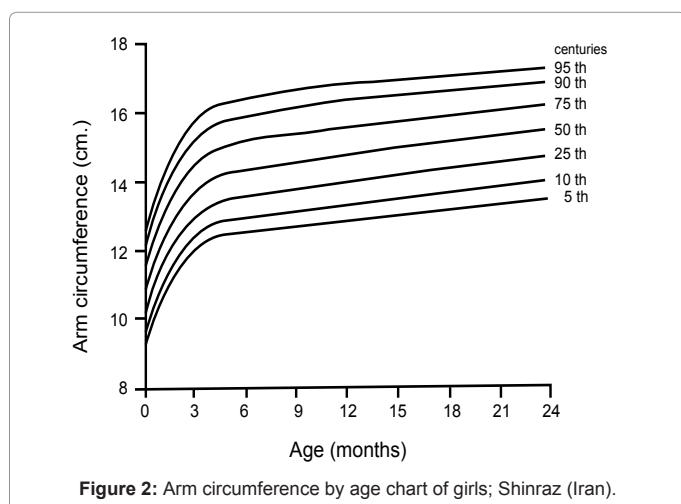
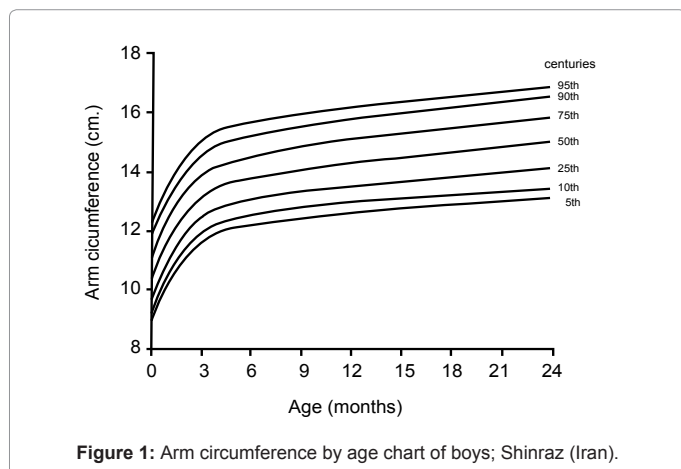
the first year, but their rates of increase in the second year of life is much lower [24,25] girls MUAC means are less than boys. Figure 1 and Figure 2 provides MUAC charts for age for boys and girls respectively.

Children MUAC Reference Data

Two studies had been carried out on MUAC of school children in Shiraz (Iran), one in 1988-89 [26] and the other in 2002-2003 academic years [27]. The first one related to 1207 subjects (642 boys and 565 girls), aged 6-12 years. The second survey was more sophisticated but followed the same logic of sampling to provide reference charts of MUAC by age and compared the results and examined the developments happened during a some 15years period.

A sample of 2283 healthy children aged 6-12 years selected had been free of any sort of congenital malformation, malnutrition or history of illnesses, using clinical interview questionnaires and seeking consultation of a pediatrician. The community came from of the same ethnic group. The MUAC was measured by two trained auxologists. Measurements had been compared and validated properly Valid measurements were available for 1145 boys (98.2%) and 1062 girls (98.9%). Collected data had been used for the study purposes only.

Table 3 presents summary statistics of MUAC measurements by age and sex and their respective significant differences reported. MUAC increases by age and is significantly higher in girls than boys ($p=0.0014$).



A comparison of MUAC centiles of boys and girls is shown in Figure 3. As can be seen, boy's charts generally lie below that of girls.

Figure 4 compares extreme as well as median centiles of our subjects with that of girls from the previous growth survey of Shiraz primary school children carried out in 1988, respectively [26].

The figure shows that our subjects had now longer MUAC than their peers born almost 15 years earlier. On the average in a 15 year period (1988-2003) boys and girls MUAC increased by 1.4 cm ($p=0.07$) and 1.6 cm ($p=0.045$) respectively (26-27), which may be attributed to the developments happened in the post war Iran from 6 to 12 years for 6 months increased.

Adults MUAC Reference Data

The data related to a random sample of 2282 married adults (1141 pairs) aged 25-55 years mean \pm SD ages of husband and wives were 39.9 ± 5.7 and 34.1 ± 5.7 years respectively. They were selected by a multistage sampling scheme and forming a 2% sample of the primary school parents from the four educational districts of Shiraz (Southern Iran), in academic year 2002-2003 [28]. Table 4 presents summary statistics of MUAC by sex and age of married adults of Shiraz. Females MUAC were significantly thicker than male ($P<0.01$). However, female MUAC were generally greater than males.

Sex and Age(year)	Boys				Girls				P-value
	n	mean	SD	%95 CI	n	mean	SD	%95 CI	
7±§	210	171	16	169-173	171	173	19	170-176	.231
8±	210	178	22	175-181	200	181	22	178-184	.162
9±	228	186	23	183-189	207	187	23	184-190	.673
10±	237	192	23	189-195	233	195	24	192-198	.272
11±	260	196	23	193-199	251	199	24	196-202	.147
Total	1145	185	24	184-187	1062	188	24	187-190	.006*

§ In this table 7 ±, 8±,... indicate 6.5-7.49 ,7.50-8.49 ,....

• **significant**

Table 3: Mid upper arm circumference (mm) [MUAC] of school children by sex and age, Shiraz 2002-2003 Number(n), Mean(mm), Standard Deviation(SD) and %95 Confidence Interval (%95CI).

Age (year)	Male				Female				P-value for sex (female > male)
	N	Mean	SD	%95 CI	n	Mean	SD	%95 CI	
25-29	11	280	31	(262-299)	259	290	33	(289-309)	0.232
30-34	194	282	33	(278-295)	393	296	34	(294-306)	0.006
35-39	379	285	29	(285-300)	257	295	36	(291-305)	0.16
40-44	299	283	26	(283-303)	159	298	36	(293-313)	0.099
45-49	179	282	30	(278-307)	44	298	34	(283-348)	0.0905
50-55	79	284	27	(275-312)	11	314	37	(293-337)	0.2065
Total	1141	283	29	(287-296)	1141	295	35	(296-303)	0.0025

Table 4: Mid upper arm circumference (mm) [MUAC] of adults by sex and age, Shiraz 2002-2003.Iran: Number (N), Mean, Standard Deviation (SD) and 95% Confidence Interval (%95 CI).

Conclusions

Nevertheless, for producing data a validation of measurements would have been advisable. The MUAC of one country may differ from that of another. Our charts would be satisfactory for use as standard MUAC charts in Iran south as the samples represented the general structure of these people. However, it is suggested that MUAC standards be re-evaluated and updated periodically, perhaps every other decade due to developments occurring in Iran. Our present results support this suggestion and favor the local standard for MUAC charts which our studies provide for both sexes of infants, school-aged children, and adults. Adolescents MUAC data are lacking in our studies, which is proposed.

The present investigations were undertaken in order to provide MUAC reference data that could be used in future clinical and community health studies in south Iranians, which comprises various socio-economic backgrounds and environmental conditions into account.

However, a comparison between our data with international references had provided evidence for the need of local standards which was unavailable. Until then, our reference values could serve this purpose for urban areas of Iran Lastly, MUAC proved to be a simple reliable tool to assess obesity with minimal training.

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