International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: SJIF: 5.995
Available Online at www.journalijcar.org
Volume 6; Issue 11; November 2017; Page No. 7281-7285
DOI: http://dx.doi.org/10.24327/ijcar.2017.7285.1116

Research Article

Z SCORE OF EGYPTIAN CHILDREN FOR HEAD CIRCUMFERENCE

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A R T I C L E I N F O

Article History:
Received 11th August, 2017
Received in revised form 16th September, 2017
Accepted 9th October, 2017
Published online 28th November, 2017

Key words:

Egyptian, z Score, head circumference

A B S T R A C T

Head circumference (HC) charts are very important as they are used for early detection of so many disorders such as megacephaly and microcephaly. In Egypt we have local charts published in 2008 (Head circumference data for Egyptian children and adolescents) in the form of percentiles. The percentiles method is routine method for assessment of growth in children but z score is more accurate method at the individual and population level. The world health organization has established HC charts available to be used all over the world but recent studies cast doubts whether these charts can be equally applicable in various populations or not. The aim of our study was to establish local reference ranges for HC in Egypt. In this study which combined a longitudinal component from birth to 12 months and a cross sectional component from 1-5 years. Measurements of HC were collected from healthy Egyptian children. The LMS parameters and Z score were calculated for Head circumference for age and then compared with these recommended by World Health Organization (WHO). A total of 27.537 of Egyptian children from birth to 5 years of both sexes were studied for L, M and S parameters and Z score for HC for age. In conclusion Egyptian HC reference ranges for children from birth to 5 years differ significantly from those provided by WHO and should be considered to be used for screening diseases related to HC in that population.

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INTRODUCTION

Growth in children is an important indicator of their health [1], [2]. There are so many factors affecting growth such as nutrition, genetic and environmental factors, e.g. maternal smoking, birth weight and maternal height [3], [4]. HC is considered an important reflection of growth and development in early childhood according to several studies [5], [6]. There is association between Small HC and low intelligence quotient (IQ) as well as learning disabilities [6], [7]. While large HC can be the first manifestation of various congenital and acquired neurologic conditions or may be just a familial trait [8]. HC is also a sensitive anthropometric indicator of malnutrition in infants so can be used as a measure of failure to thrive by clinicians [9], [10]. That's why measuring HC routinely is very helpful in detection of two groups of disorders characterized by a large head and a small head [11], [12].

The reference ranges which were established by the WHO Multicenter Growth Reference Study (MGRS) collected from 6 countries (Brazil, Ghana, India, Norway, Oman, USA) and only included breastfed children born to nonsmoking mother of high social class are currently recommended by WHO for monitoring growth including Head circumference in infants and young children [13]. However many countries have been shown to be a variance when compared with their national and regional HC growth references [14], [17] so our study was done to establish Egyptian HC reference ranges to be compared with corresponding WHO ranges.

Subject and methods

A total of 27.537 Egyptian children from birth to 5 years were studied from December 2015 to march 2017. They were selected from primary health centers and vaccination centers as representative of Egyptian children. This study combined a longitudinal component from birth to 12 months and a cross sectional component from 1-5 years. In the longitudinal component mothers and newborns are screened and enrolled at birth then visited at home and in vaccination centers monthly.

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Table 1 shows Egyptian z scores for head circumference for age for boys aged zero to 5 years

Head circumference-for-age BOYS											
Egyptian Z-score Birth to 5 Years											
Y:M	M	Mean	S	L	-3SD	-2SD	-1SD	Median	1SD	2SD	3SD
00:00	0	35.0582	1.35333	1	31.1	32.3	33.6	35.1	36.5	37.8	38.9
00:01	1	37.553	1.41096	1	33.6	34.7	36.1	37.6	39.1	40.5	41.6
00:02	2	39.5751	1.5962	1	35	36.3	38	39.6	41.2	42.8	44.1
00:03	3	40.8085	1.73736	1	36	37.3	39.1	40.9	42.7	44.4	45.6
00:04	4	41.6245	1.66993	1	37	38.2	40	41.7	43.4	45	46.4
00:05	5	42.4952	1.76113	1	37.6	38.9	40.7	42.5	44.3	46	47.4
00:06	6	43.0528	1.66815	1	38.4	39.6	41.4	43.1	44.8	46.5	47.8
00:07	7	43.6052	1.7131	1	38.8	40.2	41.9	43.7	45.4	47.2	48.6
00:08	8	44.1152	1.70163	1	39.4	40.7	42.3	44.2	45.9	47.6	48.8
00:09	9	44.4752	1.67447	1	39.7	41.1	42.8	44.5	46.2	47.9	49.3
00:10	10	44.9075	1.67744	1	40.2	41.5	43.2	45	46.6	48.3	49.6
00:11	11	45.2025	1.70134	1	40.4	41.8	43.5	45.3	47	48.8	50.2
01:00	12	45.5752	1.64271	1	40.9	42.2	43.9	45.6	47.3	49	50.3
01:01	13	45.9235	1.70667	1	41.2	42.5	44.2	46	47.8	49.3	50.6
01:02	14	46.0852	1.60402	1	41.5	42.8	44.5	46.1	47.8	49.3	50.7
01:03	15	46.2752	1.6238	1	41.6	42.9	44.7	46.3	48	49.5	50.9
01:04	16	46.4425	1.53118	1	42	43.3	44.9	46.5	48.1	49.7	51
01:05	17	46.7157	1.56272	1	42.2	43.6	45.1	46.8	48.3	49.8	51.2
01:06	18	46.9925	1.53655	1	42.5	43.7	45.3	47	48.5	50	51.3
01:07	19	47.1523	1.52983	1	42.6	44	45.5	47.2	48.7	50.2	51.6
01:08	20	47.3052	1.55694	1	42.8	44.1	45.7	47.3	49	50.5	51.8
01:09	21	47.575	1.59123	1	42.8	44.2	45.8	47.6	49.2	50.8	52.2
01:10	22	47.7321	1.59933	1	43.1	44.5	46.1	47.8	49.4	50.9	52.3
01:11	23	47.8351	1.55693	1	43.4	44.7	46.2	47.9	49.5	51.1	52.4
02:00	24	48.1532	1.59232	1	43.6	44.9	46.4	48.2	49.7	51.3	52.6
02:01	25	48.2285	1.57999	1	43.8	45.1	46.6	48.3	49.8	51.3	52.7
02:02	26	48.4445	1.56766	1	44	45.4	46.8	48.5	50	51.4	52.8
02:03	27	48.5093	1.55736	1	44.2	45.6	46.9	48.6	50.1	51.5	52.9
02:04	28	48.7755	1.54706	1	44.4	45.8	47.1	48.8	50.2	51.6	53
02:05	29	48.8852	1.54099	1	44.5	45.9	47.2	48.9	50.3	51.7	53
02:06	30	48.9156	1.53491	1	44.7	46	47.3	49	50.5	51.8	53.1
02:07	31	49.025	1.54022	1	44.7	46.1	47.4	49.1	50.6	51.9	53.2
02:08	32	49.1452	1.54552	1	44.8	46.2	47.6	49.3	50.8	52	53.4
02:09	33	49.2452	1.5396	1	45	46.4	47.7	49.4	50.9	52.1	53.5
02:10	34	49.4452	1.53369	1	45.2	46.6	47.8	49.5	51	52.3	53.7
02:11	35	49.5862	1.52664	1	45.3	46.7	47.9	49.6	51.1	52.3	53.7
03:00	36	49.6752	1.51959	1	45.4	46.8	48	49.7	51.2	52.4	53.8
03:01	37	49.7145	1.5136	1	45.5	46.9	48.1	49.8	51.3	52.5	53.9
03:02	38	49.8352	1.50761	1	45.6	47.1	48.2	49.9	51.4	52.6	54
03:03	39	49.9158	1.49383	1	45.7	47.2	48.3	50	51.5	52.6	54
03:04	40	50.0281	1.48004	1	45.9	47.4	48.5	50.1	51.6	52.7	54.1
03:05	41	50.1258	1.49244	1	45.9	47.4	48.5	50.2	51.7	52.8	54.2
03:06	42	50.2452	1.50483	1	46	47.5	48.6	50.3	51.8	52.9	54.4
03:07	43	50.2685	1.501	1	46.1	47.6	48.7	50.3	51.9	53	54.5
03:08	44	50.3012	1.49717	1	46.2	47.7	48.8	50.4	52	53.1	54.6
03:09	45	50.4156	1.501	1	46.3	47.8	48.9	50.5	52.1	53.2	54.7
03:10	46	50.6251	1.50483	1	46.4	47.9	49	50.7	52.2	53.3	54.8
03:11	47	50.7158	1.46272	1	46.6	48.1	49.1	50.8	52.2	53.3	54.8
04:00	48	50.8424	1.42061	1	46.8	48.3	49.3	50.9	52.3	53.3	54.8
04:01	49	50.9452	1.40089	1	46.9	48.4	49.4	51	52.4	53.3	54.8
04:02	50	51.0258	1.38116	1	47.1	48.6	49.5	51.1	52.5	53.4	54.9
04:03	51	51.0632	1.38192	1	47.2	48.7	49.6	51.2	52.6	53.5	55
04:04	52	51.215	1.38267	1	47.3	48.8	49.7	51.3	52.7	53.6	55.1
04:05	53	51.3412	1.39231	1	47.4	48.8	49.8	51.4	52.8	53.7	55.2
04:06	54	51.4753	1.40194	1	47.5	48.9	49.9	51.5	52.9	53.9	55.3
04:07	55	51.5452	1.41002	1	47.5	49	50	51.6	53	54	55.4
04:08	56	51.6156	1.4181	1	47.6	49.1	50.1	51.7	53.1	54.1	55.6
04:09	57	51.7145	1.42338	1	47.7	49.2	50.2	51.8	53.2	54.2	55.7
04:10	58	51.8752	1.42866	1	47.8	49.3	50.3	51.9	53.3	54.3	55.9
04:11	59	51.9452	1.39979	1	48	49.4	50.4	52	53.4	54.4	55.9
05:00	60	52.0258	1.37092	1	48.1	49.5	50.6	52.1	53.5	54.5	55.9

Y:M: Years : Months -3SD: -3 standard deviation M: Months -2SD: -2 standard deviation
S: Standard deviation -1SD: -1 standard deviation (The generalized coefficient of variation) 1SD: 1 standard deviation
L: Lambda 2SD: 2 standard deviation (The power in the Box-Cox transformation) 3SD: 3 standard deviation

In the cross sectional component the children between 1and5 years were measured once. Healthy children who fulfilled the inclusion criteria which included full term infants even with low birth weight (<2500gm) as they are normal but represented small, exclusive breast feeding at least 4 months, introduction of complementary foods by the age of 4 months and continued partial breast feeding up to at least 12 months, good nutrition and history, socioeconomic condition favorable to growth , no perinatal history of medical importance absence of significant morbidity ,being well or apparently normal. All children are examined by identical measuring equipment. Instruments needed to be highly accurate and precise to measure HC we used a self-retracting,0.7cm,wide,flat metal tape with blank lead in strip range 0-500cm calibrated to 1mm.

Metaltape was chosen because it is more robust and accurate and stays in a single plane around the head[18]. HC was measured in centimeters.

Statistical Analyses

In order to determine the standard deviation (-3to+3) of HC for boys and girls. The L, M, S method was used.

The LMS parameters are the median (M), the generalized coefficient of variation (S), and the power in the Box-cox transformation (L). The Box-cox transformation is used to adjust the distribution of anthropometric data to a normal distribution. The method models the data taking into consideration the degree of skewness (L) central tendency (M) and dispersion (L).

Table 2 shows Egyptian z scores for head circumference for age for girls aged zero to 5 years

Head circumference-for-age GIRLS											
Egyptian Z-score Birth to 5 Years											
Y:M	**M**	**Mean**	**S**	**L**	**-3SD**	**-2SD**	**-1SD**	**Median**	**1SD**	**2SD**	**3SD**
00:00	0	34.2256	1.16138	1	30.7	31.8	33	34.3	35.4	36.6	37.8
00:01	1	36.5422	1.34798	1	32.5	33.2	35.1	36.6	37.9	39.3	40.5
00:02	2	38.4015	1.58589	1	34.1	35.3	36.9	38.5	40.1	41.8	42.9
00:03	3	39.4475	1.58822	1	35	36.3	37.8	39.5	41.1	42.8	44
00:04	4	40.4357	1.61225	1	35.9	37.2	38.8	40.5	42.1	43.8	45.1
00:05	5	41.2205	1.60237	1	36.6	37.9	39.6	41.3	42.9	44.6	46
00:06	6	41.9158	1.69224	1	37.1	38.4	40.2	42	43.6	45.3	46.7
00:07	7	42.5258	1.82003	1	37.5	38.8	40.7	42.6	44.4	46.2	47.5
00:08	8	42.9258	1.73269	1	38	39.3	41.1	43	44.7	46.5	47.8
00:09	9	43.3155	1.70408	1	38.4	39.8	41.6	43.4	45.1	46.8	48.2
00:10	10	43.6025	1.67863	1	38.8	40.3	42	43.7	45.4	47.1	48.7
00:11	11	44.1475	1.68234	1	39.3	40.7	42.4	44.2	45.8	47.5	48.9
01:00	12	44.4254	1.7209	1	39.5	40.8	42.6	44.5	46.2	47.9	49.3
01:01	13	44.6732	1.65896	1	39.9	41.2	42.9	44.7	46.3	48	49.3
01:02	14	44.9928	1.64606	1	40.2	41.6	43.2	45	46.5	48.2	49.6
01:03	15	45.2801	1.68313	1	40.4	41.8	43.6	45.3	47	48.6	50
01:04	16	45.4175	1.66025	1	40.6	42.1	43.6	45.5	47.1	48.7	50.2
01:05	17	45.7035	1.65653	1	40.9	42.3	43.9	45.8	47.5	48.9	50.4
01:06	18	45.9423	1.64137	1	41.3	42.7	44.2	46	47.6	49.1	50.5
01:07	19	46.085	1.6494	1	41.5	42.8	44.4	46.2	47.8	49.2	50.7
01:08	20	46.2012	1.57244	1	41.7	43.1	44.8	46.3	47.9	49.4	50.8
01:09	21	46.4650	1.58332	1	41.9	43.3	44.8	46.5	48	49.5	50.9
01:10	22	46.6452	1.56993	1	42.1	43.5	45	46.7	48.3	49.8	51.1
01:11	23	46.7834	1.60137	1	42.3	43.7	45.2	46.8	48.5	49.8	51.3
02:00	24	47.0852	1.59411	1	42.5	43.9	45.4	47.1	48.7	50.1	51.5
02:01	25	47.1143	1.59623	1	42.7	44.1	45.5	47.2	48.7	50.2	51.6
02:02	26	47.2752	1.59835	1	42.9	44.3	45.7	47.3	48.8	50.3	51.7
02:03	27	47.4179	1.57458	1	43.1	44.5	45.8	47.5	49	50.4	51.8
02:04	28	47.6377	1.55081	1	43.3	44.7	46	47.7	49.2	50.5	51.9
02:05	29	47.7521	1.53734	1	43.5	44.9	46.1	47.8	49.3	50.6	52
02:06	30	47.9745	1.52386	1	43.7	45.1	46.3	48	49.5	50.7	52.1
02:07	31	48.0232	1.49088	1	43.8	45.2	46.4	48.1	49.5	50.7	52.1
02:08	32	48.1126	1.45789	1	44	45.4	46.6	48.2	49.6	50.8	52.2
02:09	33	48.2357	1.46028	1	44.2	45.6	46.8	48.3	49.7	50.9	52.3
02:10	34	48.4352	1.46266	1	44.4	45.8	47.1	48.5	49.8	51	52.4
02:11	35	48.5452	1.46266	1	44.5	45.9	47.2	48.6	49.9	51.1	52.5
03:00	36	48.6624	1.46266	1	44.6	46	47.3	48.7	50	51.2	52.6
03:01	37	48.6157	1.44002	1	44.7	46.1	47.4	48.7	50.1	51.3	52.7
03:02	38	48.7423	1.41738	1	44.8	46.2	47.5	48.8	50.3	51.4	52.8
03:03	39	48.8852	1.41737	1	44.9	46.3	47.6	49	50.4	51.5	52.9
03:04	40	49.175	1.41736	1	45.1	46.5	47.7	49.2	50.5	51.7	53.1
03:05	41	49.2225	1.4231	1	45.2	46.6	47.8	49.3	50.6	51.8	53.2
03:06	42	49.3756	1.42883	1	45.3	46.7	47.9	49.4	50.7	51.9	53.3
03:07	43	49.4157	1.41558	1	45.4	46.9	48	49.5	50.8	51.9	53.4
03:08	44	49.5961	1.40233	1	45.5	47.1	48.2	49.6	51	51.9	53.5
03:09	45	49.6356	1.3849	1	45.6	47.2	48.2	49.7	51.1	52	53.6
03:10	46	49.7756	1.3674	1	45.7	47.3	48.2	49.8	51.2	52.1	53.7
03:11	47	49.8962	1.36919	1	45.7	47.3	48.3	49.9	51.3	52.2	53.7
04:00	48	49.9205	1.37092	1	46	47.4	48.5	50	51.4	52.4	53.8
04:01	49	50.0246	1.3542	1	46.1	47.5	48.6	50.1	51.4	52.4	53.8
04:02	50	50.1258	1.33747	1	46.3	47.7	48.7	50.2	51.5	52.5	53.9
04:03	51	50.2356	1.33855	1	46.4	47.8	48.8	50.3	51.6	52.6	54
04:04	52	50.3632	1.33963	1	46.5	47.9	48.9	50.4	51.8	52.7	54.1
04:05	53	50.4956	1.33963	1	46.6	48	49	50.5	51.9	52.8	54.2
04:06	54	50.5537	1.33963	1	46.7	48.1	49.1	50.7	52	52.9	54.3
04:07	55	50.6626	1.32687	1	46.8	48.2	49.2	50.7	52	53	54.4
04:08	56	50.7351	1.31411	1	46.9	48.3	49.3	50.8	52.1	53.1	54.5
04:09	57	50.8205	1.31411	1	47	48.4	49.4	50.9	52.2	53.2	54.6
04:10	58	50.9703	1.31411	1	47.1	48.5	49.5	51	52.3	53.3	54.7
04:11	59	51.024	1.31411	1	47.2	48.6	49.6	51.1	52.4	53.4	54.8
05:00	60	51.1128	1.31411	1	47.3	48.7	49.7	51.2	52.5	53.5	54.9

Y:M: Years : Months -3SD: -3 standard deviation M: Months -2SD: -2 standard deviation
S: Standard deviation -1SD: -1 standard deviation (The generalized coefficient of variation) 1SD: 1 standard deviation
L: Lambda 2SD: 2 standard deviation (The power in the Box-Cox transformation) 3SD: 3 standard deviation

The L, M and S parameters are calculated and smoothed to the method of maximum penalized likelihood [19] Z score and was calculated according to the following formula:
P=M [1+LSZ]1/L,L ≠0

L,M and S models was assessed using Q-test where L,M and S models are the values from the appropriate table corresponding to the age in years of the child z is the Z- score that corresponds to the percentile [20]

For the present analysis Z-scores were statistically analyzed using SPSSV 15 and excel, we calculated the Z-score of -3,-2,-1.0,+1,+2 and +3 for head circumference for age. The goodness of fit of all L, M and S models was assessed using Q-test.

RESULTS

A total of 27.537 Egyptian children 13.888 boys (50.4%) and 13.644 girls (49.6%) from birth to 5 years of age were examined in this study for head circumference for age.

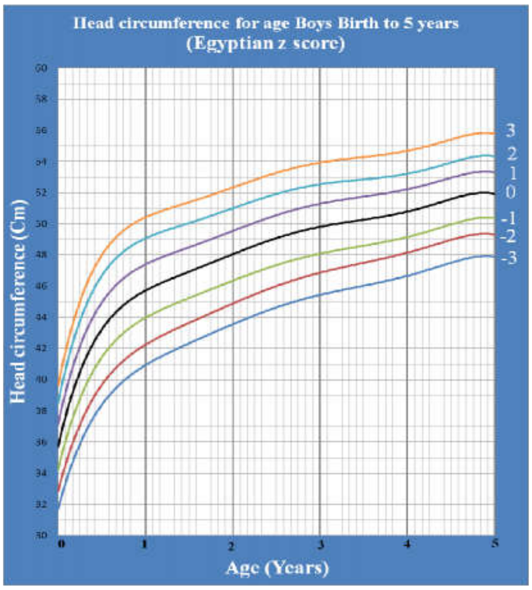

Fig 1 shows the Egyptian Z score head circumference for age from birth to 5 years for boys

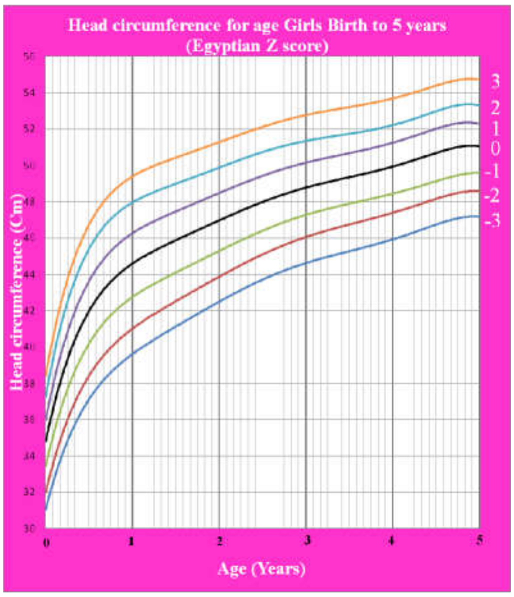

Fig 2 shows the Egyptian Z score head circumference for age from birth to 5 years for girls

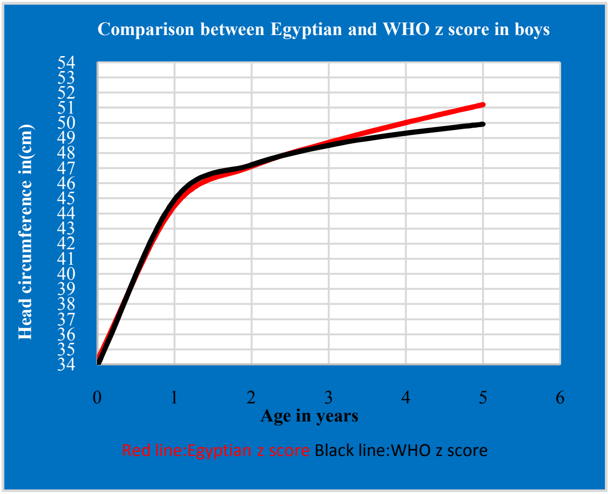

Fig 3 comparison between Egyptian and WHO z score in boys.

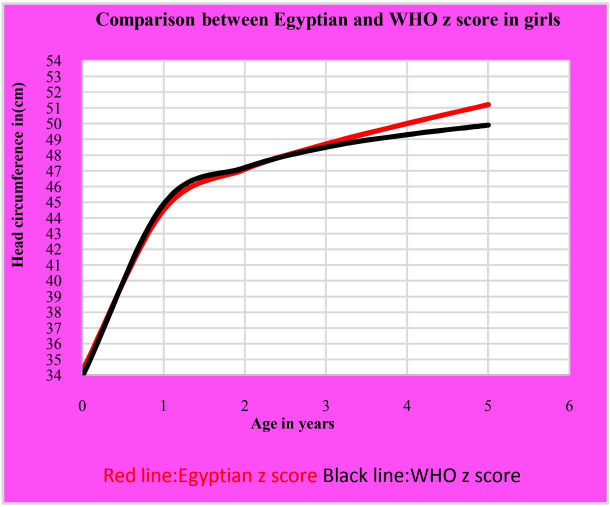

Fig 4 comparison between Egyptian and WHO z score in girls.

DISCUSSION

Early measurement of HC during the first year of life is very important as most of the conditions of increased HC or hydrocephalous are detected during this period[21].The brain grows rapidly in the early age of life as it reaches about half of its adult size by the age of 9 months and about 80% of its adult size by the age of 2 years and that's why HC is more likely to be affected by malnutrition of chronic disease in early age. Serial measurements of HC are more important than single measurement as shown by various studies that's why repeated health visits of the child are required which doesn't actually happen in developing countries. This emphasizes that the use of reference ranges that matches the target population is very important. The WHO's MGRS has established growth standards to be used for children all over the world to show how they should grow [13]. However because of the differences between populations [14] which seems to be related to nutritional, genetic and environmental back ground. Many countries have established their own reference ranges because the global one is not suitable to be used for the regional population. In our study we collected the data in a way to be representative of the Egyptian children from different areas of Egypt as much as we could.Our study presents reference ranges for HC in Egyptian children aged between 0-5 years. Egyptian +2 SD lines were found to be higher than the WHO lines in 1st 2 years of life then become converging with them from 2-5 years. The median lines (0) were found to be lower than the WHO till the age of 30 months then become higher than the WHO lines from 31 to 60 months of age. The -2 SD lines were found to be lower than the WHO lines from 0-2 years of age then converging with them from 2-5 years of age. The Egyptian +2 SD lines are located entirely above the corresponding WHO reference lines the first 2 years of life then converge with the WHO reference lines from 2 to 5 years Fig 3&4. So many Egyptian children when using the WHO reference ranges will be found to have HC that is more than 2 SD above the median although there are blow the cut off compared with Egyptian population. This result was confirmed when comparing measurements of HC in Egyptian children to the WHO ranges.

CONCLUSION

The aim of our study is to establish reference ranges for HC in Egyptian children as the WHO reference ranges has proved not to be suitable to be used in different populations because of differences in genetic, nutrition and environmental back ground.

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How to cite this article:

Ali M El-Shafie *et al* (2017) 'Z Score of Egyptian Children For Head Circumference', *International Journal of Current Advanced Research,* 06(11), pp. 7281-7285. DOI: http://dx.doi.org/10.24327/ijcar.2017.7285.1116

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