Makalenin Geliş Tarihi: 20 Mayıs 2019
Makalenin Kabul Tarihi: 30 Mayıs 2019

HEAD CIRCUMFERENCE PERCENTILES FOR 0-3-YEAR-OLD INFANTS IN TURKEY: THE RESULTS OF A NATIONWIDE GROWTH STUDY*

TÜRKİYE'DE 0-3 YAŞ BEBEKLERE AİT BAŞ ÇEVRESİ REFERANS EĞRİLERİ:
ÜLKE ÇAPINDA YÜRÜTÜLMÜŞ BÜYÜME REFERANS ÇALIŞMASI SONUÇLARI

*Berna Ertuğrul***
*İzzet Duyar****

Abstract

Population-based growth studies are important to demonstrate social, cultural, and medical milieu of the societies. The fact that there is no nationwide head circumference growth references of Turkish children is a significant deficiency. In this study, we aimed to create head growth references for 0-3-year-old children living in good conditions in Turkey. Within this scope, a total of 2061 infants and children with 1029 being boys and 1032 girls were examined in seven metropolitan city (Istanbul, Ankara, İzmir, Adana, Samsun, Diyarbakır, and Erzurum) in Turkey. LMS method was used to create percentile curves. According to the data obtained, it can be said that children of our country who grow in optimal and/or sub-optimal conditions have somewhat larger head circumference compared to their peers from the USA, but the difference is relatively low. Great similarity between the results of this study, which was conducted as multicenter, and previous reference studies performed in Istanbul is remarkable.

Keywords: *Growth References, Growth Percentiles, Head Circumference, LMS Method*.

Öz

Popülasyon bazında yürütülen büyüme çalışmaları toplumların gelişmişlik ve refah seviyelerini ortaya koyması açısından önemlidir. Türk çocuklarına ait, ülkemizin genelinden elde edilmiş güncel kafa çevresi büyüme referanslarının olmaması önemli bir eksikliktir. Bu çalışmada Türkiye'de iyi koşullarda yaşayan 0-3 yaş grubu sağlıklı çocukların baş büyüme referanslarının oluşturulması amaçlanmıştır. Bu kapsamda İstanbul, Ankara, İzmir, Adana, Samsun, Diyarbakır ve Erzurum illerinde 1029 erkek ve 1032 kız olmak üzere toplam 2061 bebek ve çocuk incelenmiştir. Yüzdelik eğrilerinin oluşturulması ve eğrilerin düzeltilmesi (smooth) için LMS metodu kullanılmıştır. Elde edilen bulgulara göre, optimal koşullarda büyüyen ülkemiz çocuklarının ABD'li yaşıtlarından bir miktar daha büyük kafa çevresine sahip oldukları, ancak aradaki farkın düşük düzeyde olduğu söylenebilir.

* This study was supported by Scientific Research Projects Coordination Unit of Istanbul University. Project number: 49981
** Res. Assist. Dr., *Sivas Cumhuriyet University*, Faculty of Literature, Department of Anthropology, *ORCID: 0000-0002-4966-601X*
*** Prof., *İstanbul University*, Faculty of Literature, Department of Anthropology, *ORCID: 0000-0002-4578-0528*

Çok merkezli olarak yürütülmüş bu çalışmanın sonuçları ile daha önce İstanbul merkezli yürütülmüş referans çalışmaları arasındaki büyük benzerlik ise dikkat çekicidir.

Anahtar Kelimeler: *Büyüme referansları, büyüme eğrileri, baş çevresi, LMS metodu*

Introduction

It is known for a long time that, children living in large cities and growing in good conditions exhibit a better growth performance than children living in rural areas and take place in a low socio-economic status. The relevant findings obviously reveal a significant correlation between growth rates of children and welfare levels of societies (Tanner, 1990). Therefore, follow up of growth at population level is important in order to put forth socioeconomic conditions and welfare levels of societies. On the other hand, regular monitoring of growth at individual basis, provides important information in the diagnosis of acute or chronic malnutrition, diseases, and genetic disorders. Ability to follow up growth cessation and growth spurt paves the way for research of the reasons for unusual conditions. This necessitate regular follow up of the growth of each children from birth, and make creating growth reference curves specific to populations inevitable (Lejarraga, 2012).

Anthropometric variables can give information about general growth. However, sensitivity shown by each variables in follow up of growth varies at different stage of growth. Head circumference measurement is highly useful for postnatal follow up of brain development. It can be said that head circumference references are necessary to follow up neural development as well as for the diagnosis of diseases such as microcephaly and macrocephaly. Since the brain grows fast, head circumference increase faster compared to body height and weight within the first years of life. Therefore, pediatricians often refer head circumference measurement in the diagnosis of early period growth retardation and diseases (Lejarraga, 2012).

Although there are some reference studies about head development of infants and children in our country from birth (Neyzi et al., 2008; Gökçay et al., 2011), these studies have been conducted only in a single province. Growth reference curves for people living in Turkey were published for the first time by Neyzi et al. in 1978, have been widely used nationwide until today, and met the need in many aspects. Istanbul can be accepted as the most appropriate city for a reference study, which is planned to be conducted in a single center,

because it has a large population, and receives migration from many regions. However, it must be stated that selection of the population studied in order to create these curves from a single center lowers the power of nationwide representation.

Nationwide multicenter growth reference percentiles to be obtained are important in terms of demonstrating physical development levels of children living in every region of Turkey. The objective of this study was to reveal head development of 0-3-year-old healthy infants who lives in good conditions in Turkey, have a family with relatively good economic status, whose health and nutrition expenditures can be largely meet, and who had no hereditary and acquired diseases, and to create growth and development reference values.

Material and Methods

In this study, a province representative of the region was selected from the 7 geographic regions of Turkey in order to create growth references that can represent all the country. For this purpose Istanbul, Ankara, İzmir, Adana, Diyarbakır, Samsun, and Erzurum provinces were included in the study.

These cities are economically the most developed cities with the highest population density of the region which they represent. Sample size of the cities was determined by quota sampling considering population information of total population and 0-18-year-old group. Accordingly, 360 boys and 358 girls from Istanbul, 173 boys and 176 girls from Ankara, 135 boys and 142 girls from İzmir, 109 boys and 108 girls from Adana, 74 boys and 69 girls from Samsun, 103 boys and 107 girls from Diyarbakır, and 75 boys and 72 girls from Erzurum province were examined. A total of 2061 0-3-year-old infants across Turkey were included in the study with 1029 being boys and 1032 girls (Table 1).

Table 1: Numbers of boys and girls examined according to cities

	İstanbul		**Ankara**		**İzmir**		**Adana**		**Samsun**		**Diyarbakır**		**Erzurum**		**Turkey**		
Age (month)	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	Total (n)
0-3 month	52	50	24	27	16	19	16	15	10	10	14	15	11	12	143	148	291
3-6 month	55	55	27	26	20	25	16	19	9	10	15	16	12	10	154	161	315
6-9 month	54	56	25	25	20	18	16	15	12	11	15	16	11	12	153	153	306
9-12 month	50	50	25	25	19	20	15	15	10	9	14	16	10	10	143	145	288
12-18 month	49	48	24	24	21	21	15	15	11	10	15	14	10	9	145	141	286
18-24 month	51	49	24	26	20	20	16	14	12	10	15	15	11	10	149	144	293
24-36 month	49	50	24	23	19	19	15	15	10	9	15	15	10	9	142	140	282
Total (n)	360	358	173	176	135	142	109	108	74	69	103	107	75	72	1029	1032	2061

The measurements were made in the pediatrics clinics of the university hospitals. Children with low birth weight, preterm infants and children with hereditary or acquired diseases were excluded from the study. The necessary ethical approval was received from the Istanbul University Social and Human Sciences Research Ethics Committee chairmanship.

Field research of the study was conducted between March 2015 and August 2017. Within the sample, infants in 0-1 year age group were examined with 3-month and those in 1-2 year age group with 6-month periods (see WHO, 1995; de Onis et al., 2001). Head circumference measurements were made with a 0.6 cm wide non-flexible measuring tape. For the measurement, the tape was wrapped so as to cross immediately over the superciliary arch and from the most protruding posterior area, and the widest measurement of the head was read (Lohman et al., 1988).

Basic statistical findings of the variables such as mean and standard deviation, and distribution statistics (kurtosis and skewness) were calculated. LMS method was used to create percentile curves and to smooth the curves. In this technique, transitions between age groups are smoothed by Box-Cox transformation. In this method, l refers to Box-Cox transformation power to correct the skewness, M median, and S coefficient of variation (Cole and Green, 1992).

For each age and gender, 3rd, 5th, 10th, 25th, 50th, 75th, 90th, 95th, and 97th percentiles were calculated (Cogill, 2003; Stinson, 2013).

Results

LMS tables and curves of head circumference growth can be seen in Table 2-3 and Figure 1-3. Difference between the percentile curves was low within the first months, the distances between the curves, namely range of variation increases in the ongoing months. Head circumference is 35.78 cm in boys and 35.30 cm in girls at the time of birth.

Table 2: Smoothed head circumference percentiles (in cm) for boys (n=1209)

Month	L	M	S	3	5	10	25	50	75	90	95	97
0	0.07	35.78	0.03	33.63	33.89	34.30	34.99	35.78	36.58	37.32	37.77	38.06
3	0.93	40.36	0.03	37.91	38.21	38.69	39.48	40.36	41.24	42.03	42.51	42.82
6	1.67	43.56	0.03	40.91	41.25	41.76	42.62	43.56	44.49	45.31	45.80	46.11
9	2.02	45.53	0.03	42.78	43.14	43.68	44.56	45.53	46.47	47.31	47.80	48.12
12	1.87	46.74	0.03	44.00	44.35	44.89	45.78	46.74	47.69	48.53	49.03	49.35
15	1.42	47.54	0.03	44.86	45.20	45.72	46.59	47.54	48.49	49.33	49.84	50.16
18	0.84	48.20	0.03	45.59	45.92	46.42	47.26	48.20	49.14	49.99	50.50	50.84
21	0.22	48.74	0.03	46.20	46.51	47.00	47.81	48.74	49.67	50.53	51.04	51.38
24	-0.49	49.12	0.03	46.67	46.97	47.43	48.22	49.12	50.04	50.90	51.42	51.76
27	-1.33	49.39	0.03	47.05	47.33	47.76	48.52	49.39	50.29	51.14	51.67	52.02
30	-2.31	49.58	0.03	47.36	47.62	48.03	48.74	49.58	50.46	51.30	51.83	52.18
33	-3.39	49.75	0.02	47.67	47.91	48.29	48.96	49.75	50.59	51.41	51.93	52.28
36	-4.51	49.80	0.02	47.88	48.10	48.45	49.06	49.80	50.60	51.38	51.88	52.23

Table 3: Smoothed head circumference percentiles (in cm) for girls (n=1032)

Month	L	M	S	3	5	10	25	50	75	90	95	97
0	1.60	35.30	0.03	33.20	33.47	33.88	34.55	35.30	36.03	36.68	37.07	37.32
3	1.51	39.81	0.03	37.48	37.78	38.23	38.99	39.81	40.63	41.36	41.80	42.08
6	1.43	42.70	0.03	40.23	40.54	41.02	41.82	42.70	43.57	44.34	44.80	45.10
9	1.35	44.40	0.03	41.86	42.18	42.68	43.49	44.40	45.29	46.09	46.57	46.88
12	1.27	45.61	0.03	43.05	43.37	43.87	44.70	45.61	46.52	47.34	47.82	48.14
15	1.18	46.33	0.03	43.76	44.08	44.58	45.41	46.33	47.24	48.06	48.55	48.87
18	1.10	47.05	0.03	44.48	44.80	45.30	46.13	47.05	47.97	48.79	49.29	49.61
21	1.02	47.55	0.03	44.99	45.31	45.81	46.63	47.55	48.47	49.29	49.79	50.11
24	0.93	47.89	0.03	45.37	45.68	46.17	46.98	47.89	48.79	49.61	50.10	50.42
27	0.85	48.13	0.03	45.66	45.97	46.45	47.24	48.13	49.01	49.82	50.30	50.61
30	0.77	48.33	0.03	45.94	46.24	46.70	47.47	48.33	49.19	49.97	50.43	50.74
33	0.68	48.62	0.03	46.34	46.62	47.06	47.80	48.62	49.45	50.19	50.64	50.94
36	0.60	49.01	0.02	46.85	47.12	47.53	48.23	49.01	49.80	50.51	50.93	51.21

Figure 1: Head circumference percentiles curves for 0-36 months of boys

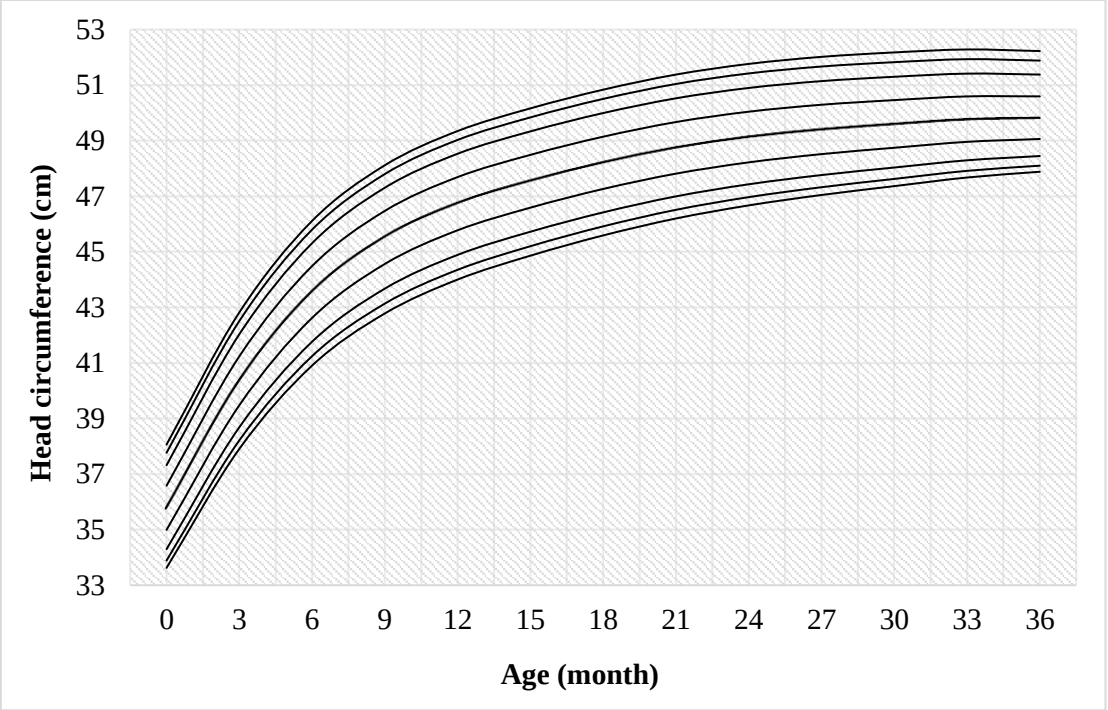


Figure 2: Head circumference percentiles curves for 0-36 months of girls

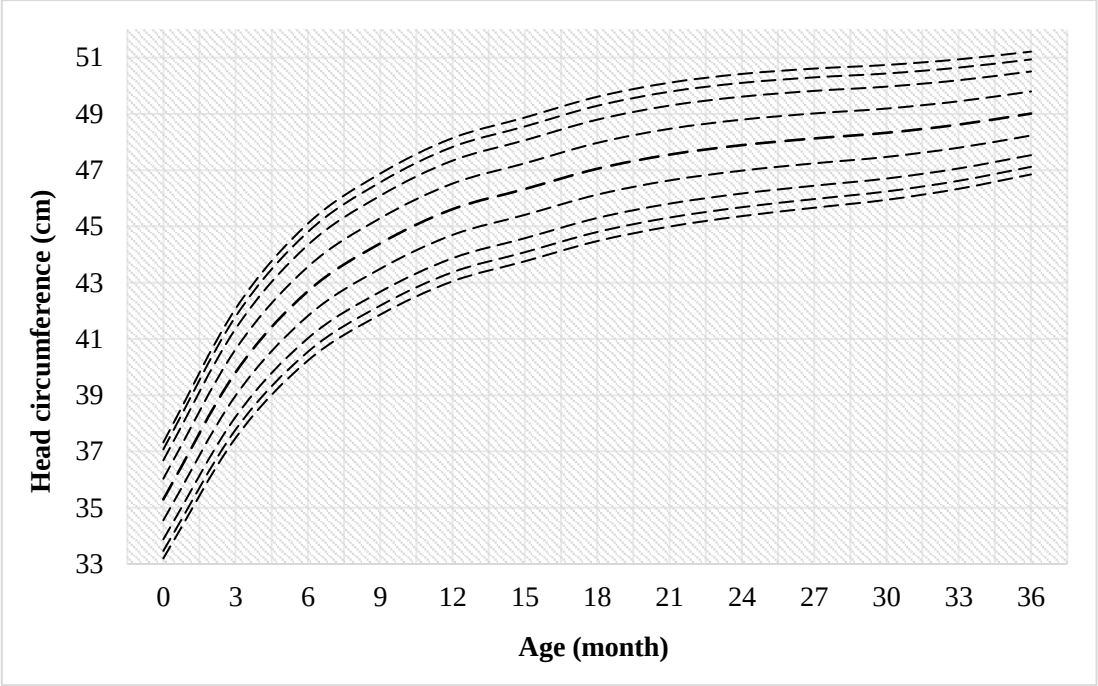


Figure 3: Head circumference percentiles curves for 0-36 months of boys and girls

Discussion

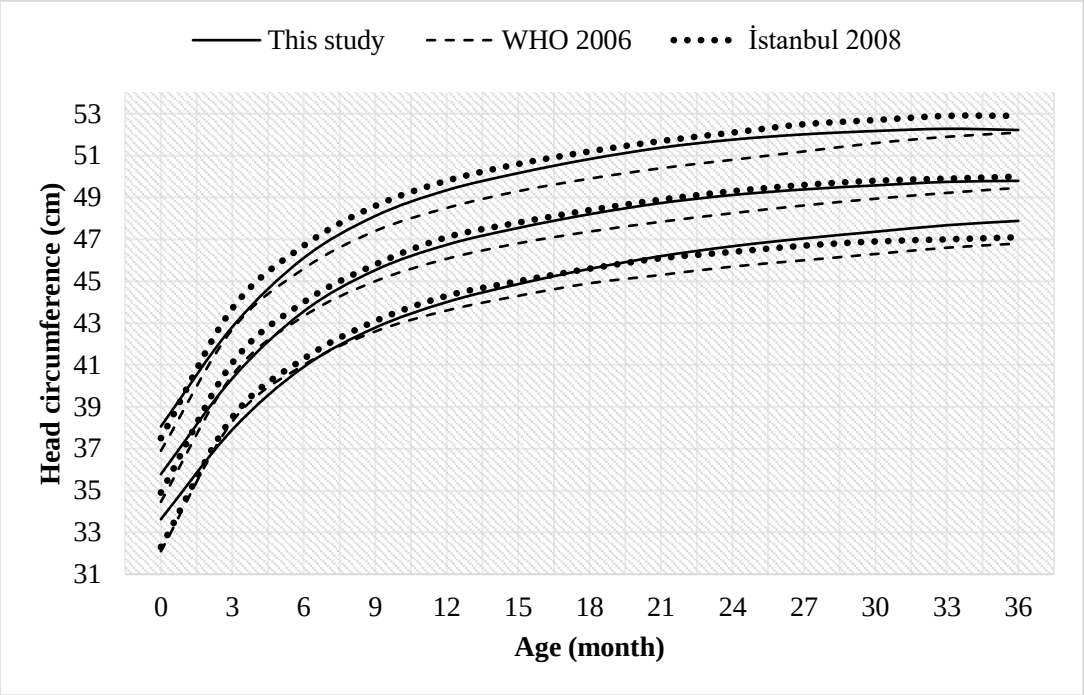
With over 80 million population, Turkey – together with Iran - is the country with the highest population of the region. According to the data by Turkish Statistical Institute (TÜİK), total fertility rate in our country was 2.15 children 2015, while this rate dropped to 2.10 children in 2016. On the other hand, looking to the change in pediatric population including 0-17 years old group which was accepted as children by definition of the United Nations (UN), we can say that the population in this age range constituted 48.5% of total population in 1970, and this rate took place in TÜİK records as 41.8% in 1990, and 28.3% in 2017. Although there was a consistent decrease both in fertility rate and ratio of 0-17 age range to total population over the last decade, current rates of Turkey remain much above the European Union countries. For example, total fertility rate is 1.6 in the European Union countries, while this rate is 1.92 in France, 1.85 in Sweden, 1.81 in Ireland, and 1.79 in Denmark and England (TÜİK, 2015).

In a report published by the World Health Organization Anthropometry Expert Committee in 1995, based on finding that obtaining growth reference data from different geographic centers is one of the priorities increasing reliability of the study (WHO, 1995). For this age group, this study is the first multicenter study in Turkey (see, Saatçioğlu 1988 for 7-11-year-old children and Duyar 1992 for 12-17-year-old adolescents).

Comparison of head circumference reference curves from the international studies and studies conducted in different countries with the curves of the present study is necessary in order to reveal the level of head growth potential of Turkish children living in relatively good conditions. Such comparisons will demonstrate how the children of our country grow according to the international references recommended by the World Health Organization (MGRS and WHO, 2007), owing the comparisons between the populations it will enable thorough examination of ethnic differences and similarities about growth specific to Turkish children.

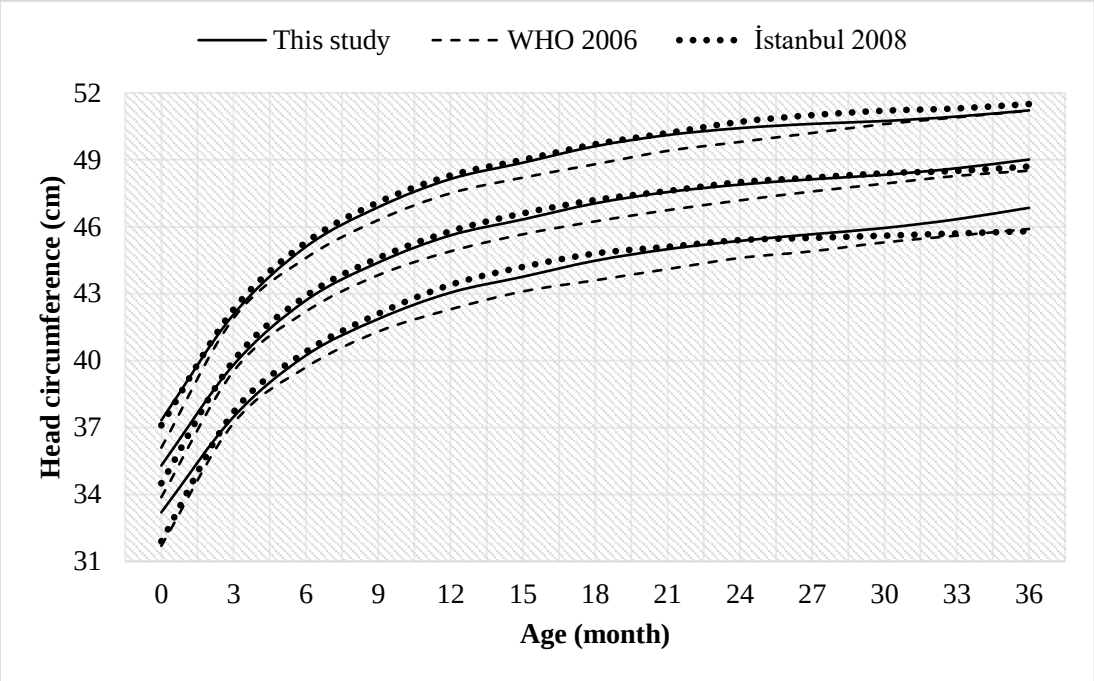
It will be appropriate to mention two important studies which are complementary for each other in 0-18 age range in our country. First is an Istanbul centered study conducted by Gökçay et al. (2011), in which head circumference reference values of 0-5 years infants and children were generated. The second study is a research conducted by Kara et al. (2016) about head circumference percentile values of children and young persons aged 5-18 years old, who were living in Kocaeli province. On the other hand, Neyzi (2008) and WHO (2006) curves include head circumference values of infants and children aged 0-36 months. In this study, the data of Neyzi (2008) and WHO (2006) comparisons are considered (Figure 4). Looking to the distance curves of boys, it can be said that the infants in 50th percentile in the current study have a head growth similar to their peers in WHO 2006 study until 6th month, and they leave their peers behind after the 6th month (Figure 4). The largest difference between the two group is in the 21th month with 0.9 cm, whereas the difference decreases and drops to 0.35 cm in the 36th month. On the other hand, as is expected Turkish children and children living in Istanbul (Neyzi, 2008) exhibit a similar head growth rate, however, it was remarkable that children living in Istanbul were somewhat above this curve. This difference begins from the second month, and is observed between 0.2 and 0.3 cm.

Figure 4: Head circumference percentiles compared from WHO and İstanbul references to 3rd, 50th, 97th percentile for boys.



In girls, WHO 2006 curves are again below the other two curves from the 3rd month, the difference from the girls included in the current study raises to 0.75 cm in the 15th month, and the difference is largely closed in the 36th month. The compliance between İstanbul (Neyzi, 2008) curves and Turkey curves in girls is remarkable (Figure 5).

Figure 5: Head circumference percentiles compared from WHO and İstanbul references to 3rd, 50th, 97th percentile for girls.



Figures 6 and 7 show head growth curves of 0-6 months infants in six countries including Turkey, Germany (Neuhauser et al., 2016), USA (Rollins et al., 2010), Belgium (Roelants et al., 2009), China (Zong and Li, 2013), Japan (Anzo et al., 2002) and Norway (Júlíusson et al., 2013). Comparisons of head circumference measurement used to follow up neural development showed no significant difference among the countries until about 1 year old. In both genders, Japanese and Chinese infants have a somewhat smaller head circumference from this age. Boys in our country have a head growth similar to their European and American peers, while Norway curves somewhat exceed the curves of our girls from the 15th month, and the USA and Germany curves from the 30th month. However, the maximum difference which occurs in the 36th month is below 0.5 cm. As is seen, similarity is high among the countries in the first months of life in terms of head growth, while the difference between Japan and China that are Far East countries and the USA and European countries begins to become evident with the 1st year of age.

Figure 6: Head circumference percentiles compared from Belgium, China, Germany, Japan, Norwegian and USA to 50th percentile for boys.

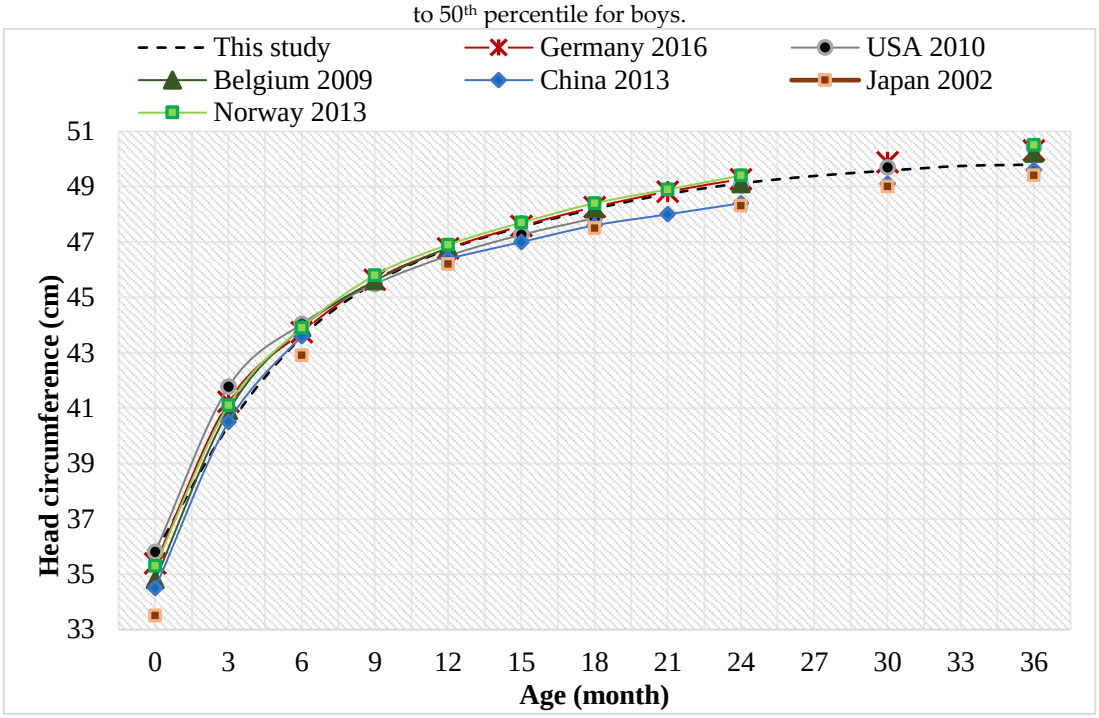
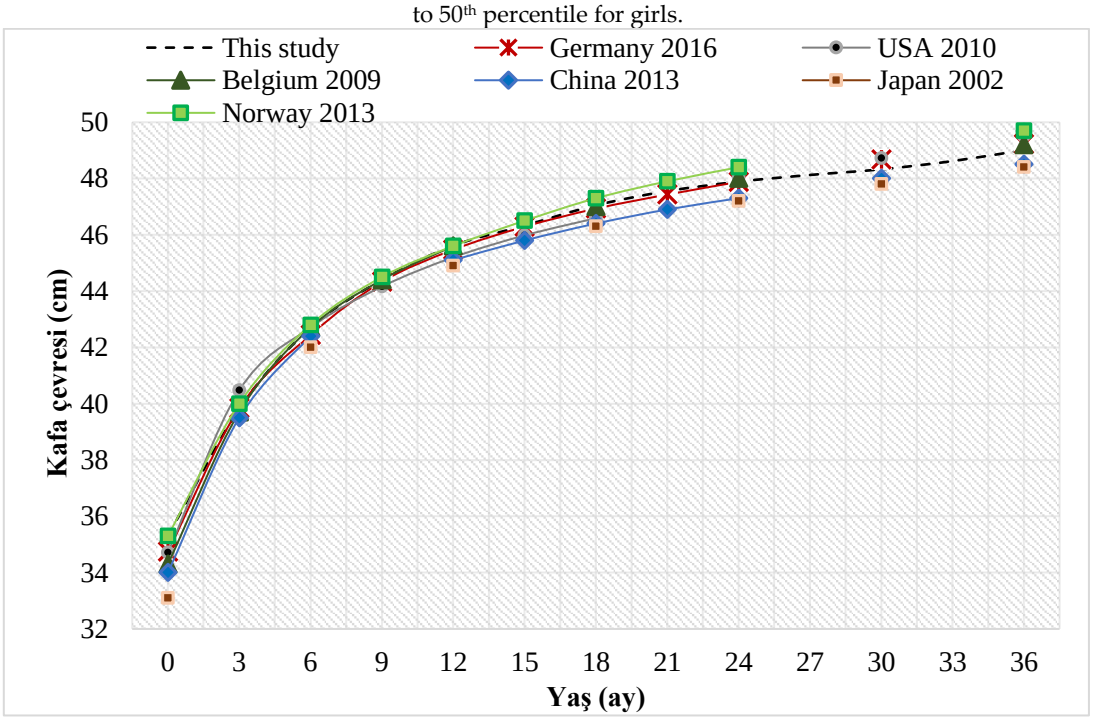


Figure 7: Head circumference percentiles compared from Belgium, China, Germany, Japan, Norwegian and USA to 50th percentile for girls.



Conclusion

Although growth potential has a strong hereditary component, it is thought that a large part of growth differences that emerge between the populations and social layers of the same population are environmental rather than genetic. As specified by the famous growth specialist JM Tanner who emphasized environmental components, "growth as a mirror of the condition of society" (Tanner, 1990). As required by this approach, we can reveal the direction of social change by following up growth status of children with routine intervals. This makes not only creation of growth reference curves specific to our country, but also renovation of these reference with certain intervals inevitable. In this study, we tried to create multicenter head reference growth curves of 0-3-year-old Turkish infants, and physical measurements were carried out in 7 metropolitans, representing 7 geographic regions of Turkey. For infants, this study is the first in Turkey in being conducted as a multicenter study and anthropometric measurements directly taken by the researcher.

Looking to the head circumference reference curves, children of our country who grow in optimal and sub-optimal conditions have somewhat larger head circumference compared to their peers from the USA, but the difference is low. Results of this multicenter study show a high similarity with the results obtained in the previous Istanbul-centered reference studies.

In conclusion, the results of this study are important in showing that not only children from Istanbul (Neyzi, 2008), but also children living in other regions of Turkey have a head growth potential at international standards, and even sometimes above these standards.

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